Application

Class V UIC Permit Application

Submitted to:

Illinois Environmental Protection Agency

Illinois ID# ID#0894075971

Submitted by:

City of Aurora

Volume 1 of 2

February 19, 2013

Deuchler Environmental, Inc. CONSULTING ENGINEERS

AURORA 1837 175 2012

UIC-147 cc: Des Plaines USEPA KL

Deuchler Environmental, Inc.
CONSULTING ENGINEERS

230 Woodlawn Avenue Aurora, Illinois 60506 630-897-8380 Fax 630-897-5696

Class V Underground Injection Control Permit Application

For the Property Located at
Southeast Corner Mettel Road and Illinois Route 25
Kane County
Aurora, Illinois

IEPA ID #0894075971

Applicant:

City of Aurora
Mr. Alex Alexandrou, Chief Administration Officer and Risk Manager
44 East Downer Place
Aurora Illinois 60507-2067

Prepared By:

Deuchler Environmental, Inc.
Mr. Marc R. Fisher
230 Woodlawn Avenue
Aurora, Illinois 60506

DEI Project Number: 07002-02

February 19, 2013

Illinois Environmental Protection Agency

Bureau of Land • 1021 North Grand Avenue East • P.O. Box 19276 • Springfield • Illinois • 62794-9276

General Application for Permit (LPC - PA1)

This form must be used for any application for permit from the Bureau of Land, except for landscape waste composting or hazardous waste management facilities regulated in accordance with RCRA, Subtitle C. One original, and two copies, or three if applicable, of all permit application forms must be submitted. Attach the original and appropriate number of copies of any necessary plans, specifications, reports, etc. to fully support and describe the activities and modifications being proposed. Attach sufficient information to demonstrate the compliance with all regulatory requirements. Incomplete applications will be rejected. Please refer to the instructions for further guidance. **Note: Applicants must provide a physical address; the post office will not deliver a certified letter (final action letter) to a P.O. Box only. Please provide an extended ZIP+4 code for the site identification and owner/operator information.**

You may complete this form online, save a copy locally, print, sign and submit it to the Bureau of Land at the address below. Note: Hand-delivered permit applications must be delivered between 8:30 am and 5:00 pm, Monday through Friday (excluding State holidays) to:

Bureau of Land, Permit Section, Mail Code #33
1021 North Grand Avenue East, P.O. Box 19276
Springfield, IL 62794-9276

I. Site Identification:

Site Name: City of Aurora Class V UIC — IEPA BOL No.: 0894075971

Street Address: SE Corner Rte 25 & Mettel Rd — P.O. Box:

City: Aurora — State: IL Zip + 4:* 60507-2067 — *Notification letters will not be sent without a 9-digit zip code. — County: Kane

Existing DE/OP Permit Numbers (if applicable): UIC-147

II. Applicant Identification:

	Owner	Operator (if Different)
Name:	City of Aurora	City of Aurora
Street Address:	44 East Downer Place	1111 Aurora Avenue
PO Box:		
City:	Aurora	Aurora
State:	IL	IL
Zip + 4:	60507-2067	60507-9731
Phone:	(630) 256-3441	(630) 256-3250
Contact:	Alex Alexandrou	Robert Leible
Email Address:	aalexandrou@aurora-il.org	rleible@aurora-il.org
FEIN ID No.	36-6005778	36-6005778

Agency correspondence mailed to: Owner ☑ Operator ☑ Other - Explain ☐

TYPE OF SUBMISSION/REVIEW PERIOD:	TYPE OF FACILITY:	TYPE OF WASTE:
☐ New Landfill/180 days (35 IAC Part 813)	☐ Landfill	☐ General Municipal Refuse
☐ Landfill Expansion/180 days (35 IAC Part 813)	☐ Land Treatment	☐ Hazardous
☐ Sig. Mod. to Operate/90 days (35 IAC Part 813)	☐ Transfer Station	☑ Special (Non-Hazardous)
☐ Other Sig. Mod./90 days (35 IAC Part 813)	☐ Treatment Facility	☐ Chemical Only (exec. putrescible)
☐ Renewal of Landfill/90 days (35 IAC Part 813)	☐ Storage	☐ Inert Only (exec. chem. & putrescible)
☐ Development/90 days (35 IAC Part 807)	☐ Incinerator	☐ Used Oil
☐ Operating/45 days (35 IAC Part 807)	☐ Composting	☐ Potentially Infectious Medical Waste
☐ Supplemental/90 days (35 IAC Part 807)	☐ Recycling/Reclamation	☐ Landscape/Yard Waste
☐ Permit Transfer/90 days (35 IAC Part 807)	☑ Other (Specify)	☐ Other (Specify)
☐ Renewal of Experimental Permit (35 IAC Part 807)	non-hazardous Class V UIC injection well	Drinking water treatment byproduct - lime sludge

RECEIVED

This Agency is authorized to require this information under Section 4 and Title X of the Environmental Protection Act (415 ILCS 5/4, 5/39). Failure to disclose this information may result in a civil penalty of not to exceed $50,000 for the violation and an additional civil penalty of not to exceed $10,000 for each day during which the violation continues (415 ILCS 5/42). This form has been approved by the Forms Management Center.

IL 532-1857
LPC 350 Rev. 5/2012

EPA - DIVISION OF RECORDS MANAGEMENT RELEASABLE

APR 30 2015

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IEPA-BOL PERMIT SECTION

REVIEWER MED

III. Description of this Permit Request: (Note: The box below will expand as needed)

A non-hazardous lime sludge generated by the treatment of drinking water (lime softening) by Aurora will be conveyed via a forcemain from the treatment plant approximately 1 mile north to a site for disposal into a former subterranean limestone/ dolomite mine (~250 feet deep) via 4 injection wells. The system includes a new pump station, forcemain, 4 injection wells, e extraction well and ancillary equipment and controls. Sludge solids will settle out and be retained in the mine and most of the water will be extracted from the mine and disposed in a sanitary sewer. The estimated storage life of the mine is >20 yrs

IV. Completeness Requirements

1. Have all required public notice letters been mailed in accordance with the LPC-PA16 instructions? Yes ☐ No ☐ N/A ☑
(If so, provide a list of those recipients of the required public notice letters for Illinois EPA retention. Such retention shall not imply any Illinois EPA review and/or confirmation of the list.)

Public Notice Recipients

Name: ____________ Title: ____________
Street Address: ____________ P.O. Box: ____________
City: ____________ State: ______ Zip Code: ____________

	Question	Yes	No	N/A
2.	Has the required Certification of Authenticity been completed and enclosed?	☑	☐	☐
3. a.	Is the Siting Certification Form (LPC-PA8) completed and enclosed?	☐	☐	☑
b.	Is siting approval currently under litigation?	☐	☐	☑
a.	Is a closure, and if necessary a post-closure plan covering these activities being submitted, or	☑	☐	☐
b.	has one already been approved? If yes, provide the permit number: ____________	☐	☑	☐
5. a.	For operating waste disposal sites, only: Has any employee, owner, operator, officer or director of the owner or operator had a prior conduct certification denied, canceled or revoked?	☐	☐	☑
b.	Have you included a demonstration of how you comply or intend to comply with 35 Ill. Adm. Code 745?	☐	☐	☑
6. a.	For waste disposal sites, only: Is the property for the facility held in a beneficial trust?	☐	☑	☐
b.	If yes, is a beneficial trust certification form (LPC-PA9) completed and enclosed?	☐	☐	☑
7. a.	Does the application contain information or proposals regarding the hydrogeology; groundwater monitoring, modeling or classification; a groundwater impact assessment; or vadose zone monitoring for which you are requesting approval?	☑	☐	☐
b.	If yes, have you submitted a third copy of the application (4 total) and supporting documents?	☑	☐	☐
8.	Has a 39(i) certification been submitted for each owner and operator business entity, and each person who signed for each entity, and each person who signed or may sign any application for this facility? Note: Only the original set of these forms need be submitted. If no, then complete this certification as indicated.	☑	☐	☐

V. Signatures:

Original signatures are required. Signature stamps or applications transmitted electronically or by FAX are not acceptable.

All applications shall be signed by the person designated below as a duly authorized representative of the owner an/or operator. A printed name for each signature should also be provided.

Corporation - By a principal executive officer of the level of vice-president or above.
Partnership or Sole Proprietorship - By a general partner or the proprietor, respectively.
Government - By either a principal executive officer or a ranking elected official.

A person is a duly authorized representative of the owner and operator only if:

1. They meet the criteria above or the authorization has been granted in writing by a person described above; and
2. Is submitted with this application (a copy of a previously submitted authorization can be used).

I hereby affirm that all information contained in this application is true and accurate to the best of my knowledge and belief. I do herein swear that I am a duly authorized representative of the owner/operator and I am authorized to sign this permit application form.

Any person who knowingly makes a false, fictitious, or fraudulent material statement, orally or in writing, to the Illinois EPA commits a Class 4 felony. A second or subsequent offense after conviction is a Class 3 felony. (415 ILCS 5/44(h))

Alex Alexandrou — Printed Name:
Chief Administrative Officer, COA — Title:

[signature] — Owner Signature:
4/29/15 — Date:

Notary: Subscribed and Sworn before me this 29TH day of April 2015.

My commission expires on: 1-18-2016

OFFICIAL SEAL
KARI L. ULRICH
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 1-18-2016

Kari L. Ulrich — Signature & Stamp/Seal of Notary Public

Robert Leible — Printed Name:
Asst Supt, Water Production Division — Title:

Robert Leible — Operator Signature:
4-29-15 — Date:

Notary: Subscribed and Sworn before me this 29TH day of April 2015.

My commission expires on: 1-18-2016

Kari L. Ulrich — Signature & Stamp/Seal of Notary Public

Licensed Professional Engineer's Name: Philippe Moreau, P.E.

Licensed Professional Engineer's Title: President

Registration Number: 062.048508

Company: Deuchler Environmental, Inc.

Street Address: 230 Woodlawn Avenue PO Box:

City: Aurora State: IL Zip + 4: 60506

Email Address: pmoreau@deuchler.com Phone: 630-897-8380

License Expiration Date: 11-29-2015

PHILIPPE F. MOREAU
062-048508
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

Licensed Professional Engineer's Seal

Signature: [signature] Date: 04.29.15

Illinois Environmental Protection Agency

Bureau of Land • 1021 North Grand Avenue East • P.O. Box 19276 • Springfield • Illinois • 62794-9276

Certification of Authenticity of Official Forms

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This form must accompany any application submitted to the Illinois EPA Bureau of Land, Division of Land Pollution Control, Permit Section on forms other than the official copy printed and provided by the Illinois EPA. The only allowed changes to the form are in spacing, fonts, and the addition of the information provided. Any additions must be underlined. The forms would not be considered identical if there is any change to, addition or deletion of words on the form or to the language of the form.

The same individuals that sign the application form it accompanies must sign the following certification.

I hereby certify under penalty of law that I have personally examined, and am familiar with the application form or forms and all included supplemental information submitted to the Illinois EPA herewith, and that the official Illinois Environmental Protection Agency application form or forms used herein is or are identical in all respects to the official form or forms provided by the Illinois EPA Bureau of Land Permit Section, and has not or have not been altered, amended, or otherwise modified in any way. I further certify under penalty of law that any attached or included electronic data version of the application form or forms complies with the official Illinois EPA's Electronic version thereof, and is or are identical in all respects to the official electronically downloadable form or forms provided by the Illinois EPA Bureau of Land Permit Section, and has not or have not been altered, amended or otherwise modified in any way.

[signature] — Owner Signature | 4/29/15 — Date

Alex Alexandrou — Printed Name | Chief Administrative Officer, COA — Title

[signature] — Operator Signature | 4-29-15 — Date

Robert Leible — Printed Name | Asst Supt, Water Production Division — Title

[signature] — Engineer Signature (if necessary) | 04.29.15 — Date

Philippe F. Moreau, P.E. — Printed Name

RECEIVED
APR 30 2015
IEPA-BOL
PERMIT SECTION

Subscribed and Sworn to Before Me, a Notary Public in and for the above-mentioned County and State.

Kari L. Ulrich — Signature | 4-29-15 — Date

Kari L. Ulrich — Printed Name

My commission expires on: 1-18-2016

OFFICIAL SEAL
KARI L. ULRICH
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 1-18-2016

Seal of Notary Public

IL 532-2941
LPC 670 Rev. 5/2012

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City: Aurora State: IL Zip + 4:* 60507-2067 *Notification letters will not be sent without a 9-digit zip code. County: Kane

Existing DE/OP Permit Numbers (if applicable): UIC-147

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Street Address:	44 East Downer Place	Street Address:	1111 Aurora Avenue
PO Box:		PO Box:	
City:	Aurora State: IL	City:	Aurora State: IL
Zip + 4:	60507-2067 Phone: (630) 256-3441	Zip + 4:	60507-9731 Phone: (630) 256-3250
Contact:	Alex Alexandrou	Contact:	Robert Leible
Email Address:	aalexandrou@aurora-il.org	Email Address:	rleible@aurora-il.org
FEIN ID No.	36-6005778	FEIN ID No.	36-6005778

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IL 532-1857
LPC 350 Rev. 5/2012

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REVIEWER MED

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OCT 01 2014

IEPA-BOL PERMIT SECTION

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Public Notice Recipients

Name: ______________________ Title: ______________________

Street Address: ______________________ P.O. Box: __________

City: ______________ State: _____ Zip Code: __________

		Yes	No	N/A
2.	Has the required Certification of Authenticity been completed and enclosed?	☑	☐	☐
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	b. Is siting approval currently under litigation?	☐	☐	☑
	a. Is a closure, and if necessary a post-closure plan covering these activities being submitted, or	☑	☐	☐
	b. has one already been approved? If yes, provide the permit number: ______________________	☐	☑	☐
5.	a. For operating waste disposal sites, only: Has any employee, owner, operator, officer or director of the owner or operator had a prior conduct certification denied, canceled or revoked?	☐	☐	☑
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Alex Alexandrou — Printed Name:
Chief Administrative Officer, COA — Title:

[signature] — Owner Signature:
9/29/14 — Date:

Notary: Subscribed and Sworn before me this 29th day of Sept. 2014.

My commission expires on: 11-29-15

OFFICIAL SEAL
MICHELE M RHODEN
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:11/29/15

Michele M. Rhoden
Signature & Stamp/Seal of Notary Public

Robert Leible — Printed Name:
Asst Supt, Water Production Division — Title:

[signature] — Operator Signature:
9-29-14 — Date:

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NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:11/29/15

Michele M. Rhoden
Signature & Stamp/Seal of Notary Public

Licensed Professional Engineer's Name: Philippe Moreau, P.E.

Licensed Professional Engineer's Title: President

Registration Number: 062.048508

Company: Deuchler Environmental, Inc.

Street Address: 230 Woodlawn Avenue PO Box:

City: Aurora State: IL Zip + 4: 60506

Email Address: pmoreau@deuchler.com Phone: 630-897-8380

License Expiration Date: 11-29-2015

PHILIPPE F. MOREAU
062-048508
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

Licensed Professional Engineer's Seal

Signature: [signature] Date: 09.29.14

Illinois Environmental Protection Agency

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[signature] Owner Signature	9/29/14 Date
Alex Alexandrou Printed Name	Chief Administrative Officer, COA Title
[signature] Operator Signature	9-29-14 Date
Robert Leible Printed Name	Asst Supt, Water Production Division Title
[signature] Engineer Signature (if necessary)	09.29.14 Date
Philippe F. Moreau, P.E. Printed Name	

Subscribed and Sworn to Before Me, a Notary Public in and for the above-mentioned County and State.

Michele M. Rhoden Signature	09-29-14 Date
Michele M. Rhoden Printed Name	

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OCT 01 2014
IEPA-BOL
PERMIT SECTION

My commission expires on: 11-29-2015

OFFICIAL SEAL
MICHELE M RHODEN
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:11/29/15

Seal of Notary Public

IL 532-2941
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Street Address:	44 East Downer Place	Street Address:	
PO Box:		PO Box:	
City:	Aurora State: IL	City:	State:
Zip + 4:	60507-2067 Phone: (630) 256-3441	Zip + 4:	Phone:
Contact:	Alex Alexandrou	Contact:	
Email Address:	AAlexandrou@aurora-il.org	Email Address:	
FEIN ID No.	36-6005778	FEIN ID No.	

Agency correspondence mailed to: Owner ☐ Operator ☐ Other - Explain ☐

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TYPE OF SUBMISSION/REVIEW PERIOD:	TYPE OF FACILITY:	TYPE OF WASTE:
☐ New Landfill/180 days (35 IAC Part 813)	☐ Landfill	☐ General Municipal Refuse
☐ Landfill Expansion/180 days (35 IAC Part 813)	☐ Land Treatment	☐ Hazardous
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EPA - DIVISION OF RECORDS MANAGEMENT
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IL 532-1857
LPC 350 Rev. 5/2012

III. Description of this Permit Request: (Note: The box below will expand as needed)

A non-hazardous lime sludge generated by the treatment of drinking water (lime softening) by Aurora will be conveyed via a forcemain from the treatment plant approximately 1 mile north to a site for disposal into a former subterranean limestone/ dolomite mine (~250 feet deep) via 4 injection wells. The system includes a new pump station, forcemain, 4 injection wells, one extraction well and ancillary equipment and controls. Sludge solids will settle out and be retained in the mine and most of the water will be extracted from the mine and disposed in a sanitary sewer. The estimated storage life of the mine is >20 yrs

IV. Completeness Requirements

1. Have all required public notice letters been mailed in accordance with the LPC-PA16 instructions? Yes ☐ No ☐ N/A ☑
(If so, provide a list of those recipients of the required public notice letters for Illinois EPA retention. Such retention shall not imply any Illinois EPA review and/or confirmation of the list.)

Public Notice Recipients

Name: ____________ Title: ____________
Street Address: ____________ P.O. Box: ____________
City: ____________ State: ______ Zip Code: ____________

		Yes	No	N/A
2.	Has the required Certification of Authenticity been completed and enclosed?	☑	☐	☐
3.	a. Is the Siting Certification Form (LPC-PA8) completed and enclosed?	☐	☐	☑
	b. Is siting approval currently under litigation?	☐	☐	☑
4.	a. Is a closure, and if necessary a post-closure plan covering these activities being submitted, or	☑	☐	☐
	b. has one already been approved? If yes, provide the permit number: ____________	☐	☑	☐
5.	a. For operating waste disposal sites, only: Has any employee, owner, operator, officer or director of the owner or operator had a prior conduct certification denied, canceled or revoked?	☐	☐	☑
	b. Have you included a demonstration of how you comply or intend to comply with 35 Ill. Adm. Code 745?	☐	☐	☑
6.	a. For waste disposal sites, only: Is the property for the facility held in a beneficial trust?	☐	☑	☐
	b. If yes, is a beneficial trust certification form (LPC-PA9) completed and enclosed?	☐	☐	☑
7.	a. Does the application contain information or proposals regarding the hydrogeology; groundwater monitoring, modeling or classification; a groundwater impact assessment; or vadose zone monitoring for which you are requesting approval?	☑	☐	☐
	b. If yes, have you submitted a third copy of the application (4 total) and supporting documents?	☑	☐	☐
8.	Has a 39(i) certification been submitted for each owner and operator business entity, and each person who signed for each entity, and each person who signed or may sign any application for this facility? Note: Only the original set of these forms need be submitted. If no, then complete this certification as indicated.	☑	☐	☐

V. Signatures:

Original signatures are required. Signature stamps or applications transmitted electronically or by FAX are not acceptable.

All applications shall be signed by the person designated below as a duly authorized representative of the owner an/or perator. A printed name for each signature should also be provided.
Corporation - By a principal executive officer of the level of vice-president or above.
Partnership or Sole Proprietorship - By a general partner or the proprietor, respectively.
Government - By either a principal executive officer or a ranking elected official.

A person is a duly authorized representative of the owner and operator only if:

1. They meet the criteria above or the authorization has been granted in writing by a person described above; and
2. Is submitted with this application (a copy of a previously submitted authorization can be used).

I hereby affirm that all information contained in this application is true and accurate to the best of my knowledge and belief. I do herein swear that I am a duly authorized representative of the owner/operator and I am authorized to sign this permit application form.

Any person who knowingly makes a false, fictitious, or fraudulent material statement, orally or in writing, to the Illinois EPA commits a Class 4 felony. A second or subsequent offense after conviction is a Class 3 felony. (415 ILCS 5/44(h))

Printed Name: Alex Alexandrou — Title: Chief Administrative Officer, COA

Owner Signature: [signature] — Date: 2/18/13

Notary: Subscribed and Sworn before me this 18TH day of February 2013.

My commission expires on: 1-18-16

OFFICIAL SEAL
KARI L. ULRICH
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 1-18-2016

Kari L. Ulrich
Signature & Stamp/Seal of Notary Public

Printed Name: Alex Alexandrou — Title: Chief Administrative Officer, COA

Operator Signature: [signature] — Date: 2/18/13

Notary: Subscribed and Sworn before me this 18TH day of February 2013.

My commission expires on: 1-18-16

OFFICIAL SEAL
KARI L. ULRICH
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 1-18-2016

Kari L. Ulrich
Signature & Stamp/Seal of Notary Public

Licensed Professional Engineer's Name: Philippe Moreau, P.E.

Licensed Professional Engineer's Title: President

Registration Number: 062.048508

Company: Deuchler Environmental, Inc.

Street Address: 230 Woodlawn Avenue — PO Box:

City: Aurora — State: IL — Zip + 4: 60506

Email Address: pmoreau@deuchler.com — Phone: 630-897-8380

License Expiration Date: 11.30.2013

PHILIPPE F. MOREAU
062-048508
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

Licensed Professional Engineer's Seal

Signature: [signature] — Date: 02.18.13

Illinois Environmental Protection Agency

Bureau of Land • 1021 North Grand Avenue East • P.O. Box 19276 • Springfield • Illinois • 62794-9276

Certification of Authenticity of Official Forms

You may complete this form online, save a copy locally, print and sign it before submitting it to the Illinois EPA.

This form must accompany any application submitted to the Illinois EPA Bureau of Land, Division of Land Pollution Control, Permit Section on forms other than the official copy printed and provided by the Illinois EPA. The only allowed changes to the form are in spacing, fonts, and the addition of the information provided. Any additions must be underlined. The forms would not be considered identical if there is any change to, addition or deletion of words on the form or to the language of the form.

The same individuals that sign the application form it accompanies must sign the following certification.

I hereby certify under penalty of law that I have personally examined, and am familiar with the application form or forms and all included supplemental information submitted to the Illinois EPA herewith, and that the official Illinois Environmental Protection Agency application form or forms used herein is or are identical in all respects to the official form or forms provided by the Illinois EPA Bureau of Land Permit Section, and has not or have not been altered, amended, or otherwise modified in any way. I further certify under penalty of law that any attached or included electronic data version of the application form or forms complies with the official Illinois EPA's Electronic version thereof, and is or are identical in all respects to the official electronically downloadable form or forms provided by the Illinois EPA Bureau of Land Permit Section, and has not or have not been altered, amended or otherwise modified in any way.

Alex B. Alexandrou — 2/18/13
Owner Signature — Date

Alex Alexandrou — Chief Administrative Officer, COA
Printed Name — Title

Alex B. Alexandrou — 2/18/13
Operator Signature — Date

Alex Alexandrou — Chief Administrative Officer, COA
Printed Name — Title

[signature] — 02.18.13
Engineer Signature (if necessary) — Date

Philippe F. Moreau, P.E.
Printed Name

RECEIVED
FEB 26 2013
IEPA-BOL
PERMIT SECTION

Subscribed and Sworn to Before Me, a Notary Public in and for the above-mentioned County and State.

Kari L. Ulrich — 2-18-13
Signature — Date

Kari L. Ulrich
Printed Name

My commission expires on: 1-18-16

OFFICIAL SEAL
KARI L. ULRICH
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES 1-18-2016

Seal of Notary Public

IL 532-2941
LPC 670 Rev. 5/2012

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION
Form I – GENERAL INFORMATION

USEPA I.D. NUMBER ________
IEPA I.D. NUMBER 0894075971
UIC Well Number ________

I. This application is (check one) New ✓ Renewal ____ Permit Number ________

II. POLLUTANT INFORMATION

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the IEPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the form attached line if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements.

Yes	No	Form Attached	
	✓		A. Is this facility a publicly owned treatment works which results in a discharge to waters of the State or US? (Form 2A)
	✓		B. Does or will this facility (either existing or proposed) include a concentrated animal feeding operation or aquatic production facility which results in a discharge to the waters of the State? (Form 2B)
	✓		C. Is this a facility which currently results in discharges to waters of the State other than those described in A or B above? (Form 2C)
	✓		D. Is this a proposed facility (other than described in A or B above) which will result in a discharge to waters of the State? (Form 2D)
	✓		E. Does or will this facility treat, store or dispose of hazardous waste? (RCRA)
	✓		F. Do you or will you inject at this facility industrial or municipal effluent below the lower most stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (Form 4)
	✓		G. Do you or will you inject at this facility and produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (Form OG3)
	✓		H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (Form 4)

UIC Permit Form 1

__ ✓ __ I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may effect or be located in an attainment area? (Form 5)

__ ✓ __ J. Is this facility a proposed stationary source which is NOT one of the 28 industrial Categories listed in the instructions and which will potentially emit 250 tons per year of and air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (Form 5)

III. NAME OF FACILITY City of Aurora Class V UIC

IV. FACILITY INFORMATION

CONTACT (Name and Title) Alex Alexandrou, Chief Administrative Officer, City of Aurora
PHONE (630) 256-3441
MAILING ADDRESS 44 East Downer Place
Aurora, IL 60507-2067

LOCATION SE Corner IL Route 25 and Mettel Road
Aurora, IL

COUNTY KANE
SIC CODES (First) 1623
(Second) 1629
(Third) 4941
(Fourth) 4953
OPERATOR (Name) City of Aurora
Is the operator also the owner Yes ✓ No ____
STATUS OF OPERATOR
____ Federal ✓ Public (Specify)
____ State ____ Other (Specify)
____ Private
OPERATOR PHONE (630) / 256 - 3441
STREET or PO BOX 44 E. Downer Place
(City/Town) Aurora
(State & Zip Code) IL 60507-2067

V. EXISTING ENVIRONMENTAL PERMITS

NPDES NA
UIC NA
RCRA NA
OTHER (Specify) ____
OTHER (Specify) ____

UIC Permit Form 1

VI. MAP (Location) Fig 2.3, p.2-7
Attach a topographic map of the area extending to at least 2.5 miles beyond property boundary. Refer to instructions for precise requirements.

VII. NATURE OF BUSINESS (Location) Sec 3.0
(Provide a brief description)

CERTIFICATION (see instructions)
I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

NAME & OFFICIAL TITLE Alex Alexandrou, Chief Admin Officer, City of Aurora PHONE (630) 256-3441

SIGNATURE [signature] DATE 9/29/14

FACILITY OWNER* ____________ PHONE ________

SIGNATURE ____________ DATE ________

*Required if owner is different than operator.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION
GENERAL UIC PROGRAM REQUIREMENTS

FORM 4
UIC

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

I. Well Status
Operating _____ Modification/Conversion _____ Proposed ✓

II. Type of Permit
Individual:
New _____ Renewal _____ Emergency _____
Permit Number ________________

Area: ✓ Number of Wells 4 Name of Field Route 25 Site
New ✓ Renewal _____ Emergency ___ ___
Permit Number ________________

III. Class V

IV. Location of Well (if area permit is requested, give approximate center of area)
A. Township-Range-Section system of the Bureau of Land Management of the US Government (specify distance, direction and number; circle pertinent direction where applicable)
____ feet north/south and ____ feet east/west of the ____corner of the _____quarter of the NW quarter of Section 10, Township 38N north/south, Range 8E east/west of the 3rd Principal Meridian, KANE County, Illinois.

B. Latitude N41, 47', 32" (degs. mins. secs.) C. Longitude W88,18',42" (degs. mins. secs.) Closest Municipality Aurora (Name & County)

V. Land Ownership
(Enter name of the site landowner if not the applicant or operator)
A. Name and Title ________________ B. Phone Number ________________
C. Street, PO Box or Route ________________
D. City or Town E. State F. County G. Zip Code ________________
H. Lease is to terminate on (month, day, year) ________________

VI. Attachments (see instruction sheet)
A. Application Forms (enter form number) Forms 4a through 4g, LPC PA-1, 39i, Cert. of Authenticity

UIC Permit From 4

B. Are five (5) copies of the Feasibility Report attached? Yes ✓ No ____ (explain)

C. Are five (5) copies of the Well Completion Report attached?
Yes ____ No ✓ (explain) Proposed area permit

D. Has the applicant applied to proper local government unit(s) to secure siting approval? Yes ____ No ✓ (explain) Applicant is the zoning authority

E. Is a certification of financial responsibility to close, plug and abandon the well(s) attached? Yes ____ No ✓ (explain) Municipality

F. If the land is leased, is a copy of the lease agreement attached?
Yes _____ No_____ (explain) NA

VII. Illinois State Legislative Requirements (see instruction sheet)
(Applicable to hazardous waste disposal sites except those publicly-owned sewage works or the disposal or utilization of sludge from publicly owned sewage works.)

A. Is the proposed or existing hazardous waste disposal site located:

1. Above an active in inactive shaft or tunneled mine or within 2 miles of an active fault in the earth's crust or active quarry doing blasting?
Yes _____ No _____

2. In a county populated with less than 225,000:

a. Within 1-1/2 miles of the corporate limits as defined on June 30, 1978 of any municipality?
Yes _____ No _____
If "yes", has approval been given by the governing body of the municipality in an official action?
Yes _____ No _____

b. Within 1000 feet of an existing private well or the existing source of a public water supply measured from the boundary of the actual active permitted site and excluding existing private wells on the property of the permit applicant?
Yes _____ No _____

B. Is the proposed or existing well a pollution control facility? Yes _____ No _____

Have the requirements of SB172 been met? Yes _____ No _____
Attach a dated copy of the approval by the county board or city council

UIC Permit Form 4

VIII. Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Alex Alexandrou, Chief Administrative Officer, City of Aurora
Name & Official Title

(630) 256-3441
Phone Number

Alex G Alexandrou
Signature

2/18/13
Date Signed

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4a – HYDROGEOLOGIC INFORMATION

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

Location in Application			
12.3.1	I.		Elevation of Land Surface at Well Location
2.5.1	II.		Faults, known or suspected within the area of review.
5.3/App I	III.		Maps and cross sections as required by Section 730.114(a) or 730.134(a).
5.0	IV.		Injection Zone
11.1/5.3.2	A.		Geologic name(s) of injection zone.
11.1/Fig 11.2	B .		Depth interval of injection zone beneath land surface.
5.0/11.0	C.		Characteristics of injection zone.
5.4/App B		1.	Lithologic description
12.3.1		2.	Injection zone thickness available to accept waste.
NA		3.	Fracture pressure at top of injection zone, include source
NA		4.	Effective porosity, include source
10.8/5.5		5.	Intrinsic permeability, include source
5.5		6.	Hydraulic conductivity or permeability, include source
NA		7.	Storage coefficient, include source
NA		8.	Seepage velocity (ft/yr) and flow direction of formation water, include source.
NA	D.		Characteristics of injection zone formation water.
NA		1.	Temperature, include source
NA		2.	Pressure, include source
NA		3.	Density, include source
NA		4.	Viscosity, include source
NA		5.	Total Dissolved Solids, include source
NA		6.	Potentiometric surface, include source
NA	E.		Additional or alternative zones considered for injection.
5.2.2	V.		Upper Confining Zone
5.2.2/App B	A.		Geologic name(s) of confining zone
App B	B.		Depth interval of upper confining zone beneath land surface.
5.2.2/App B	C.		Characteristics of confining zone
5.2.2/App B		1.	Lithologic description
NA		2.	Fracture pressure at depth, include source
NA		3.	Intrinsic permeability, include source
NA		4.	Hydraulic conductivity, include source
NA		5.	Alternative confining zones proposed, including explanation and depth interval(s).

UIC Permit Form 4a

5.2.3/5.2.4	VI.	Lower Confining Zone		
5.2.3/5.2.4		A.	Geologic name(s) of confining zone.	
5.2.4/App I		B.	Depth interval of lower confining zone beneath land surface	
5.2.3/5.2.4		C.	Characteristics of confining zone	
5.2.3/5.2.4			1.	Lithologic description
5.2.3/5.2.4			2.	Fracture pressure at depth, include source
NA			3.	Intrinsic permeability, include source
5.5			4.	Hydraulic conductivity, include source
NA			5.	Alternative confining zones proposed, include explanation and depth interval(s)
6.1/6.2	VII.	Overlying Sources of Groundwater at the Site		
6.1/6.2		A.	Characteristics of the aquifer immediately overlying the confining zone	
6.1/6.2			1.	Elevation at top of aquifer, include source
NA			2.	Potentiometric surface, include source
NA			3.	Total Dissolved Solids, include source
5.2.1/5.2.2			4.	Lithology, include source
6.1/6.2			5.	Aquifer thickness
NA			6.	Specific gravity, include source
6.0		B.	Underground Sources of Drinking Water (USDW)	
5.3/App I			1.	Maps and cross sections required by 730.114(a)(4) or 730.134(a)(4)
6.3/6.4/App			2.	Lowest depth of USDW
6.6			3.	Elevation of potentiometric surface of lowest USDW referenced to mean sea level
Tables2.1/3.1			4.	Distance to nearest water supply well
Tables 2.1/3.1			5.	Distance to nearest down gradient water supply well
NA	VIII.	Minerals and Hydrocarbons		
NA		A.	Mineral or natural resources beneath or within 5 miles of the site, include types and depth intervals	

UIC Permit Form 4a

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Alex Alexandrou, Chief Administrative Office, City of Aurora	(630) 256-3441
Name & Official Title	Phone Number
[signature]	2/18/13
Signature	Date Signed

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4b – INJECTION WELL DESIGN, CONSTRUCTION, TESTS and LOGS

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

Location in Application				
12.3.1	I.	Well Depth		
NA	II.	Anticipated fracturing pressure		
8.3	III.	Static Water level and type of fluid		
14.0	IV.	Expected service life of well		
12.3.2	V.	Injection well completion, see instructions		
Fig 12.2 to 12.5	VI.	Schematic or other appropriate drawing of the surface and subsurface construction details of well		
12.3	VII.	Well Design and Construction		
12.3		A.	Well hole diameters and corresponding depth intervals	
12.3.2		B.	Casing, see instructions	
NA			1.	Conductive casing
NA			2.	Surface casing
NA			3.	Intermediate casing(s)
NA			4.	Long string casing
12.3.2/p.12-10			5.	Other casing
12.3.2/p.12-11		C.	Injection tubing, see instructions	
p.12-14 to12-15			1.	Maximum allowable suspended weight based on joint strength of Injection tubing
p.12-14			2.	Weight of injection tubing string (axial load) in air
12.3.2		D.	Cement, see instructions	
NA			1.	Conductive casing
NA			2.	Surface casing
NA			3.	Intermediate casing
p.12-10			4.	Long string casing
NA			5.	Other casing
NA			6.	Cementing techniques, equipment positions and staging depths
NA			7.	Perforation depths
12.3.2		E.	Annulus Protection System	
12.3.2			1.	Annular space(s), specify ID and OD
12.3.2			2.	Type of annular fluid(s)
NA			3.	Specific gravity of annular fluid(s)
NA			4.	Type of additive(s) and Inhibitor(s)
NA			5.	Coefficient of annulus fluid(s)
12.3.2			6.	Packer or fluid seal, see instructions

UIC Permit Form 4b

NA	a.	Packer(s), see instructions
NA	b.	Fluid spotting procedure, frequency and quantity
will be provided	VIII.	Information on well drilling company used during construction, see instructions.
5.4 to 5.6	IX.	Tests and Logs, see instructions
NA	A.	During drilling
NA	B.	During and after casing installation
NA	C.	Demonstration of mechanical integrity
App B&C	D.	Copies of the logs and tests listed above

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Alex Alexandrou, Chief Administrative Officer,
City of Aurora
Name & Official Title

(630) 256-3441
Phone Number

[signature]
Signature

9/29/14
Date Signed

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4c – OPERATION PROGRAM AND SURFACE FACILITIES

USEPA ID NUMBER ______
IEPA ID NUMBER 0894075971
WELL NUMBER ______

Location in Application				
4.0/12.0	I.	Operation Program		
4.0/12.0		A.	Area Injection Project (if applicable)	
4.8/14.3			1.	Maximum fluid to be injected per day
14.4			2.	Years remaining in area injection project
4.0/12.0/13.0			3.	Anticipated total number of injection wells required
4.0/12.0			4.	Injection wells operate with/without common manifold
NA			5.	Number of injection zone monitoring wells, include list and schematics
fig 2.3/fig 4.6/ Sec 2.1			6.	Number of, name and location of injection wells currently in project, see instructions
NA		B.	Single Injection Well (if area permit is applied for, provide for typical well)	
12.3/Fig 4.6			1.	Number or name of well
fig 2.3/fig 4.6/ Sec 2.1			2.	Location, see instructions
14.0			3.	Expected service life
3.2			4.	Operation during 24 hour period
3.2			5.	Operation days per month
2.2			6.	Injection pressure, average and maximum
Sec 1.6/12.1.2			7.	Injection rate, average and maximum
NA			8.	Casing-tubing annulus pressure, average and maximum
NA				a. During operation, average and maximum
NA			9.	Other annulus pressure
NA			10.	Number of injection zone monitoring wells, include schematics
12.0/App D	II.	Surface Facilities		
12.1.1/App D		A.	Injection fluid storage	
12.1.1/App D			1.	Storage capacity in days and gallons
12.1.1/App D			2.	Type of storage facility(s)
4.11			3.	Storage capacity in case of well failure, describe
12.0/App D		B.	Holding tanks and flow lines, describe	
Exhib B		C.	Process and Instrumentation Diagram attachment	
12.1.1		D.	Filter(s)	
12.1.1			1.	Location
12.1.1			2.	Type

UIC Permit Form 4c

NA		3.	Name
NA		4.	Model Number
NA		5.	Capacity, gallons per minute
NA		6.	Pore size, microns
12.1.2	E.	Injection Pumps(s)	
App D, Sec 3		1.	Location
App D, Sec 3		2.	Type
App D, Sec 3		3.	Name
App D, Sec 3		4.	Model Number
App D, Sec 3		5.	Capacity, gallons per minute

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Alex Alexandrou, Chief Administrative Officer, City of Aurora
Name & Official Title

(630) 256-3441
Phone Number

[signature]
Signature

4/29/15
Date Signed

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4d – AREA OF REVIEW

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

Location in Application

Location			
2.0	I.	Radius of the Area of Review	
2.4	II.	Method of Radius determination, see instructions	
Fig 2.1/2.2/2.4	III.	Map with information required by Section 730.114(a)(2) or 730.134(a)(2)	
10.8/10.9	IV.	Description of Anticipated Injection Fluid Movement During the Life of the Project, see instructions	
2.5.2	V.	Wells Within the Area of Review	
Table 2.1		A.	Tabulation of well data required by 730.114(a)(3) or 730.134(a)(3)
2.5.2		B.	Number of wells within 2-1/2 miles of injection well penetrating within 300 feet of the uppermost injection zone which are:
2.5.2			1. Properly plugged and abandoned
2.5.2			2. Temporarily abandoned
2.5.2			3. Operating
2.5.2			4. Improperly sealed, completed or abandoned
NA		C.	Plugging affidavits for all plugged wells
NA		D.	Proposed corrective action for unplugged wells penetrating the injection zone

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Alex Alexandrou, Chief Administrative Officer, City of Aurora
Name & Official Title

(630) 256-3441
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Alex G. Alexandrou
Signature

2/18/13
Date Signed

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4e – MONITORING, INTEGRITY TESTING and CONTINGENCY PLAN

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

Location in Application				
Exhib t A	I.	Waste Sampling and Analysis		
Exhibit A, Section 2 3		A.	Sampling frequency	
Exhibit A, Section 2 2		B.	Analysis parameters	
Exhibit A, Section 2 1		C.	Sampling location	
Exhibit A Section 2 0		D.	Detailed waste analysis plan	
Exh bit A Sec 2 1 to 2 3	II.	Monitoring Program		
Section 16.5		A.	Recording devices, see instructions	
12 1 3/p. 12-4			1.	Injection pressure gauges
NA			2.	Casing-tubing annulus pressure gauges
12 1 3/p 12-3			3.	Flow meters
NA			4.	pH recording devices
NA			5.	Temperature
NA		B.	USDW Monitoring in Area of Review	
NA			1.	Number of wells
NA			2.	Type of wells
NA			3.	Frequency of monitoring
NA			4.	Type of sample
NA			5.	Parameters
NA			6.	Map of well location and logs
NA		C.	Detailed Groundwater Monitoring Plan	
Sec. 12 4	III.	Mechanical Integrity Tests During Service Life of Well, see instructions		
12 1 3/4 11/Exh A,Sec2 4	IV.	Contingency Plan for Well Failure or Shut In, see instructions		
12 1 3/4 11/Exh A,Sec2 4		A.	Detailed contingency plan	

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4f – CHARACTERISTICS, COMPATIBILITY and PRE-INJECTION TREATMENT of INJECTION FLUID

USEPA ID NUMBER ________
IEPA ID NUMBER 0894075971
WELL NUMBER ________

Location in Application

Location				
9.0/9.5	I.	Component Streams Forming Injection Fluid		
3.3	II.	Source and Generation Rate of Component Streams		
3.3/14.1/14.3	III.	Volume of Injection Fluid Generated Daily and Annually		
9.3 to 9.5	IV.	Physical and Chemical Characteristics of Injection Fluid, see instructions		
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APP a, p7-1		B.	Compatibility with minerals in the injection zone	
NA		C.	Compatibility with minerals in the confining zone	
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NA			3.	Cement
NA			4.	Annular fluid
NA			5.	Packer(s)
12.9			6.	Well head equipment
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NA		F.	Full description of compatibility concerns	
NA	VI.	Pre-Injection Fluid Treatment, see instructions		

UIC Permit Form 4f

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

FORM 4g – PLUGGING AND ABANDONMENT PROCEDURE

USEPA ID NUMBER ______
IEPA ID NUMBER 0894075971
WELL NUMBER ______

Location in Application

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17.2	C.	Type and quantity of plugging materials, depth intervals
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Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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1.0 EXECUTIVE SUMMARY

The City of Aurora ("COA") has prepared this Area Class V Underground Injection Control ("UIC") permit application for review and consideration by the Illinois Environmental Protection Agency ("Illinois EPA" or "Agency") in accordance with the following Parts of Title 35 of the Illinois Administrative Code ("IAC"):

- Part 702, "RCRA and UIC Permit Programs";
- Part 704, "UIC Permit Program"; and
- Part 730, "Underground Injection Control Operating Requirements".

1.1 *Background and Project Goals*

The COA operates a Community Water Supply ("CWS"; Facility No. 0894070) that serves a population of approximately 198,000 residents. Drinking water is treated by a lime softening treatment process at the COA Water Treatment Plant ("WTP").

Source water for the Aurora CWS is drawn from the Fox River and a network of 18 active municipal water supply wells. The raw source water is blended at an average percentage of 60% surface water and 40% ground water. Average water production rates currently range from approximately 15.4 million gallons per day ("MGD") from October through April to 19.2 MGD from May through September.

Dissolved solids are removed as part of the lime softening process. In this treatment process, lime (calcium/magnesium oxide) in powder form is mixed with the raw source water and forms a floc with the dissolved solids within 5 claricones at the WTP.

The lime sludge that is generated during the treatment process must be removed from the claricones at regular intervals during plant operation (called "blowdowns"). The discharge rate from the blowdowns is about 800 gallons per minute ("GPM") and typically occur every 3 hours of operation for a duration of 3 minutes under normal operating conditions.

The amount of lime sludge that is produced at the WTP is proportional to the total water production. The average lime sludge production for the past three years has been approximately 45 million gallons. The daily volume injected into the mine is anticipated to average approximately 165,000 gallons over the life of the system, factoring in potential future increases in production rate.

Currently, the lime sludge that is generated by blowdowns is diverted from the claricones to five different dewatering lagoons located outside of the building at the

WTP property. Typically, only one lagoon is used at a time and lime sludge is diverted to the same lagoon until it has reached its capacity.

The lime sludge flows by gravity to the dewatering lagoon as a slurry that averages 6% solids and 94% water. The sludge quickly covers the bottom of the lagoon and the solids begin to settle out of suspension almost immediately. As the solids settle out of suspension, water is forced to the top of the settled solids (called decant water or supernatant) to a depth of approximately 5 feet. The solids deposit themselves in a beach extending progressively away from the discharge pipe at an approximate angle of 1%. The lime sludge is dewatered until it passes a standard paint filter test and it is then excavated, loaded into trucks and transported either to a licensed municipal waste landfill for disposal or for use as an agricultural soil amendment (land applied).

The cost of lime sludge management is dependent upon the amount of sludge generated and the unit costs incurred for the publicly bid contract. Over the past three years the average annual cost for lime sludge management, reuse or disposal is about $1,675,000.

The goals of this project are to:

- More economically and efficiently manage the WTP lime sludge;
- Develop a comprehensive management solution that is cost-effective and sustainable long-term;
- Comply with all applicable State of Illinois statutes and regulations; and
- Develop a solution that is protective of human health and the environment ("HH&E").

The intent of the project is to construct a fully closed disposal system to deliver lime sludge directly from the WTP to the proposed point of injection, approximately 3,500 feet to the north. The proposed injection area is within a subterranean limestone and dolomite mine located approximately 250 feet below ground surface ("bgs") at the injection area. The mine will serve as a permanent detention area for the lime sludge which will be injected in an economically feasible and environmentally safe manner.

The property where the proposed injection is to occur is approximately 50-acres is currently owned by the COA and is located at the southeast corner of the intersection of Illinois Route 25 and Mettel Road, Aurora, Illinois ("site"). The legal description of the property is the northwest quarter of Section 10, Township 38 North, Range 8 East of the Third Principal Meridian, Kane County, Illinois.

Most of the footprint of the property is comprised of a former surface quarry pit. The quarry was developed to extract the Silurian Dolomite and the floor of the quarry pit is approximately 40 to 50 feet below the natural ground surface. The site is located approximately 550 feet east of the Fox River with an unnamed first-order tributary creek along the northern and western property boundaries of the site. The natural topography of the site slopes to the west-southwest, from the highest elevation of 705 feet along the eastern property boundary to an elevation of 660 feet along the western property boundary. The lowest elevation in the bottom of the quarry is 625 feet in the north central portion of the site.

1.2 *Area of Review*

The Area of Review ("AOR") for this permit application was determined through computer modeling and is equivalent to the physical boundaries of the mine, plus a distance of approximately 1,070 feet in all directions. This is equivalent to a radius of approximately ½ mile (2,640 feet) from the boundaries of the site.

1.3 *Geology, Hydrogeology and Mine Description*

A monitoring well was constructed at the northwest corner of the site and was logged to determine the site-specific geology. The well extends to a depth of 605 feet below ground surface ("bgs") and is screened in the St. Peter Formation, which is the nearest underground source of drinking water ("USDW"). Based upon a review of the boring log for this well along with dozens of borings logs from wells within the AOR, the geology of the site is as follows (intervals are in feet bgs where logged from the on-site well; average thickness from AOR boring logs reviewed below the St. Peter Formation):

- Quaternary System: 0 to 12;
- Silurian System Dolomites (local aquifer unit at fractured base): 12 to 53;
- Ordovician Maquoketa Group (shale; aquitard): 53 to 207;
- Ordovician Galena – Platteville Groups (limestone and dolomite; aquitard): 207 to 540;
- Ordovician St. Peter Formation (sandstone; USDW): starting at 540 and averages 231 feet thick in area;
- Cambrian Knox Megagroup Dolomites (aquitard): averages 367 feet thick;
- Cambrian Ironton – Galesville Formations (sandstone; USDW): averages 164 feet thick;
- Cambrian Eau Claire Formation (shale, dolomite, sandy dolostones; aquitard): averages 379 feet thick;
- Cambrian Mt. Simon Formation (sandstone; USDW): averages over 2,600 feet thick; and
- Precambrian basement rock.

The underground mine was operated beginning in the 1980's at a property located north of the Interstate 88 Tollway ("I-88") by Conco Western Stone Company, Inc. (referred to as the North Mine). Mining was conducted at this property and eventually was extended under I-88 beneath the subject site (referred to as the South Mine and is the mine proposed to receive the lime sludge). Both the North Mine and the South Mine are currently operated by Lafarge North America as a result of their acquisition of Conco.

Both the North and South Mines were created to extract limestone and dolomite from the Ordovician Galena and Platteville Groups for use primarily as construction aggregate. The South Mine is accessible only from a ramp from the surface of the North Mine via three tunnels under I-88 on Level 1 and through a ramp connecting Level 1 of the North Mine to Level 2 of the South Mine.

The South Mine represents the injection site and consists of two mining levels and a proposed third level. The ceiling of Level 1 of the mine occurs at an approximate depth of 240 feet bgs. The limestone and dolomite of the Galena and Platteville Groups were mined in a standard room and pillar fashion. The pillars are approximately 50-feet square with approximately 47-foot square rooms between them. The rooms range in height from 23 to 50 feet, ceiling to floor. The two levels of the mine are configured on top of one another such that the pillars of both levels are vertically aligned, with an approximate 25-foot sill between levels.

It is intended that Lafarge will mine a new third level beneath Level 2 while lime sludge injection is being conducted. This level will be mined with the same configuration as Levels 1 and 2 and a 25 foot sill of rock will exist between Levels 2 and 3.

Field mapping of both levels of the South Mine was conducted as part of the feasibility evaluation for the permit application. The results of this field mapping indicated the following:

- No faulting with vertical or horizontal offsets or folding of the rock was identified;
- Bedding planes were near-horizontal;
- The rock mass within the mine exhibited four sets of through-going, nearly vertical joints identified as J1 (northeast-southwest), J2 (northwest-southeast), J3 (east-west) and J4 (north-south);
- The joints were:
  - Closed Joints with no infilling, measured apertures of less than 0.0015-inch and a calculated hydraulic conductivity of 6.16×10^{-2} cm/s: 69 total (23%);
  - Simple clay infilling: 227 total (75.4%);

  - Clay pods: 2 total (0.60%); and
  - Calcite infilling: 3 total (1.0%);
- The measured mean hydraulic conductivity of the clay infilling samples ranged from of 2.5 x 10^{-7} cm/s to 2.7 x 10^{-8} cm/s;
- The primary joint sets J1 and J2 had an average length of 70 to 80 feet, with a maximum of 200 feet; and
- The spacing of the joints (as measured perpendicular to the joint faces) averages between approximately 110 to 120 feet, with the maximum observed joint spacing ranging from 350 to over 500 feet.

1.4 *Overview of Injection System*

It is proposed that the lime sludge generated by the water treatment process is to be transmitted from its point of origin at the WTP to its point of proposed injection via an underground forcemain. From the forcemain, the lime sludge will be injected into the rooms within the mine via 4 injection wells ("IW's") at the site. Finally, the water within the sludge will be removed from the lime sludge detention area, pumped to the surface via a single extraction well ("EW") and disposed into a Fox Metro Water Reclamation District ("FMWRD") sanitary sewer.

The proposed system has the following general characteristics:

- The mine is configured across the footprint of the injection site's property boundaries, less a 5-foot setback zone;
- A third level will be mined concurrent with lime sludge injection into Levels 1 and 2 of the mine;
- The system will not be injecting hazardous waste;
- The injection fluid is a lime sludge that averages 6% solids generated as a byproduct from drinking water treatment;
- The lime sludge will be transmitted in an entirely closed system, directly from its point of origin at the WTP to the IW's therefore outside contaminants cannot be introduced into the system and into the waste stream;
- A pump station will be constructed at the WTP to deliver the lime sludge directly from the claricones to the injection site;
- All 4 IW's will be injecting into the same geologic formation within the mine (Galena and Platteville Groups);
- All IW's will be connected near the ceiling of Level 1 to a series of distribution pipes that will, in turn, be connected to 18 different injection points constructed through the 25-foot thick rock sill between Levels 1 and 2 of the mine and the lime sludge will be deposited into Level 2;
- Permeable berms will be constructed between certain pillars on Levels 1 and 2 of the mine to create sedimentation basins that will allow for the more even

distribution of lime sludge solids across the floors of the mine;

- Once injected into the mine, the lime sludge solids will fall out of suspension quickly and deposit along the floor of the mine and the water will separate (called supernatant) and stand on top the solids;
- The supernatant will be pumped out of the mine to maximize the volume of solids that can be deposited within the mine;
- The underground mine limits represent the limits of the proposed injection;
- It is anticipated that only one IW will be operated at any one time throughout the life of the system. The injection wells will be operated sequentially for a period of approximately 3 to 6 months each during the initial phases of system operation in order to blanket the floor of the mine with sludge solids in order to inhibit the potential downward movement of water into rock fractures;
- After the initial operation to blanket the mine floor, each IW well will be operated in sequence for approximately one year or more each for the purpose of exercising the valves and filling the mine in approximate equal volumes until each area of the mine on Level 2 has reached its maximum sludge solids storage capacity;
- Filling on Level 1 will not occur until Level 2 has been filled to its capacity;
- The injection will occur above a USDW; and
- Since injection will be occurring into a cavernous mine, the formation injection pressure will essentially be zero.

At the north end of the mine, the four openings connecting the North Mine to the South Mine will be closed using bulkheads so that the South Mine will be completely sealed off from the Lafarge mining operations in the North Mine. These bulkheads will be constructed so the openings will be completely sealed. Lafarge will be designing and constructing the bulkheads and they will also seal any fractures in the rock surrounding the stoppings so as to create a leak-proof seal. Piping spaced at 5-foot intervals from the floor to the ceiling will be constructed as part of the bulkhead structure, in order to convey the supernatant out of the lime sludge detention area and to pump it to the surface via a single EW for disposal into a nearby sanitary sewer.

1.5 *Feasibility Study Summary*

Since the system will be injecting lime sludge above a USDW, a comprehensive feasibility evaluation was conducted in order to assess any potential environmental impacts. This study included:

- Field mapping of the mine to determine its physical characteristics (as summarized above);
- Retrieval of a continuous rock core for detailed geologic logging and to conduct down-hole geophysics;

- Water pressure (packer) testing of the geologic units which comprise the lime sludge detention area
- Rock stability calculations in order to determine the stability of the detention area and to assess the feasibility of mining Level 3;
- Hydrogeologic flow modeling based upon the collected data to determine the potential for fluid movement;
- Evaluation of the potential wetting, drying and chemical effects on pillar stability;
- Determination of the chemistry of the injection fluid; and
- Determination of the background chemistry of the nearest USDW via sampling of the on-site monitoring well.

The feasibility evaluation focused on the determination of the potential for fluid movement and whether such movement would impact the nearest USDW above the maximum contamination limits ("MCL's") as outlined in 35 IAC 611, *"Primary Drinking Water Standards"* in accordance with the requirements of Section 122 of 35 IAC 704, *"UIC Permit Program"*. The "fluid" in this permit is simply water from the COA municipal wells and the Fox River that has been in contact with lime powder used in the water treatment process for a period of time. Most of this water will exist as supernatant which will be captured and pumped from the detention area and will not be available for potential flow.

The avenues of potential fluid movement were evaluated to be:

- Vertically downward from the detention area via the joints identified in the field mapping of the mine; and
- Outward along bedding planes in the rock, and then vertically downward via joints.

These potential migration pathways were evaluated using a two dimensional numerical model (UDEC 4.0). The model assumed that the intact rock mass is impermeable, and flow would occur only along bedding planes and joints. The following data was used in the model:

- The percent type occurrence and associated hydraulic conductivities of the unfilled joints and the joint infillings;
- The mapped physical properties of the joints (measured average length and spacing) to establish their frequency of occurrence and spatial characteristics; and
- The hydraulic conductivity (mean value of 9.26×10^{-6} cm/sec from packer tests), thickness and spacing of the horizontal bedding planes as determined from the logging, geophysics and packer testing of the on-site core hole.

Using these data, the model predicted a maximum vertical flow rate of 0.9 to 1.5 GPM across the entire lime sludge detention area under worst case assumptions (mine filled completely with water with 50-feet of head with no solids present. This translates to a maximum flow of 0.021 to 0.035 GPM/acre. The model predicted virtually no flow horizontally along bedding planes and vertical joints due to the circuitous flow path and low hydraulic conductivity values. The model accounted for the mining of Level 3 and, once completed, it predicted that any potential water flow out of the detention area will be captured in Level 3, with very little reaching the St. Peter Formation.

Additionally, the following will have the effect of reducing the potential for water movement out of the detention area that were not taken into account by the model:

- Supernatant will be pumped out of the mine and the head will be maintained at 5-feet or less, thus reducing the amount of fluid available for potential migration;
- The lime sludge solids have a grain size that is smaller than the measured aperture size of the unfilled joints, therefore the sludge will partially in-fill such joints reducing their ability to transmit water;
- Lafarge will seal all mapped, unfilled joints along the floors and perimeter of Levels 1 and 2 of the mine; and
- The lime sludge retained in the mine has a characteristic low hydraulic conductivity (measure to have a mean of 1.0×10^{-5} cm/sec) and will also act to impede the potential downward flow of water.

Rock stability calculations conducted and the evaluation of wetting/drying and chemical effects indicate that:

- Mining has not and will not in the future have a significant influence on the hydraulic conductivity of the natural system or on the stability of the rock mass of the mine;
- Mining of Level 3 can be conducted safely with the simultaneous injection of lime sludge into Levels 2 and then Level 1 of the mine; and
- Wetting, drying and chemical effects will not adversely impact the stability of the pillars in the mine.

The chemistry of the entire waste stream that comprises the injection fluid is known, and is summarized as follows:

- The chemistry of the lime powder used in the water treatment process is known and is free of contamination (it is an almost pure, calcium/magnesium oxide with a pH of 12.4;
- The COA raw and finished source water is below 611 MCL's; and
- The results of the supernatant laboratory testing, which is analogous to the

chemistry of water that could potentially flow out of the detention area, meets all water quality standards as outlined in both 35 IAC 620, *"Ground Water Quality"* and 35 IAC 611.

Based upon the feasibility evaluation, there will only be minor amounts of water that could potentially move out of the lime sludge detention area and reach the St. Peter Formation. Furthermore, it is not likely that the nearest USDW can be impacted above the MCL's outlined in 35 IAC 611, because:

- The chemistry of the supernatant itself, meets those standards; and
- The entire injection system will be closed from its point of origin at the WTP to its point of injection in the mine, therefore outside contaminants cannot be introduced into the system.

It is therefore concluded that the injection proposed in this permit application has no reasonable ability to impact the water quality of the nearest USDW and it will meet the requirements of 35 IAC 704.122.

1.6 *System Operation, Life Calculations and Monitoring*

Once the entire system is constructed, a pilot test will be conducted using water. The test will be conducted while the mine is accessible and all safety structures are in place so that the function of the injection system and distribution piping can be directly observed. All observations and data will be recorded and evaluated and all necessary system modifications will be made until its operation is optimal and is performing as it was designed.

During full-scale system operation, the IW's will be initially operated one at a time, in sequence, starting with IW-1 at the south end of the mine, progressing in order to IW-4 at the north end of the mine. During this initial period, each well will be operated for a limited period of time (currently anticipated to be 3 to 6 months per well) to create a blanket of lime sludge solids on the floor of the mine.

After this initial operation period, each injection well will be operated in sequence as described above for approximately one year or more per well for the purpose of exercising the valves and filling the mine in approximate equal volumes for each siltation basin, until that area of the mine on Level 2 has reached its maximum sludge solids storage capacity.

The performance of all system components will be monitored and the entire system will be maintained, and wear parts replaced as needed and in accordance with the manufacturers recommendations.

Estimating the effective life of the system is based upon a mass balance using the following assumptions:

- An average daily injection rate of 165,000 gallons;
- An average solids content of 6% with a specific gravity of 1.04;
- A solids content of 27% with a specific gravity of 1.32;
- A total air space volume (volume available for holding lime sludge) of 93.5 million cubic feet; and
- A filling efficiency of between 40 and 80 percent of the total air space.

Using these assumptions, which have all been directly measured or calculated, the estimated storage life for Levels 1 and 2 of the mine will be approximately 48 to 59 years.

The following are proposed to be included in the monitoring program associated with the Class V UIC permit for this site:

- Sampling and analysis of the influent lime sludge from the pump station wet well at the WTP;
- Sampling and analysis of the supernatant effluent from a sampling port at the extraction wellhead; and
- Monitoring of the chemistry of the nearest USDW (the St. Peter Formation) from the existing deep monitoring well at the site.

Other monitoring of the system will be conducted as follows:

- Monitoring of bulkheads: This will include data from pressure transducers that will be installed in the bulkheads to warn against excessive pressures being exerted against the bulkhead walls.
- Supernatant inlet monitoring: The supernatant inlets will have sludge monitoring devices to detect the elevation of the solids prior to reaching the inlet pipe. At such time, the valve for that inlet will be closed, and the next vertically higher inlet will be opened.
- System influent flow monitoring.
- System effluent flow monitoring.

Upon reaching the effective disposal life of the system, or in the case that the COA wishes to discontinue use of the system, it will be closed and properly abandoned. This will include:

- Abandoning the IW's and EW;
- Plugging the blowdown forcemain at the WTP wet well;

- Disconnection and removal of the blowdown forcemain pumping system;
- Disconnection and removal of the extraction pumping system;
- Abandonment of the extraction well;
- Disconnection of the extraction forcemain from the extraction well and the sanitary sewer; and
- Securing the vent shaft.

The City of Aurora respectfully requests that the Illinois EPA approve the request for a Class V UIC Permit for the proposed injection system because:

- The lime sludge solids are not contaminated and will be safely contained in the detention area within the Lafarge Conco South Mine in perpetuity;
- Very little water could potentially move out of the detention area;
- The lime sludge water is not contaminated and, therefore, even if some of it moves into the nearest USDW, it will not contaminate it nor will it adversely affect HH&E;
- The proposed system is a more environmentally friendly method of managing the lime sludge generated by the WTP because it will not use valuable landfill space and it will reduce the carbon footprint associated with its management; and;
- The proposed system will save the City of Aurora over $50 million dollars over its effective operational life.

2.0 PERMIT TYPE, SITE DESCRIPTION AND AREA OF REVIEW

The City of Aurora ("COA") has prepared this Class V Underground Injection Control ("UIC") permit application for review and consideration by the Illinois Environmental Protection Agency ("Illinois EPA" or "Agency") in accordance with the following Parts of Title 35 of the Illinois Administrative Code ("IAC"):

- Part 702, "RCRA and UIC Permit Programs";
- Part 704, "UIC Permit Program"; and
- Part 730, "Underground Injection Control Operating Requirements".

2.1 Site Description

The site of the proposed injection is located at the southeast corner of the intersection of Illinois Route 25 and Mettel Road, Aurora, Illinois ("site"). The legal description of the property is the northwest quarter of Section 10, Township 38 North, Range 8 East of the Third Principal Meridian, Kane County, Illinois. The site is approximately 50-acres in size and is currently owned by the COA. Please refer to **Section 5.0** for a more detailed description of the site and its history.

2.2 General Characteristics of the Proposed Injection

The type of injection proposed in this permit application has the following general characteristics:

- The mine is configured across the footprint of the injection site's property boundaries, less a 5-foot setback zone;
- A third level will be mined concurrent with lime sludge injection into Levels 1 and 2 of the mine;
- The system will not be injecting hazardous waste;
- The injection fluid is a lime sludge that averages 6% solids generated as a byproduct from drinking water treatment;
- The lime sludge will be transmitted in an entirely closed system, directly from its point of origin at the COA Water Treatment Plant ("WTP") to the Injection wells ("IW's") therefore outside contaminants cannot be introduced into the system and into the waste stream;
- A pump station will be constructed at the WTP to deliver the lime sludge directly from the claricones to the injection site;
- All 4 IW's will be injecting into the same geologic formation within the mine (Galena and Platteville Groups);
- All IW's will be connected near the ceiling of Level 1 to a series of distribution

pipes that will, in turn, be connected to 18 different injection points constructed through the 25-foot thick rock sill between Levels 1 and 2 of the mine and the lime sludge will be deposited into Level 2;

- Permeable berms will be constructed between certain pillars on Levels 1 and 2 of the mine to create sedimentation basins that will allow for the more even distribution of lime sludge solids across the floors of the mine;
- Once injected into the mine, the lime sludge solids will fall out of suspension quickly and deposit along the floor of the mine and the water will separate (called supernatant) and stand on top the solids;
- The supernatant will be pumped out of the mine to maximize the volume of solids that can be deposited within the mine;
- The underground mine limits represent the limits of the proposed injection;
- It is anticipated that only one IW will be operated at any one time throughout the life of the system. The injection wells will be operated sequentially for a period of approximately 3 to 6 months each during the initial phases of system operation in order to blanket the floor of the mine with sludge solids in order to inhibit the potential downward movement of water into rock fractures;
- After the initial operation to blanket the mine floor, each IW well will be operated in sequence for approximately one year or more each for the purpose of exercising the valves and filling the mine in approximate equal volumes until each area of the mine on Level 2 has reached its maximum sludge solids storage capacity;
- Filling on Level 1 will not occur until Level 2 has been filled to its capacity;
- The injection will occur above an Underground Source of Drinking Water ("USDW"); and
- Since injection will be occurring into a cavernous mine, the formation injection pressure will essentially be zero.

2.3 *Permit Type*

Based upon these characteristics, it was determined by the Illinois EPA (see correspondence dated October 10, 2001, included in **Appendix E**) that the operation of this system will require a Class V UIC operating permit. Furthermore, since the injection will be occurring above a USDW, it was determined that a permit application will be prepared and submitted to the Agency for review and approval prior to system construction and operation. The COA was instructed by the Illinois EPA to complete the draft Class V permit application forms for this project. The following forms are included with this application, as per instruction from the Illinois EPA:

- LPC-PA1 – General Application for Permit;
- Certification of Authenticity of Official Forms;
- 39(i) Certification for a Legal Entity;

- 39(i) Certification for a Person;
- UIC Permit Form 1 – General Information;
- UIC Permit Form 4 – General UIC Program Requirements;
- UIC Permit Form 4a – Hydrogeologic Information;
- UIC Permit Form 4b – Injection Well Design, Construction, Tests and Logs;
- UIC Permit Form 4c – Operation Program and Surface Facilities;
- UIC Permit Form 4d – Area of Review;
- UIC Permit Form 4e – Monitoring, Integrity Testing and Contingency Plan;
- UIC Permit Form 4f – Characteristics, Compatibility and Pre-injection Treatment of Injection Fluid; and
- UIC Permit Form 4g – Plugging and Abandonment Procedure.

Based upon the fact that 4 IW's are proposed to inject within the same geologic formation, the COA is seeking an Area Permit in accordance with 35 IAC 704, "UIC Permit Program", section 704.162, "Area Permits".

2.4 *Area of Review Determination*

Section 730.106 identifies the two methods for the determination of the Area of Review ("AOR") for the project. Mathematical modeling was conducted for the proposed injection using empirical and theoretical characteristics. Since the injection will occur into a solid bedrock unit, the theoretical pathways of fluid movement are in secondary porosity features such as bedding planes, dissolution structures and fractures (called joints) in the rock. The solid rock mass is itself essentially impermeable and the dissolution structures are present, but very small and are not horizontally or vertically continuous. These secondary porosity features were physically mapped within the mine in order to create the mathematical model.

This model is discussed in detail in **Section 10** of this permit application narrative and a copy of the report which discusses the results of the model is presented in **Appendix A.** The mapping and subsequent modeling identified major and minor potential flow pathways. Since dissolution structures are not anticipated to be flow pathways, the major potential flow pathways are the through-going, essentially vertical joints identified in the mine and as documented in literature regarding the Galena and Platteville Groups and the minor potential flow pathways are through the bedding planes of the rocks.

Three types of joints were identified in the mine:

- Unfilled, tightly healed joints;
- Clay filled joints; and
- Calcite and sulfide filled joints.

The hydraulic conductivity of these structures averages (as determined by packer tests, laboratory tests of joint infilling materials, and mathematically based upon the measured aperture size for the unfilled joint type):

- Bedding planes: 9.26 x 10^{-6} cm/sec (average of packer test data);
- Clay filled joints (24% of total as mapped): 2.7 x 10^{-8} cm/sec (laboratory test average);
- Calcite filled joints (1% of total as mapped): 2.5 x 10^{-7} cm/sec (laboratory test average); and
- Unfilled joints (75% of total as mapped): assumed to be 6.16 x 10^{-2} cm/sec.

The joints occur at intervals of 120 feet apart and have an average length of 200 feet. These joints are assumed to repeat at this interval beyond the limits of the mine. Based upon the hydraulic conductivities identified at the site, the major pathway is vertical along the unfilled joints due to its comparatively high conductivity, with minor horizontal components along bedding planes. Essentially, any potential flow along the bedding planes will be cut off in all directions surrounding the mine by the vertical joints.

Based upon the mapped geometry of the joints and upon the proposed depth of injection, the maximum horizontal distance for potential flow is approximately 1,070 feet into the rock units from the center point of the mine.

Based upon this evaluation, the AOR was therefore determined to be a fixed radius of approximately 1,000 feet from the site boundaries. In order to provide the Agency with adequate information for the review of this permit application, data was collected within a fixed radius of ½ mile (2,640 feet) from the boundaries of the site.

2.5 *Information Presented within the Area of Review*

The information within the AOR for this project is provided or referenced below In accordance with 730.114(a)(2) as requested in Form 4d.

2.5.1 Geology

Please refer to **Section 5.0 and 6.0** for a detailed discussion of the regional and site specific geology including identification of all USDW's presented above and below the proposed injection zone.

There are no known faults or other seismic features within the AOR. The figure below (from Graese, 1991) depicts the geological map of northeastern Illinois. The fault nearest to the AOR is the Sandwich Fault zone located approximately 18 miles to the southwest of the AOR.

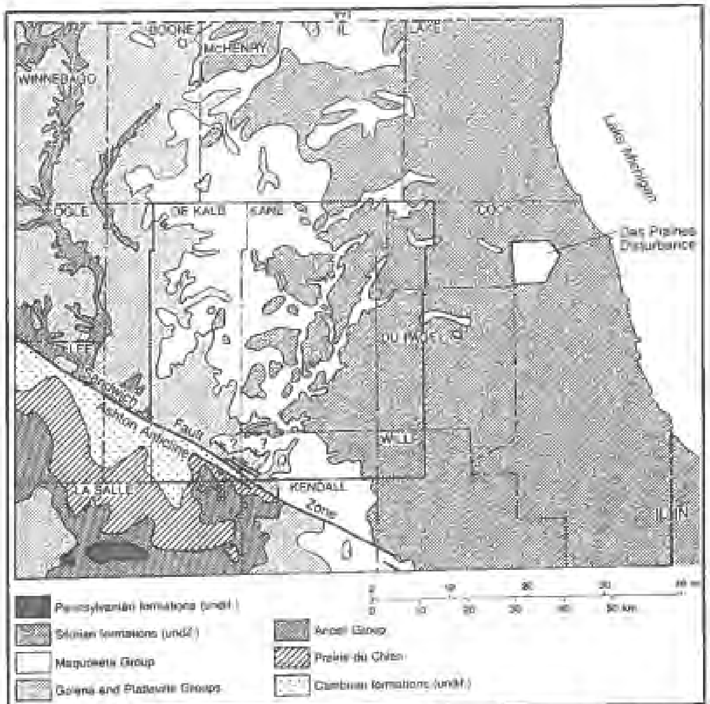


Figure 2.1 – Geologic map NE Illinois (from Graese, 1991)

2.5.2 Wells, Borings and Test Holes

A total of 35 wells, borings and test holes were identified within the AOR. No abandoned or inactive wells were identified. The following is a map of the well locations:

Illinois EPA FOIA Exemption Reference Sheet

SID: 33134

.gency ID: 170000614271 Media File Type: LAND
Bureau ID: 0894075971
Site Name: Aurora, City Of
Site Address1: Rte 25
Site Address2:
Site City: Aurora State: IL Zip: 60507-

This record has been determined to be partially or wholly exempt from public disclosure

Exemption Type:

Redaction

Exempt Doc #: 1 **Document Date:** 2 /26/2013 **Staff:** MED

Document Description: TABLE 2.1 AOR WELL LIST PP.2-6 AND 2-7

Category ID: 23A **Category Description:** UIC/ADMIN REC - UNDERGROUND INJECTION CONTROL **Exempt Type:** Redaction

Permit ID: UIC-147 **Date of Determination:** 5 /21/2015

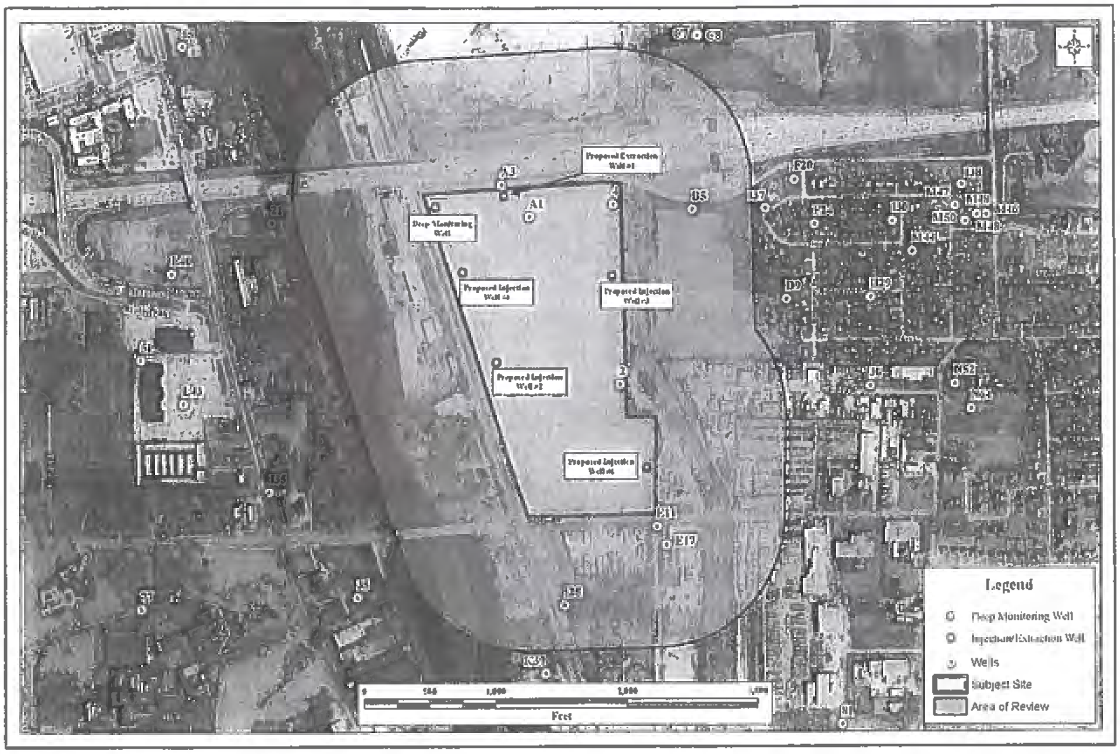


Figure 2.2 – Well search location map

The well information is summarized in the table below:

Table 2.1 – AOR Well List

MAP REF. #	OWNER	TYPE	API NUMBER	DISTANCE*	DEPTH	LIKELY UNIT	LOG
2	IDOT	Outcrop	120893315400	0′	50	NA	Y
21	[redacted]	Private	120890065300	1185′	83	Silurian	Y
35/ E13/E14	[redacted]	Private	120890021300 (same as 071930?)	1705′	772	St. Peter	Y
36	Jim Popp Builders	Commercial	120890101700	1883′	115	Silurian	Y
4	IDOT	Outcrop	120893315300	0′	50	NA	Y
51	[redacted]	Private	120890064600	2454′	80	Silurian	Y
55	[redacted]	Private	120890064300	2154′	610	St. Peter	Y
81/S83	[redacted]	Private	120892894500	2826′	160	Silurian	Y
A1	Conco Western Stone Co.	Test	120893541900	0′	239	No screen	N
A3	Conco Western Stone Co.	Test	120893414400	0′	92	No screen	N
B5/B6	Ill. Toll Highway Comm. EP-1	Private	120890016900	564′	215	Silurian	Y
C7/G26	[redacted]	Private	120892201500	1255′	133	Silurian	Y

MAP REF. #	OWNER	TYPE	API NUMBER	DISTANCE*	DEPTH	LIKELY UNIT	LOG
C8/G27	[redacted]	Private	120890122800	1255′	92	Silurian	Y
D9/D10	[redacted]	Private	120892222300	1248′	190	Silurian	Y
E11/E18	[redacted]	Private	120890005000	854′	341	Silurian and Galena-Platteville	Y
E17/E23	Chicago Title and Trust	Industrial	120890064900	1006′	111	Silurian	Y
	City of Aurora	Municipal #26	120893540200	[redacted]	[redacted]	St. Peter and Ironton-Galesville	Y
F24/I31	[redacted]	Subdivision Water Supply	120890119200	1476′	200	Silurian	Y
H28/ N64	Weldstar Company/Chapple Co.	Commercial	120890097000	2662′	120	Silurian	Y
H29/H34	[redacted]	Private	120892222200	1904′	190	Silurian	Y
I25	IDOT	Outcrop	120893315500	1400′	5	NA	Y
I30/M41	[redacted]	Private	120890129700	2088′	135	Silurian	Y
I37	[redacted]	Private	120893355700	1107′	140	Silurian	Y
I38	[redacted]	Private	120893431300	2630′	300	Silurian and Galena-Platteville	Y
	Lincolnway Enterprises	Noncom Public Water	120893457400	[redacted]	UNK	NA	N
K39/K42	Aurora Athletic Club	Noncom Public Water	120893457500	[redacted]	U NK	UNK	N
L40	[redacted]	Private	120890482300	2030′	100	Silurian	Y
L43	Thorton Oil Co.	Monitoring Well	120893122900	2240′	28	Prairie Aquigroup	Y
M44/M45	[redacted]	Private	120890055600	2240′	165	Silurian	Y
M46/M49	[redacted]	Private	120890122400	2820′	145	Silurian	N
M47/O53	[redacted]	Private	120890172500	2580′	145	Silurian	Y
M48/O58	[redacted]	Private	120890118600	2688′	135	Silurian	Y
M48/O65	[redacted]	Private	120890121700	2746′	135	Silurian	N
M50/O57	[redacted]	Private	120892284000	2654′	140	Silurian	Y
N52/54	[redacted]	Private	120890170300	2540′	152	Silurian	Y

*Distance calculated from the nearest site border using GIS by DEI. Latitude/longitude obtained from ISGS database

The logs for all of the wells identified above as having well logs available are presented in **Appendix G**. No abandoned, temporarily abandoned or improperly sealed wells were identified within the AOR.

2.5.3 Land Use

The figures below illustrate the surrounding land use within the AOR. The first figure is a reproduction of the United States Geological Survey ("USGS") 7.5 degree topographic map (Aurora North Quadrangle). This map shows the topography, general land use and surface drainage features.

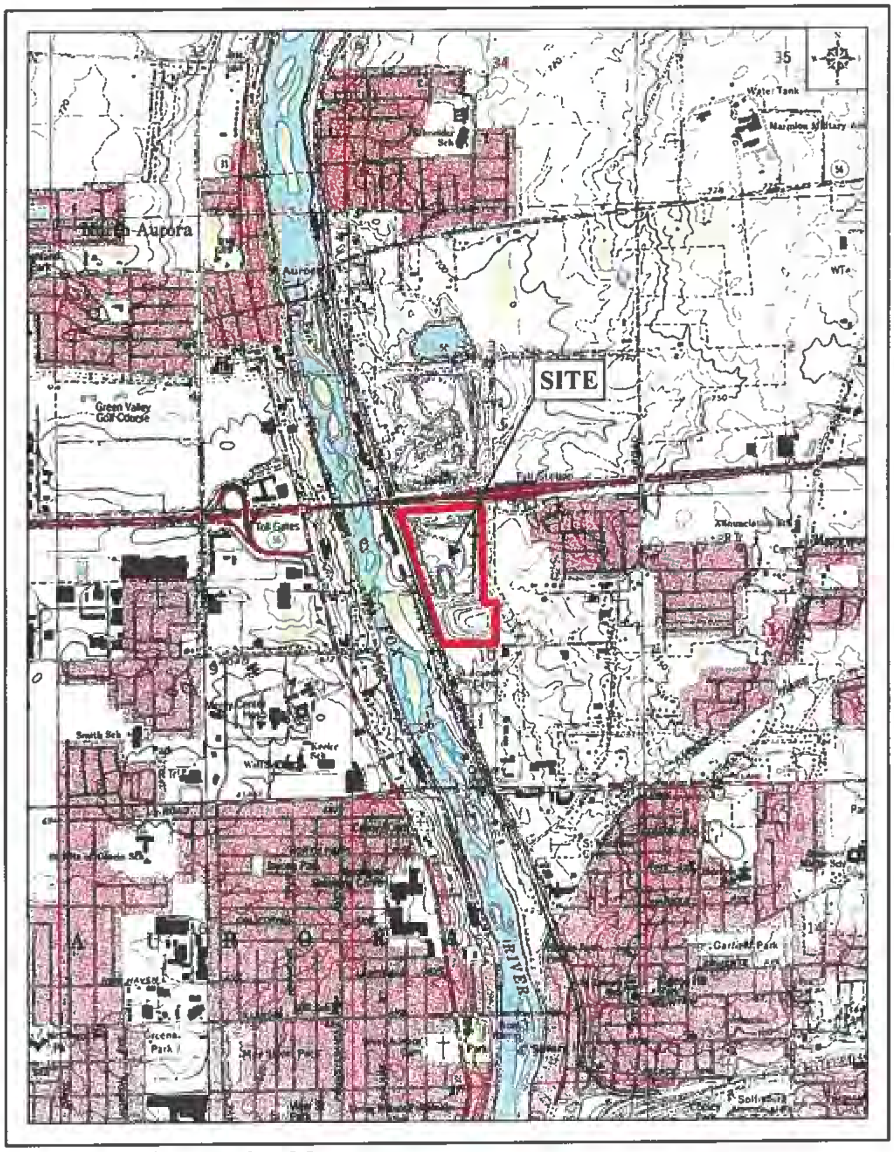


Figure 2.3 – Site Location Map

The next figure is a detailed map of land use within the AOR.

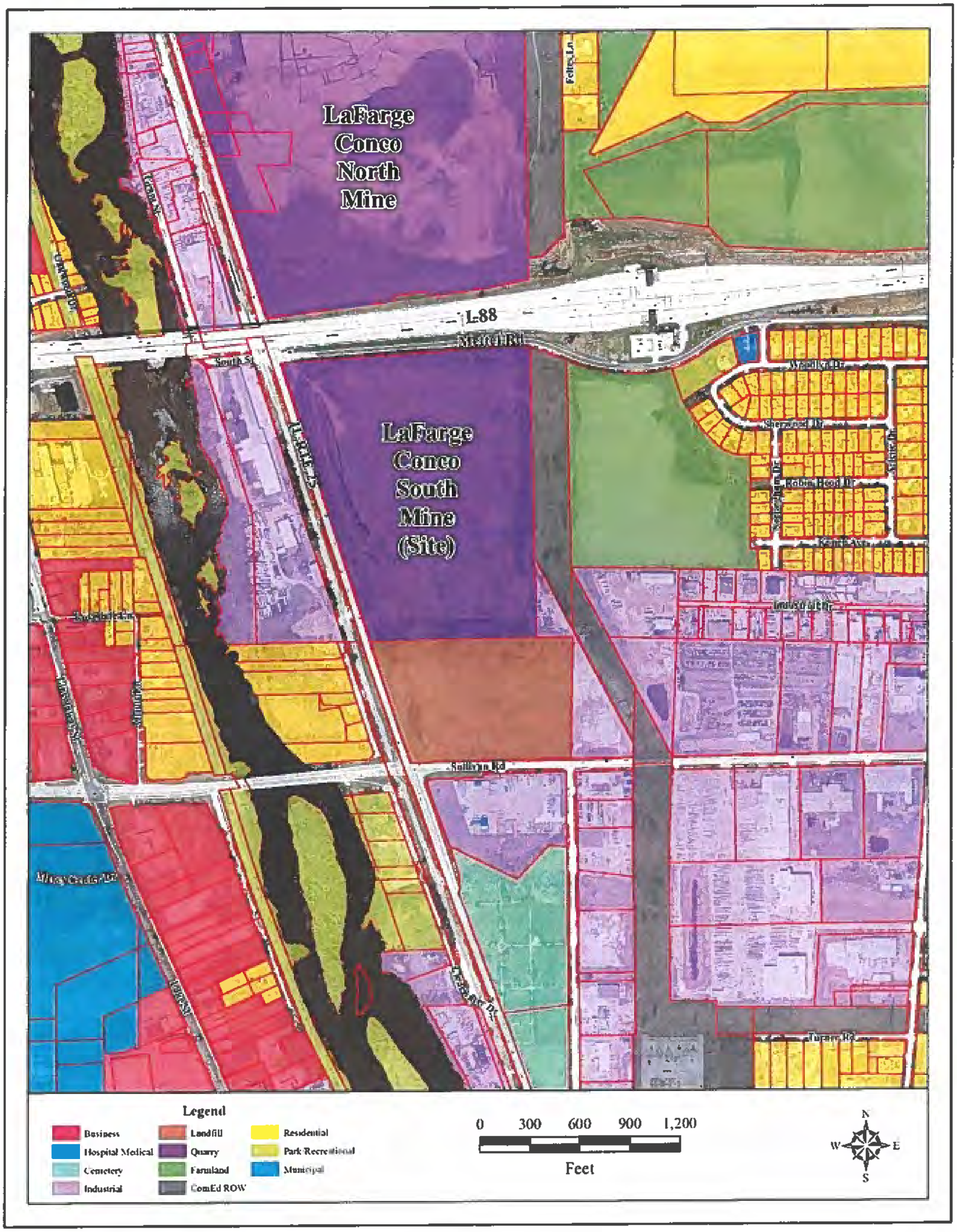


Figure 2.4 – Land use map

3.0 CITY OF AURORA WATER SYSTEM

According to the 2010 census, the COA had a population of approximately 198,000 residents. Drinking water is supplied by the Aurora Community Water Supply ("CWS") system (Facility No. 0894070). The Aurora CWS has approximately 48,500 service connections and approximately 750 miles of water mains.

Photograph 3.1 – Aurora WTP with surface water intake in foreground

Source water for the CWS is from the Fox River and a network of 18 active ground water wells. The CWS includes one surface water intake on the Fox River located at 1110 Aurora Avenue, directly west of the WTP. The ground water source for the CWS comes from the following wells:

Illinois EPA FOIA Exemption Reference Sheet

SID: 33134

Agency ID: 170000614271
Media File Type: LAND
ureau ID: 0894075971
Site Name: Aurora, City Of
Site Address1: Rte 25
Site Address2:
Site City: Aurora
State: IL
Zip: 60507-

This record has been determined to be partially or wholly exempt from public disclosure

Exemption Type:

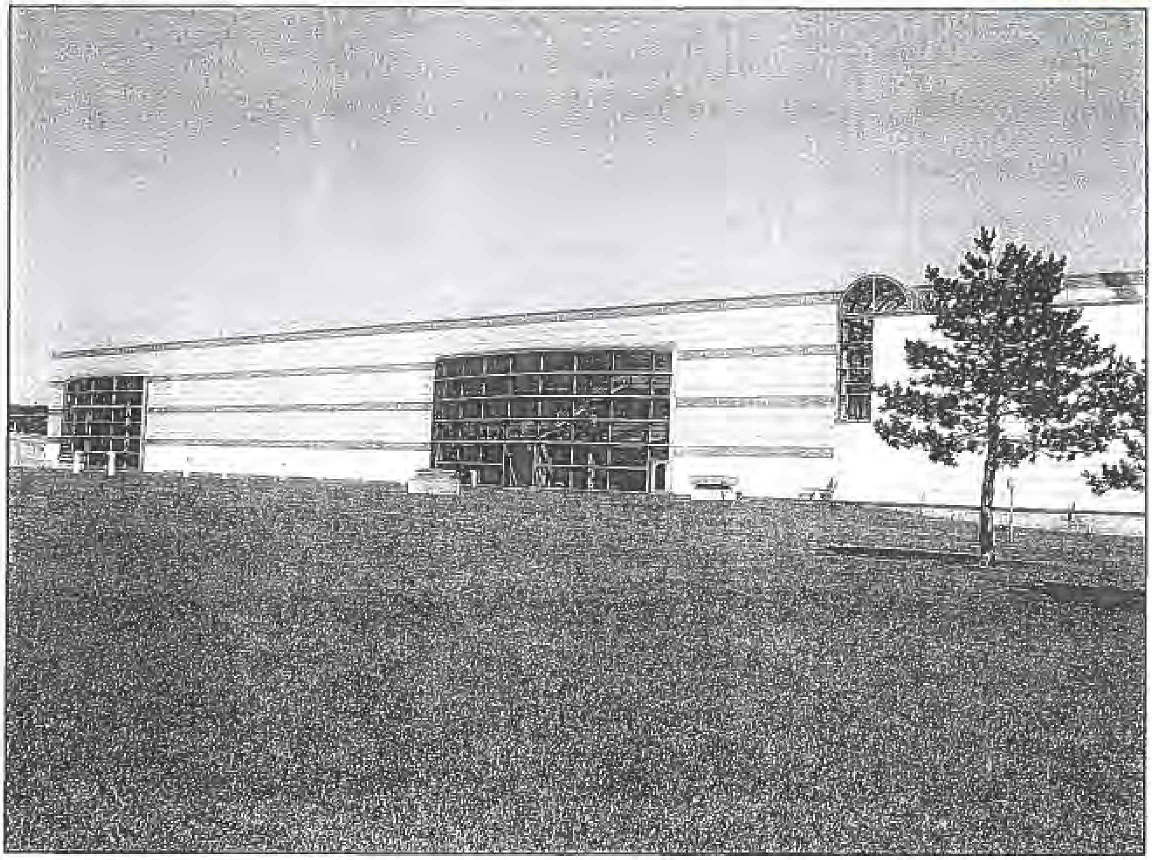
Redaction

Exempt Doc #: 2
Document Date: 2 /26/2013
Staff: MED

Document Description: TABLE 3.1 CWS WELL LIST PP.3-2 AND 3-3

Category ID: 23A
Category Description: UIC/ADMIN REC - UNDERGROUND INJECTION CONTROL
Exempt Type: Redaction

Permit ID: UIC-147
Date of Determination: 5 /21/2015



Photograph 3.2 – Aurora WTP

Table 3.1 – Aurora CWS Well List

WELL ID	WELL #	STATUS	DEPTH	MINIMUM SETBACK	AQUIFER TYPE	GEOLOGIC UNITS
WL00344	101	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL00610	119	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL00611	115	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL00612	103	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL01379	24	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL01526	26	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton Galesville
WL01541	127	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL01547	27	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton Galesville
WL01758	28	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL01849	29	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville

WELL ID	WELL #	STATUS	DEPTH	MINIMUM SETBACK	AQUIFER TYPE	GEOLOGIC UNITS
WL01859	129	ACTIVE	[redacted]	400	Sand & Gravel	Quaternary
WL21127	8	EMERGENCY	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21129	15	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21130	16	EMERGENCY	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21131	17	ACTIVE	[redacted]	200	Deep Bedrock	Ironton-Galesville
WL21132	18	EMERGENCY	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21133	19	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21134	20	ACTIVE	[redacted]	200	Deep Bedrock	Ironton-Galesville
WL21135	21	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21136	22	EMERGENCY	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21137	23	ACTIVE	[redacted]	200	Deep Bedrock	St. Peter, Ironton-Galesville
WL21138	25	ACTIVE	[redacted]	200	Deep Bedrock	Ironton-Galesville

3.1 *Description of Water System*

The Aurora CWS blends the raw source water at an average percentage of 60% surface water and 40% ground water. This blending percentage varies depending upon water needs and the general quality of the water drawn from the Fox River. During peak demand during the mid- to late summer, the percentage of ground water increases to approximately 50 to 60% when the water quality of the Fox River is at its lowest. During other times of the year, the ground water percentage is 30 to 40%.

Average water production rates currently range from approximately 15.4 million gallons per day ("MGD") October through April to 19.2 MGD from May through September. The maximum production rate for the Aurora CWS is approximately 27 MGD. Based upon current estimates, the water production needs of the Aurora CWS are planned to decrease 1 percent per year in accordance with a water rate study conducted by Black & Veatch dated May 11, 2011.

The following are the seasonal water production statistics for the Aurora CWS:

Table 3.2 – Aurora CWS Average Seasonal Production

Year	October through April Average (MGD)	May through September Average (MGD)	Annual Average (MGD)	Annual Total (MG)
2010	14.71	17.30	15.57	5,684
2011	14.89	19.32	16.51	6,025
2012	15.41	20.74	17.39	6,346

The following are the average daily production statistics for the Aurora CWS:

Table 3.3 – Aurora CWS Average/Maximum Daily Production by Year

Year	Average Daily Production (MGD)	Maximum Daily Production (MGD)	Population
2001	17.13	29.91	147,749
2002	16.56	28.92	152,508
2003	16.58	26.75	157,267
2004	16.80	23.85	159,910
2005	17.81	28.58	162,553
2006	16.65	26.02	165,197
2007	17.15	27.25	173,373
2008	16.73	22.69	181,548
2009	16.24	22.25	189,724
2010	15.57	21.29	197,899
2011	16.51	26.08	197,899
2012	17.39	27.28	198,000+

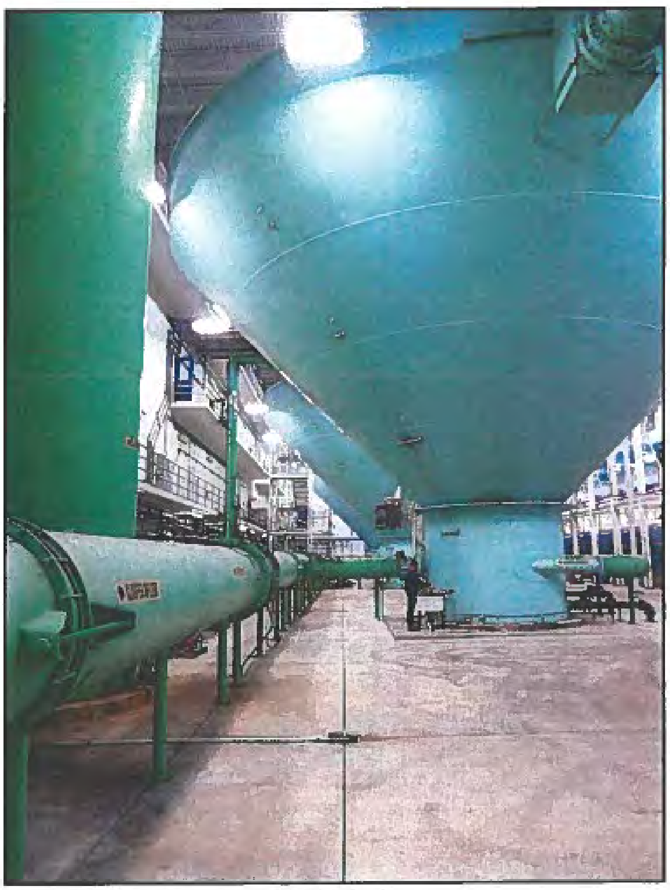
The average daily production per capita has decreased from 115.93 gallons per person in 2001 to 87.83 gallons per person in 2012.

3.2 *Water Treatment Process*

Source water from the ground water wells and the Fox River (collectively called raw source water) is conveyed in separate collection mains to the COA WTP, located at 1111 Aurora Avenue, Aurora, Illinois.

The raw source water is blended at the WTP prior to treatment. The percentage of blending is dependent upon the production needs and the quality of the raw water extracted from the Fox River. During peak demand in the summer months, a higher percentage of well water is blended into the system. This is done to meet the water use needs (which are highest during the summer) and due to the generally poorer quality of the Fox River water during its low flow stage during the summer.

Dissolved solids are removed as part of the lime softening process. In this treatment process, lime (calcium/magnesium oxide) in powder form is mixed with the raw source water and forms a floc with the dissolved solids. The floc that is formed is settled within the claricones at the WTP. The plant has a total of 5 cones and 3 to 5 are operational at any one time depending upon the production needs and maintenance schedules.



Photograph 3.3 – Aurora WTP claricones

The lime sludge that is generated during the treatment process must be removed from the cones at regular intervals during plant operation. Lime sludge must also be removed when the cones are taken off-line for maintenance. This process is called a "blowdown". There are two types of blowdowns that are conducted at the WTP; grit blowdowns and blanket blowdowns. Blanket blowdowns are conducted in order to remove the precipitates and solids that collect in the sludge blanket to allow continuous flow-through operations of the claricone vessels. The discharge rate from either type of blowdown from the claricones is about 1000 gallons per minute ("GPM").

Blanket blowdowns are set on timers that are integrated into each cone that is in operation. Each cone has its own separate timer that controls when the blanket blowdowns occur. The timers count down from the point set by WTP personnel and once they have counted to zero, automatic valves are opened and the sludge is released from the bottom of the claricones. The sequencing (the order in which the cones blowdown), duration and frequency of the blowdowns can be modified by WTP personnel but typically occur every 3 hours for a duration of 3 minutes under normal operating conditions for each cone that is in operation. Blanket blowdowns may be conducted as frequently as every hour for a duration of up to 6 minutes during periods of peak summer water production.

Grit blowdowns are manually controlled by opening a valve at the bottom of each claricone where the heavy solids settle out. This is done to prevent these solids from plugging the inlet lines to the claricones. Grit blowdowns last for a duration of 5 minutes and occur once per shift (every 12 hours) at no particular time.

Flow meters (for both types of blowdowns) record the total volume and flow rates. When a claricone is taken out of service for maintenance (usually between the fall and the spring), the sludge blanket and all of the water are removed from the cone.

3.3 *Lime Sludge Production Rates*

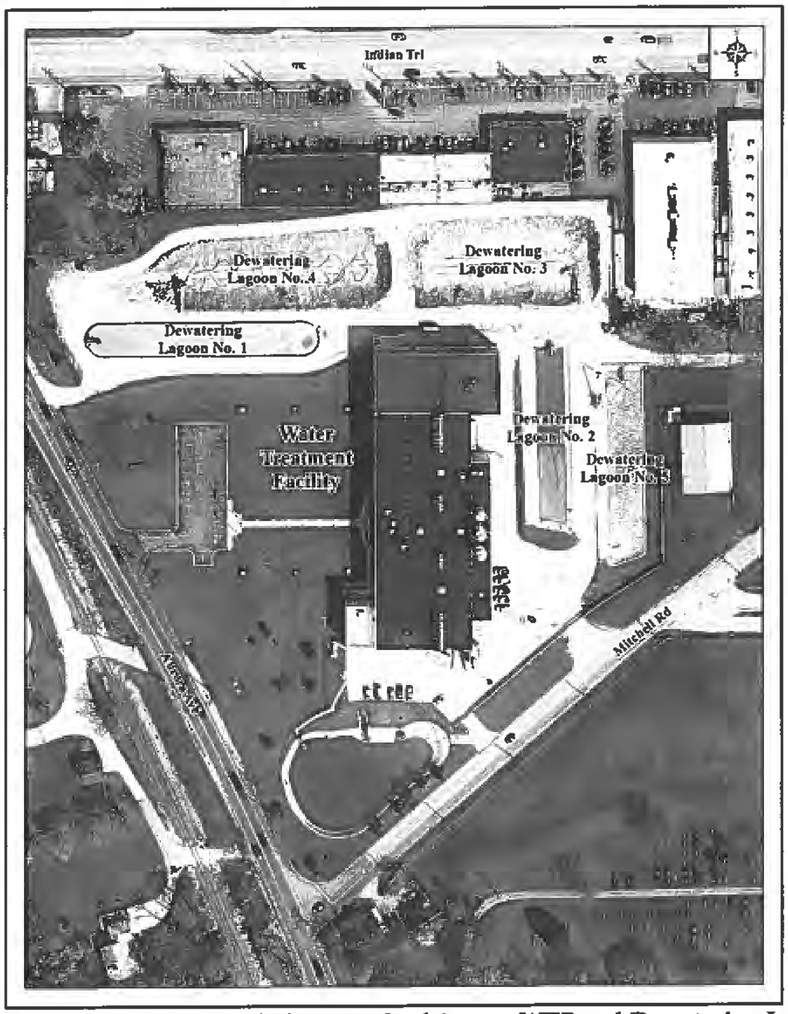
The amount of lime sludge that is produced at the WTP is proportional to the total water production. As water production increases, there is a proportional increase in the amount of lime sludge that is produced. The following table summarizes the monthly and average annual lime sludge production from the WTP:

Table 3.4 – Annual Lime Sludge Production 2010 to 2012 (in millions of gallons)

YEAR	MONTHLY MAXIMUM	MONTHLY MINIMUM	MONTHLY AVERAGE	ANNUAL TOTAL
2010	4.9	2.9	3.8	45.5
2011	4.5	2.7	3.6	43.4
2012	5.7	2.8	3.9	45.4

3.4 *Current Method of Lime Sludge Management*

Currently, the lime sludge that is generated by blowdowns is diverted from the claricones to one of five different dewatering lagoons outside of the building at the WTP property. Typically, only one lagoon is used at a time and lime sludge is diverted to the same lagoon until it has reached its capacity. In the dewatering lagoon, the lime sludge dewaters until it passes a standard paint filter test. Once it is determined that the sludge has sufficiently dewatered, it is excavated from the lagoon, loaded into trucks and transported either to a licensed municipal waste landfill for disposal or for use as an agricultural soil amendment (land applied).



Photograph 3.4 – Aerial Photograph of Aurora WTP and Dewatering Lagoons

Currently, there are a total of 5 dewatering lagoons at the WTP as depicted in the photograph above. The lagoons are roughly rectangular in shape with the following capacities (in cubic yards):

- Lagoon #1: 2,500;
- Lagoon #2: 3,000;
- Lagoon #3: 6,000;
- Lagoon #4: 7,000; and
- Lagoon #5: 3,000.

The lime sludge flows by gravity to the dewatering lagoon as a slurry that averages 6% solids and 94% water. The sludge is delivered into the lagoons via an 8-inch diameter pipe that is located at one end of the basin. The sludge quickly covers the bottom of the lagoon and the solids begin to settle out of suspension almost immediately. The solids deposit themselves in a beach extending progressively away from the discharge pipe at an approximate angle of 1%.

Photograph 3.5 – Lime sludge deposited in dewatering lagoons with supernatant formed

As the solids settle out of suspension, water is forced to the top of the settled solids (called decant water or supernatant) to a depth of approximately 5 feet. The supernatant then overflows into a manually controlled telescopic valve and is discharged by gravity to the local sanitary sewer.

Photograph 3.6 – Dewatered lime sludge solids ready to be excavated for landfill disposal

The following table summarizes the COA annual expenditures to manage and dispose of the WTP lime sludge as described above:

Table 3.5 – Lime Sludge Management Costs 1997 to 2011

YEAR	EXPENDITURE
1997	$770,000
1998	$785,000
1999	$590,000
2000	$740,000
2001	$775,000
2002	$755,000

YEAR	EXPENDITURE
2003	$805,000
2004	$1,242,000
2005	$1,554,000
2006	$1,352,000
2007	$1,514,000
2008	$1,484,000
2009	$1,462,000
2010	$1,740,000
2011	$1,636,000
2012	$1,650,000

The cost of lime sludge management is dependent upon the amount of sludge generated and the unit costs incurred for the publicly bid contract.

4.0 DESCRIPTION OF THE PROJECT

The purpose of the project is to construct a fully closed disposal system to deliver lime sludge directly from the WTP claricones to the lime sludge detention area in the mine and to prepare the mine in such a manner so as to minimize or eliminate potential adverse environmental impacts of the system.

4.1 *Evaluation of Management Alternatives, Costs and Project Goals*

The COA currently spends on average approximately $1,675,000 annually to manage the lime sludge generated at the WTP through landfilling and agricultural land application. Other methods of management have been evaluated such as use for the production of other materials (non-spec concrete, cinder blocks, etc.). Unfortunately, these solutions were determined to be unsuitable as a comprehensive, long-term solution. The COA currently has a permit to land-apply the WTP lime sludge, and in 2012 a total of 42% of the lime sludge produced was land applied resulting in savings of approximately $200,000 over landfilling alone. It is anticipated that once the Class V permit application is approved and the system is operational, land application will no longer be conducted.

The goals of this project are to:

- More economically and efficiently manage the WTP lime sludge;
- Develop a comprehensive management solution that is cost-effective and sustainable long-term;
- Comply with all applicable State of Illinois statutes and regulations; and
- Develop a solution that is protective of human health and the environment ("HH&E").

It is anticipated that the operation, maintenance and management of the proposed system will save the COA up to $1,300,000 annually once it is constructed. In addition to the significant cost reductions, other benefits of this proposal are as follows:

- It is a fully closed system for waste management, from its point of generation to its point of disposal;
- It saves valuable landfill space;
- Drastically reduces the amount of handling of the waste;
- Eliminates the need for the use of heavy equipment and over-the-road transportation, reducing the chance for accidents and reducing its carbon footprint; and
- Eliminates the potential for accidental spillage of lime sludge during transport.

4.2 *Concept and Overview of System*

In order to reduce the cost of handling and disposal of the lime sludge, the COA is seeking a Class V Permit from the Illinois EPA under its UIC program for the disposal of its lime sludge into a subterranean limestone and dolomite mine, located approximately 3,500 feet north of the WTP at the southeast corner of Mettel Road and Illinois Route 25.

The lime sludge that is generated by the water treatment process is proposed to be transmitted from its point of origin at the WTP to its point of proposed injection to the north via an underground forcemain. From the forcemain, the lime sludge will be injected into the rooms within the mine via 4 IW's at the site. Finally, the water within the sludge will be removed from the lime sludge detention area, pumped to the surface via a single extraction well ("EW") and disposed into a Fox Metro Water Reclamation District ("FMWRD") sanitary sewer. The subsections below will give background information on the project, describe the mine and generally describe the different elements of the lime sludge disposal system.

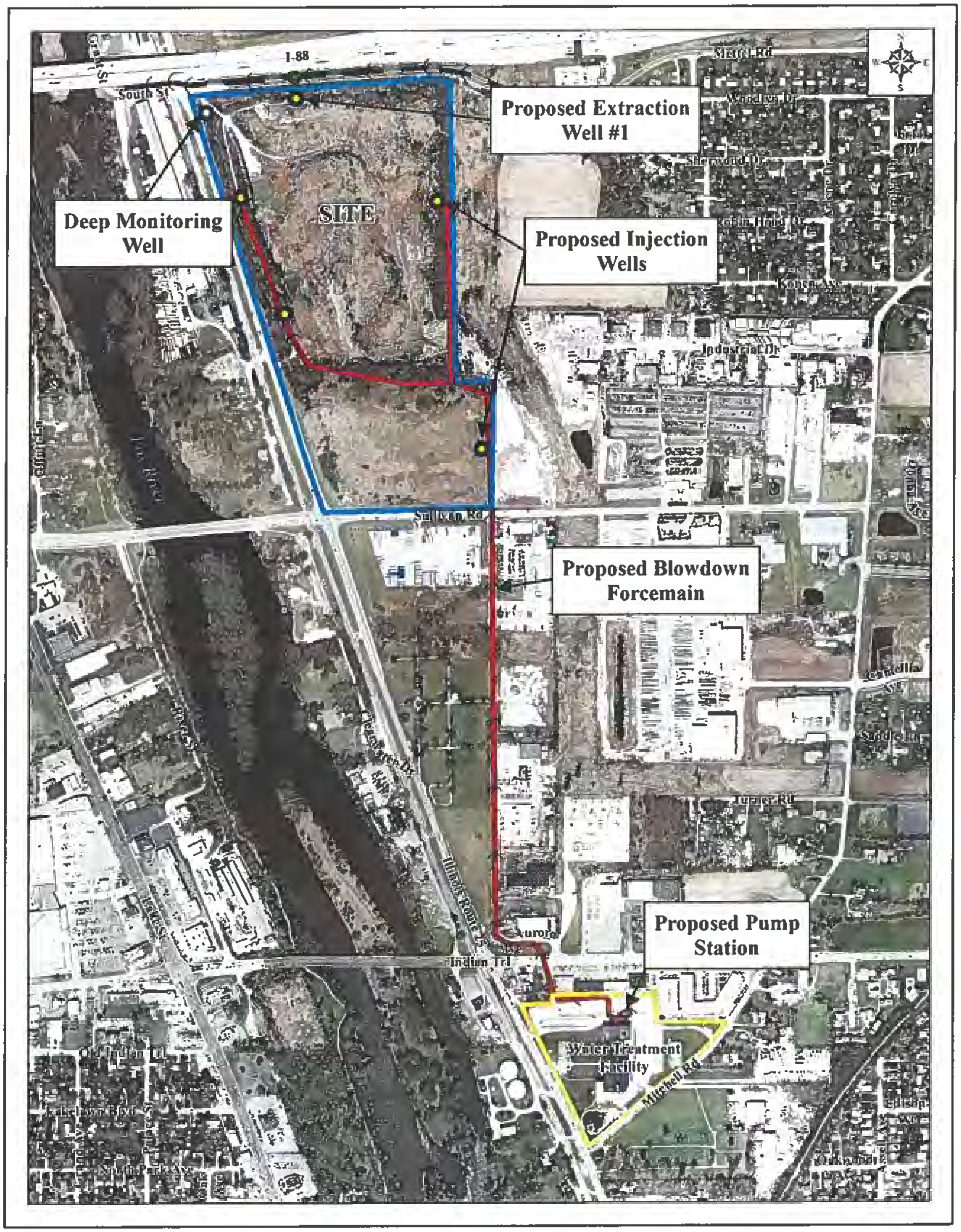


Figure 4.1 – Overview of proposed injection system layout

4.3 *Background Information*

The COA purchased the injection site from Conco Western Stone Company, Inc. in 1986 and leased the mineral rights back to Conco for the development of an underground limestone and dolomite mine. A surface dolomite quarry was operated at the site leaving a pit that encompasses most of the footprint of the site.

Conco operated the underground mine (henceforth called the South Mine) beneath the surface of the property. Conco also operated an underground limestone and dolomite mine north of the site (henceforth called the North Mine) in the Village of North Aurora, Illinois, north of the Interstate 88 Tollway ("I-88"). Both the North and South Mines were created to extract limestone and dolomite from the Ordovician Galena and Platteville Groups for use primarily as construction aggregate. Lafarge North America, Inc. subsequently acquired Conco and currently operates both of the mines. The North Mine is connected to the South Mine via three tunnels under I-88 on Level 1 and through a ramp connecting Level 1 of the North Mine to Level 2 of the South Mine. The South Mine is accessible only through the North Mine via a decline constructed from the ground surface to Level 1 of the North Mine.

4.4 *General Description of the South Mine*

The South Mine consists of two mining levels and a proposed third level. Level 1 of the mine begins at an approximate depth of 240 feet below ground surface ("bgs"). The limestone and dolomite of the Galena and Platteville Groups were mined in a standard room and pillar fashion. The pillars are approximately 50-feet square with approximately 47-foot square rooms between them. The breasted areas of the mine created rooms that are 23-feet high ceiling to floor and the benched areas of the mine created rooms that are approximately 50-feet high ceiling to floor. The two levels of the mine are configured on top of one another such that the pillars of both levels are vertically aligned, with an approximate 25-foot sill between levels in order to enhance mine stability.

At the north end of the mine, the four openings connecting the Conco North Mine to the Conco South Mine will be sealed using bulkheads so that the South Mine will be completely sealed off from the Lafarge mining operations in the North Mine. These bulkheads will be constructed such that the openings will be completely sealed. Lafarge will design and construct the bulkheads and they will also seal any fractures in the host rock surrounding the bulkheads so as to create a leak-proof seal.

It is intended that Lafarge will mine a new third level beneath Level 2 while lime sludge injection is being conducted. This level will be mined with the same configuration as Levels 1 and 2 and a 25 foot sill of rock will exist between Levels 2 and 3. A full rock stability evaluation was conducted to determine the safety both to the injection system and to Lafarge personnel mining in Level 3. Please refer to **Section 10.0** of this narrative for a summary of this study and to **Appendix A** for the complete report. The results of this study indicate that Level 3 can be mined safely with no reasonable potential of damaging the integrity of either the injection system or to the indefinite storage of lime sludge solids within Levels 1 and 2 of the mine.

4.5 System Description and Elements

In order to deliver the lime sludge from the WTP to the mine, a lime sludge delivery and injection system will be constructed. The system will have the following elements:

- A new pump station and wet well to be constructed along with a forcemain to deliver sludge to the site;
- An injection system which will include 4 IW's and distribution piping on the floor of Level 1 of the mine, ; and
- A supernatant extraction and disposal system.

Each of these system elements are described in more detail in the subsections below.

4.6 Lime Sludge Depositional Characteristics

The lime sludge will deposit itself into the mine with similar characteristics as when it is deposited within the dewatering lagoons at the WTP. As the lime sludge is deposited into the mine via the injection wells, it will quickly cover the floor and the solids will settle out of suspension soon thereafter. The water in the sludge will quickly decant and form supernatant. The level of the supernatant will be maintained at a maximum head of 5-feet by design in order minimize the amount of free liquid in the detention area at any particular point in time.

A cone will form under each injection point and the solids will form a beach sloping away from each injection point at a slope of approximately 1%. Please refer to **Section 13.0** for a detailed description of the bench scale experiment that was conducted to determine the precise characteristics of lime sludge deposition.

4.7 Lime Sludge Delivery System

The portion of the system that will deliver the lime sludge generated by the blowdowns from the claricones at the WTP will have the following elements:

- A pumping station and wet well connecting the claricones to the forcemain with associated valving, electrical and control systems;

- An 8-inch diameter forcemain connecting the wet well to the injection system.

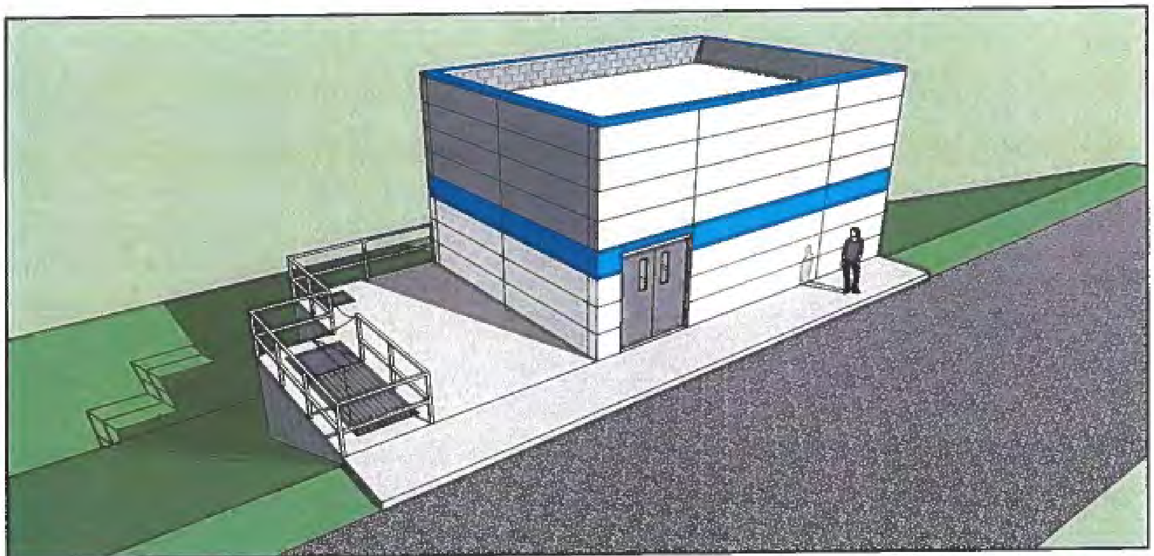


Figure 4.2 – North elevation of proposed pump station

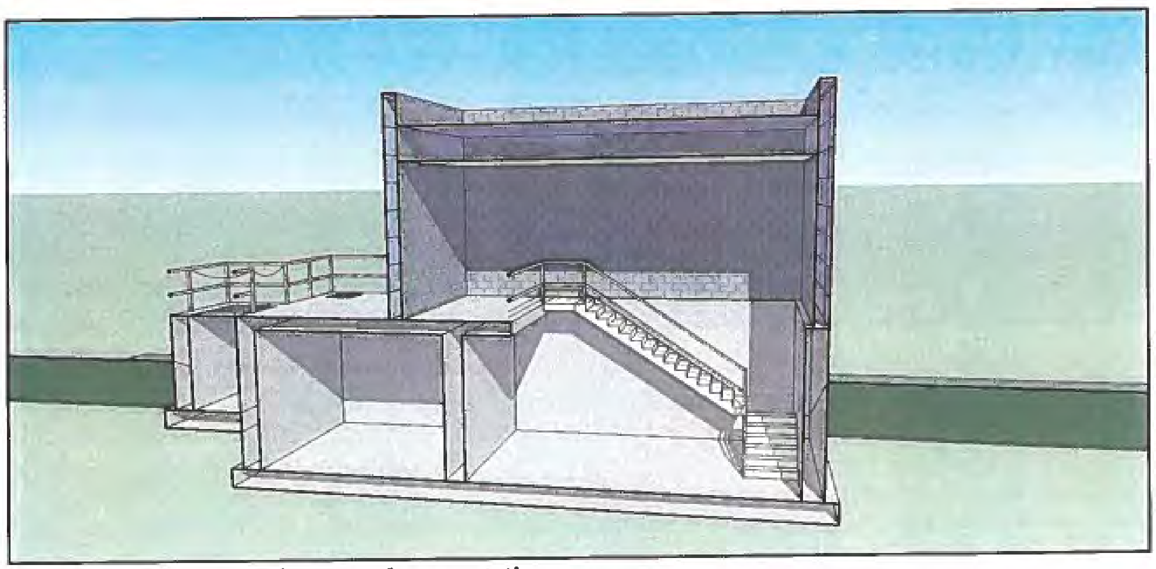


Figure 4.3 – Cut-a-way of proposed pump station

The purpose of the wet well is to provide for a mechanism to remove solids from the sludge that could damage the pumps. This will allow more even and uniform pumping of the lime sludge to the site for injection and will eliminate the need to synchronize the pumps with the blowdowns at the WTP. The wet well will have an active volume of 2,240 gallons/foot and in plan will have the approximate dimensions of 20 feet by 15 feet.

The forcemain will be connected to the wet well pumps and will be constructed of class 52 ductile iron pipe ("DIP") with an interior cement lining and will be 8-inches in diameter. The forcemain will be constructed along Aurora Avenue Lane at a depth of 5.5-feet bgs to the site.

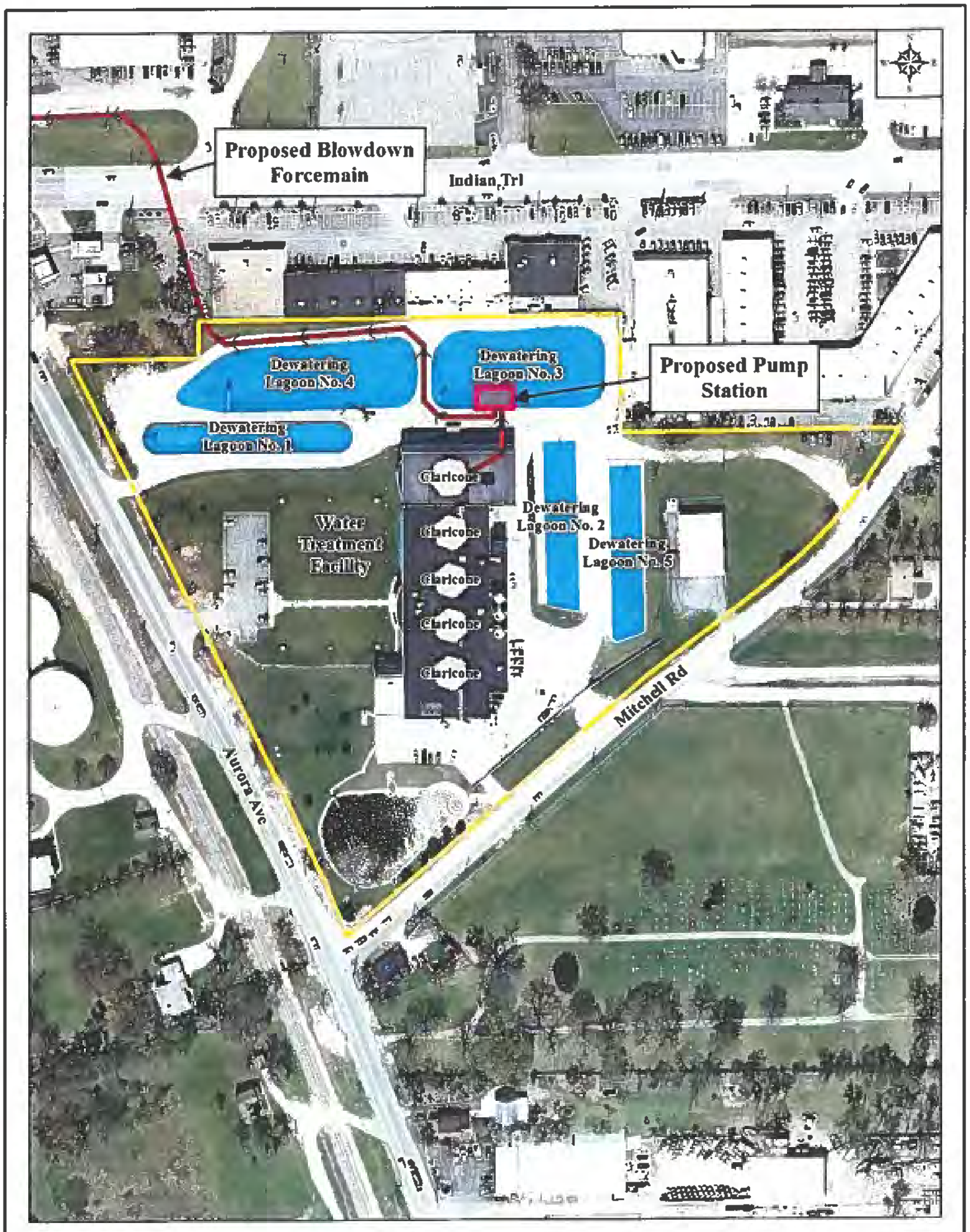


Figure 4.4 – WTP layout, dewatering lagoons, pump station and forcemain

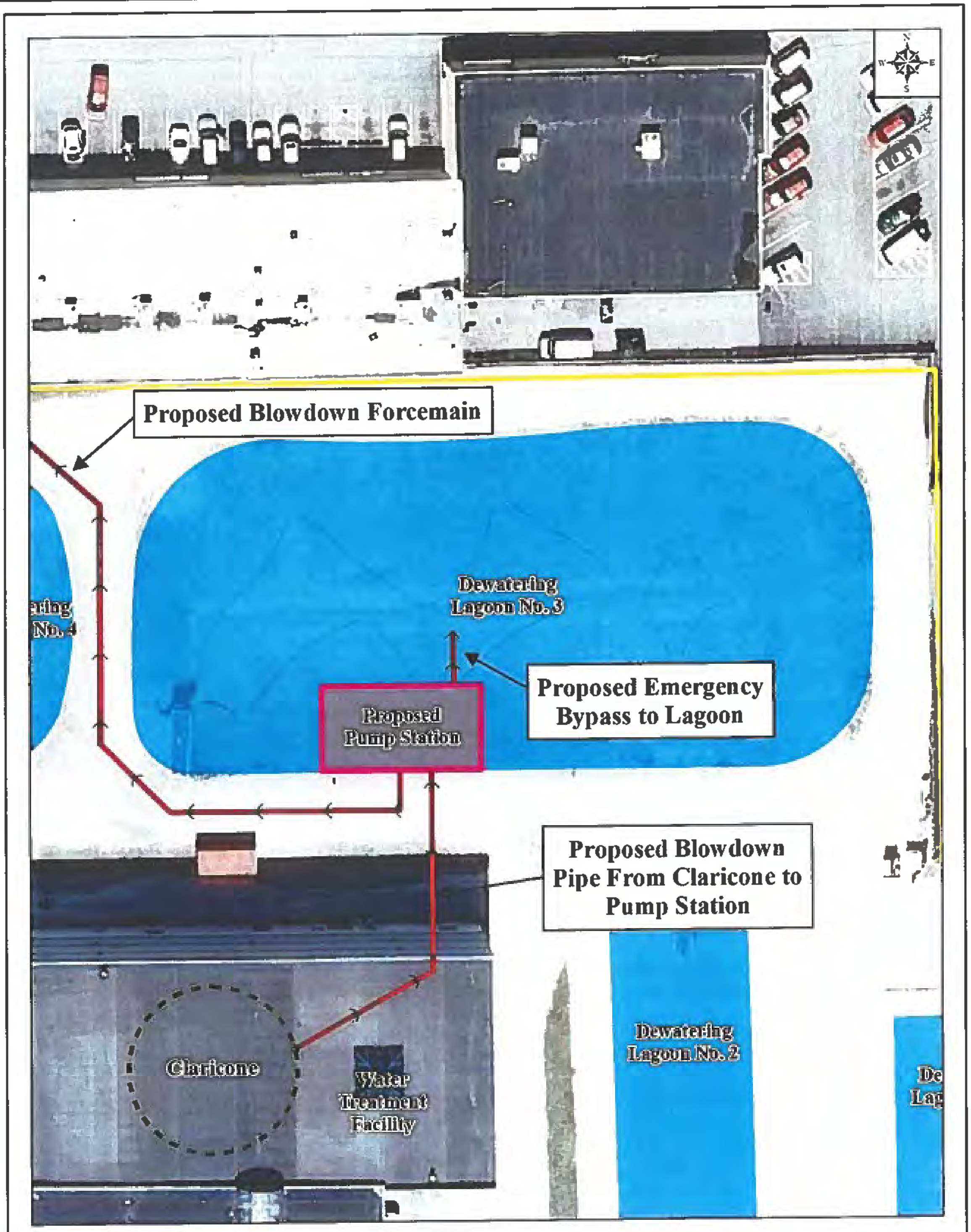


Figure 4.5 – Connection of claricones to pump station and forcemain

Please refer to **Section 12.1** of this narrative for a more detailed discussion of the lime sludge delivery elements of the system.

4.8 *Injection and Distribution Piping Systems*

At the site, the forcemain will connect to each of 4 different IW's. These IW's will be located in areas of the mine that will increase the efficiency of space utilization and subsequently to increase the storage capacity of the system.

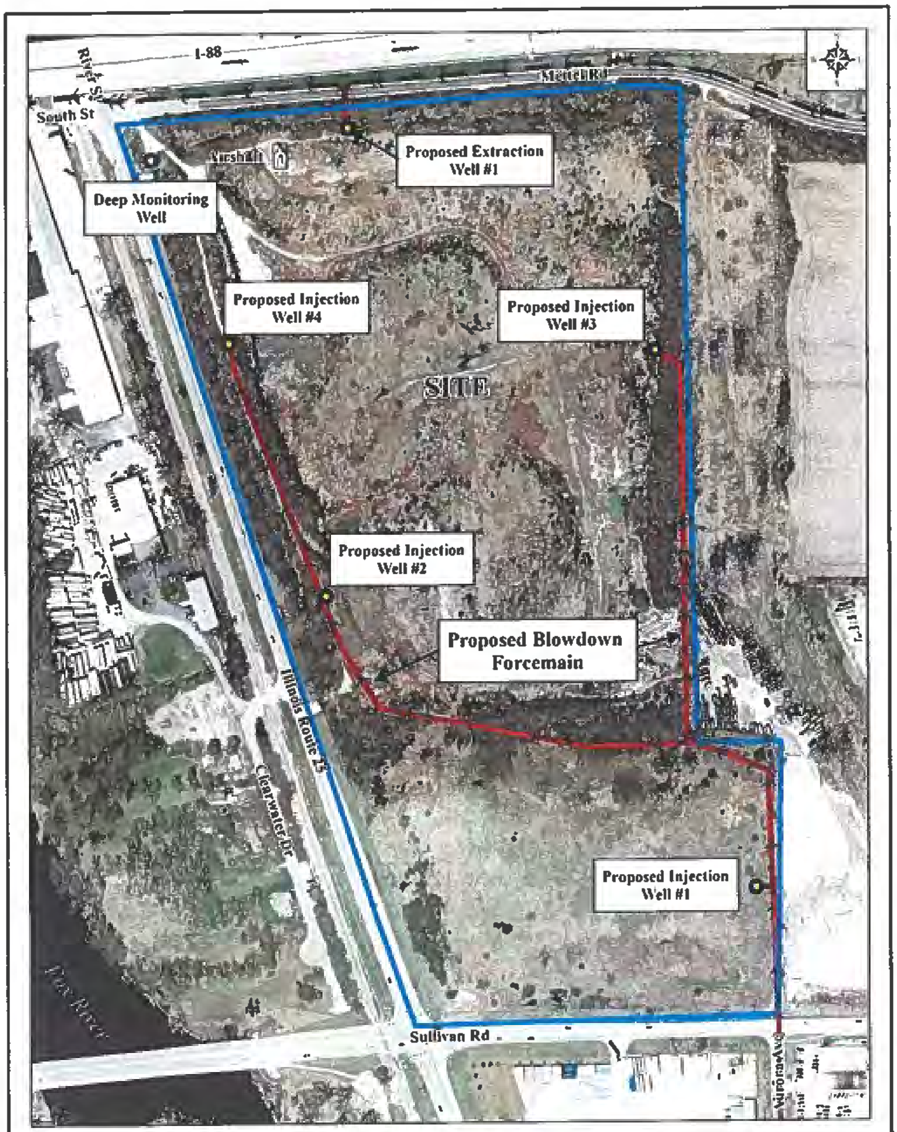


Figure 4.6 – Site map with proposed IW locations and forcemain layout

The injection wells will be constructed into Level 1 of the mine and will be anchored at the ceiling to a vertical pipe in the mine. This pipe will be designed with a radius curve to reduce energy within the pipe and will be connected to an 8-inch (or less) diameter steel distribution pipe braced to the floor of Level 1 of the mine.

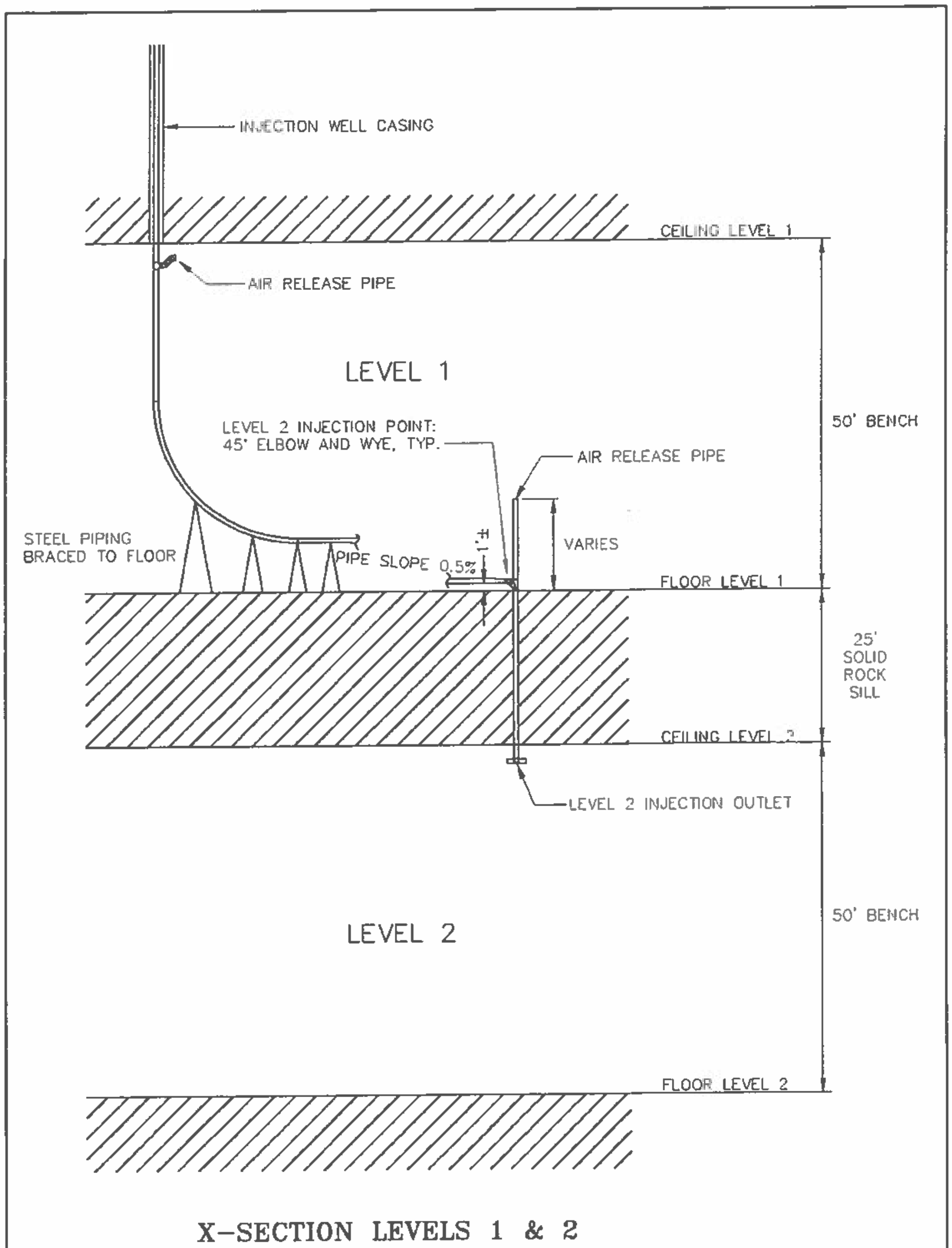


Figure 4.7 – Injection well connection to distribution piping and injection point

The distribution piping will lead from the 4 injection wells to various clusters of 18 uncased, drilled holes (injection points) through the sill between Levels 1 and 2 of the mine of sufficient diameter to accommodate the 8-inch or less diameter distribution pipes. There will be a 90-degree connection from the pipe along the floor of Level 1 of the mine into the injection points. There will be steel piping from the bottom of the 90-degree connection into the holes, slightly protruding through the ceiling and into Level 2 of the mine. At the end of the pipe at the ceiling of Level 2 of the mine, there will be a fitting with 4, 90-degree openings. The openings of this fitting will be parallel to the floor of Level 2 and will be suspended approximately 2 feet from the ceiling. From this fitting, the lime sludge will deposit into the second level of the mine.

The system will be constructed so that each of the 4 IW's will have dedicated distribution piping and injection points connected to it. IW-1 will be connected to 6 injection points at the south end of the mine, IW-2 will also be connected to 6 injection points, IW-3 and IW-4 will both be connected to 3 injection points each. By constructing permeable berms between certain pillars on Level 2 of the mine, 3 siltation basins will be created, such that each injection well will deposit sludge into these siltation basins. The purpose of the basins is to insure that the solids will deposit from the south end of the mine, progressing to the north end, while allowing the decant water to travel to the north end of the mine for extraction to the surface. IW-1 will deposit into siltation basin 1, IW-2 into siltation basin 2 and IW-3 and IW-4 into siltation basin 3.

The daily volume injected into the mine is anticipated to average approximately 165,000 gallons over the life of the system.

Please refer to **Sections 12.2 to 12.5** of this narrative for a more detailed discussion of the lime sludge injection elements of the system.

4.9 Supernatant Extraction System

At the north end of the mine, the four openings connecting the South Mine to the North Mine will be sealed by bulkheads called Kennedy Stoppings. The bulkheads will seal the lime sludge detention area in the South Mine from the Lafarge's mining operations in the North Mine. These bulkheads will be constructed in a manner so that each of the openings will be completely sealed. Lafarge will design and construct the bulkheads and they will also seal any fractures in the host rock surrounding the bulkheads so as to create a leak-proof seal. The bulkheads will include a series of pressure transducers equipped with alarms to monitor the load on the bulkhead walls over time to warn against excessive loadings.

As the lime sludge is deposited in the mine via the injection wells, the water in the sludge will decant and the solids will settle. The level of the decant water, or

As the lime sludge is deposited in the mine via the injection wells, the water in the sludge will decant and the solids will settle. The level of the decant water, or supernatant, will be maintained at a maximum head of 5-feet by spacing of inlet pipes that will be constructed through the bulkhead on Level 2 and through one of the bulkheads on Level 1. The supernatant will be collected via the inlet pipes and will be pumped out of the mine via a single EW and discharged into a nearby sanitary sewer.

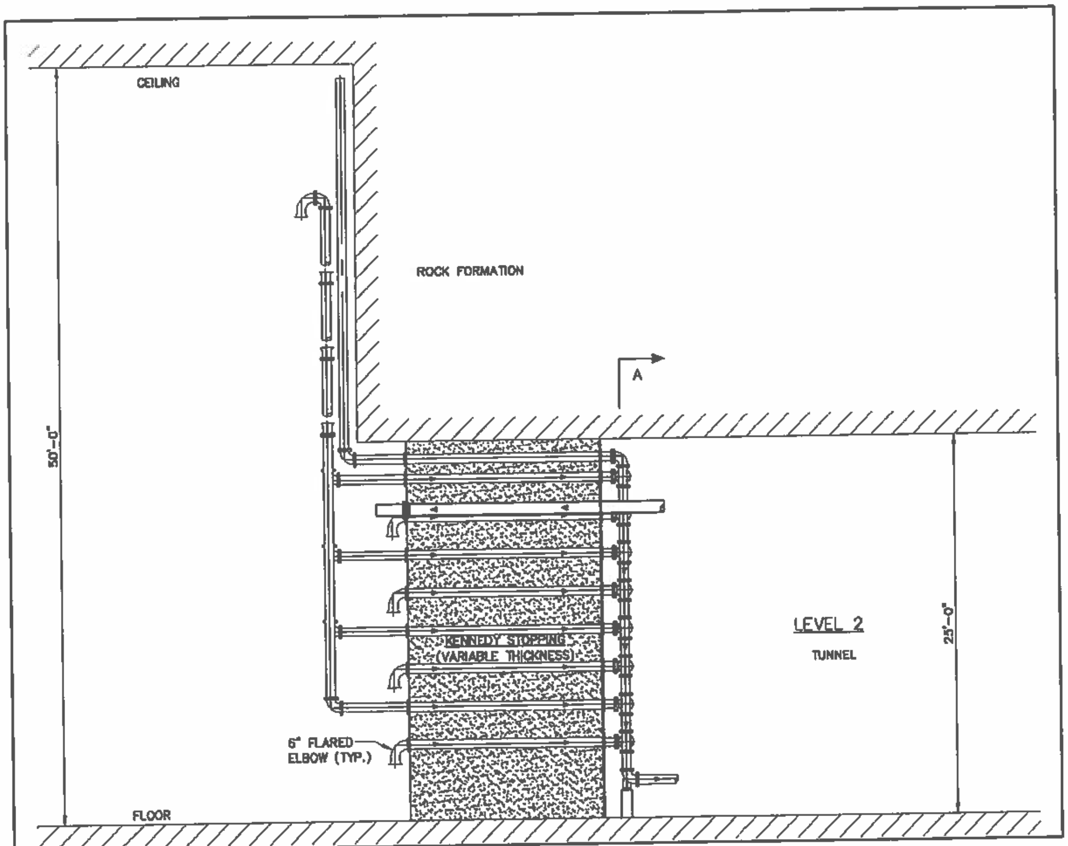


Figure 4.8 – Typical bulkhead with supernatant extraction piping

On the "dry" side of the Kennedy Stoppings, the supernatant will be pumped through inlet pipes, in progression from the bottom to the top, to a single discharge pipe that will be connected to the EW. The EW will extend from Level 2 of the mine to the ground surface (approximately 360 feet vertical distance). The extraction well will be connected to a forcemain approximately 5.5-feet below ground surface that will discharge the supernatant to a nearby sanitary sewer.

Please refer to ***Section 12.7*** of this narrative for a more detailed discussion of the lime sludge extraction elements of the system.

anticipated that the effective disposal life of the mine will likely be between 48 to 59 years for both Levels 1 and 2. Please refer to **Section 14.0** of this narrative for a more detailed discussion of the life estimates for the system.

4.10 *Sealing and Preparation of Storage Area*

In addition to sealing the openings at the north end of the mine with bulkheads and construction of the berms to create sedimentation basins, the following activities will be conducted to prepare the mine for system construction and lime sludge injection system operation:

- Sealing of any unfilled joints that exist on the floors and perimeter of Levels 1 and 2 of the mine;
- Removal of all mining equipment; and
- Cleaning mine of all debris from mining and system construction prior to initiation of injection operations.

Please refer to **Section 11.0** of this narrative for a more detailed discussion of these activities.

4.11 *Contingency Plan*

In the event of an emergency, the system will have the ability to divert lime sludge from the pump station to Dewatering Lagoon #3 that currently exists at the WTP. This lagoon has the capacity to store up to 6,000 cubic yards of lime sludge that can be dried, excavated and transported to a landfill on an as-needed basis. This volume represents approximately 7 weeks of storage, under average operating conditions.

In addition, the COA is contemplating leaving dewatering lagoons #2, 4 and 5 in place in the event of unforeseen situations. These lagoons, as shown on **Figure 4.4**, have a combined capacity of 13,000 cubic yards, which represents an additional 17 to 22 weeks of storage under average operating conditions. In total, the COA would have approximately 6 months of storage at the WTP site to meet any type of issues with the proposed lime sludge injection system infrastructure.

5.0 SITE LOCATION AND GEOLOGY

The injection site located at the southeast corner of the intersection of Illinois Route 25 and Mettel Road, Aurora, Illinois. The legal description of the property is the northwest quarter of Section 10, Township 38 North, Range 8 East of the Third Principal Meridian, Kane County, Illinois. The site is approximately 50-acres in size and is currently owned by the COA. The COA is in the process of selling the surface rights of the property to Heartland Recycling, LLC for use as an Illinois EPA permitted Clean Construction and Demolition Debris ("CCDD") disposal facility. The plat of survey and topographic map of the property are located in **Appendix F**.

The site is bounded on the north by Mettel Road, on the east by a Commonwealth Edison utility easement, on the west by Illinois Route 25 and on the south by Sullivan Road. Please refer to **Figures 2.3 and 2.4** for the USGS topographic and the surrounding land use maps respectively.

5.1 *Site Background*

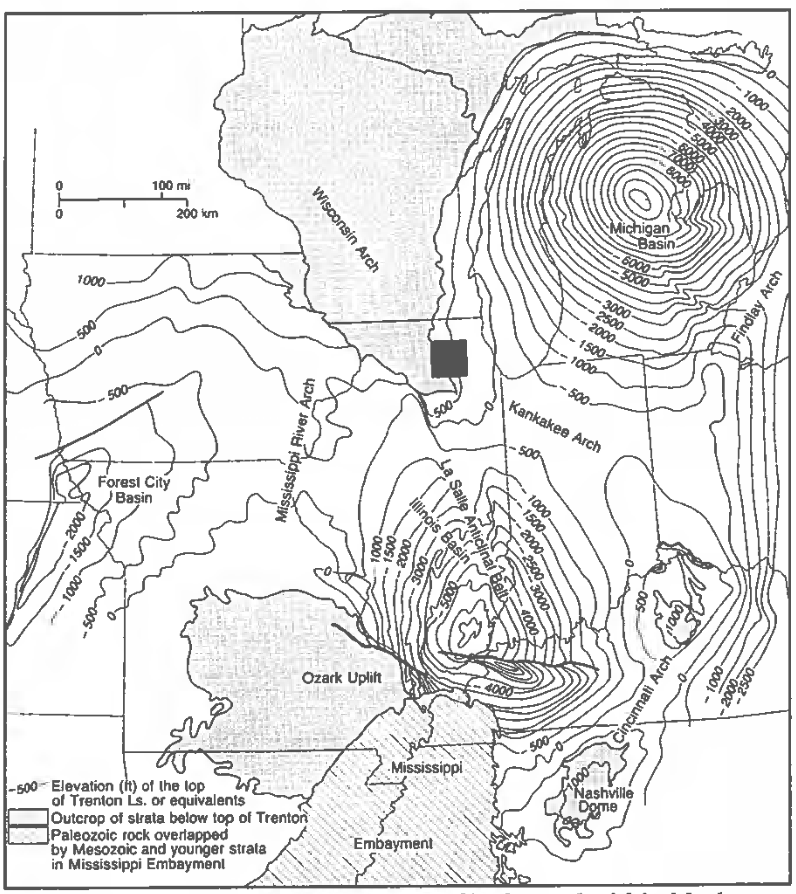
A review of historical documents including aerial photographs and USGS topographic maps indicate that the site was lightly wooded and used for agricultural purposes from 1939 through the end of the 1940's. In the late 1940's and into the mid-1950's gravel quarrying operations were conducted on the west half of the site. Beginning in the mid- to late-1950's the site was used as a surface quarry.

Most of the footprint of the property is comprised of a former quarry pit. The quarry was operated from approximately 1950 to 1986, most recently by Conco Western Stone Company, Inc. ("Conco"). The quarry was developed to extract the Silurian Dolomite from the site and the floor of the current quarry pit is located approximately 40 to 50 feet below the natural ground surface. The site is located approximately 550 feet east of the Fox River with an unnamed first-order tributary creek along the northern and western property boundaries of the site. The natural topography of the site slopes to the west-southwest, from the highest elevation of 705 feet along the eastern property boundary to an elevation of 660 feet along the western property boundary. The lowest elevation in the bottom of the quarry is 625 feet in the north central portion of the site.

The COA purchased the site including the mineral rights from Conco in 1986 and later leased the mineral rights back to Conco for the development of an underground limestone and dolomite mine. From 1998 to 2007, Conco operated an underground mine (henceforth called the South Mine) beneath the surface of the property. Conco also operated an underground limestone and dolomite mine north of the site (henceforth called the North Mine) in the Village of North Aurora, Illinois, north of I-88. Both the North and South Mines were created to extract limestone and dolomite from the Ordovician Galena and Platteville Groups for use primarily as construction aggregate. Lafarge North America, Inc. purchased Conco in 2007 and currently operates both of the mines. The mines are accessed from the surface through a decline constructed from the ground surface to Level 1 of the North Mine. The North Mine is connected to the South Mine via three tunnels under I-88 on Level 1 and through a ramp connecting Level 1 of the North Mine to Level 2 of the South Mine. The mine operations and configuration are described in more detail in **Section 11.0** of this permit application.

5.2 *Regional Geology*

The stratigraphic succession for the vicinity of the Conco South Mine that is presented in **Table 5.1** was compiled from boring logs obtained from the Illinois State Geological Survey ("ISGS"), the *Handbook of Illinois Stratigraphy* (Willman et al. 1975) and the boring log from the monitoring well constructed at the site for COA.



<u>**Figure 5.1 – Regional Geologic Setting – Site located within black square**</u>

Table 5.1 – Regional Geology

Geologic Unit	Description	Anticipated/Average Thickness (feet)
Quaternary System	Glacial Sediments	**12 to 20**
Silurian System$ Joliet Formation Kankakee Formation Elwood Formation Wilhelmi Formation	Dolomite	**40 to 50**
Ordovician System		**900 to 1000**
Maquoketa Group	Upper and Lower Shale Members with a thin middle Dolomite Member	155
Galena-Platteville Group$	Limestone and Dolomite	335
St. Peter Formation**+	Sandstone	225
Prairie du Chien Group	Dolomite and Sandstone	185
Cambrian System		**Approx. 3000**
Eminence-Potosi Formations	Dolomite and Sandstone	130
Franconia Formation	Dolomite and Sandstone	100
Ironton-Galesville Formation**	Sandstone	150
Eau Claire Formation	Dolomite, Siltstone and Sandstone	370
Mt. Simon Formation**	Sandstone	2,250
Precambrian System		

* : Resource aquifer
** : Potable aquifers in northern Illinois
$: Mined for construction aggregates and agriculture limestone
+ : Quarried for silica sand

A graphical representation of the geology is presented in **Figure 5-2** below (modified from (Burch 2008, Figure 2).

AQUIFER	SYSTEM	FORMATION OR GROUP	LOG	DESCRIPTION
Glacial or Unconsolidated	Quaternary			Unconsolidated glacial deposits. Commonly pebbly clay, but with silt, sand, and gravel. Some glacial deposits consist of very permeable bodies of sand and gravel.
Shallow Bedrock	Silurian			Dolomite, very pure to very silty. Upper part frequently creviced and broken. Lower part contains thin shale layers and tends to be silty.
	Ordovician	Maquoketa		Shale, gray or brown.
		Galena-Platteville		Dolomite, commonly creviced when not underlying the Maquoketa Shale. Some limestone layers and thin shale partings.
		Glenwood		Sandstone and dolomite, shale at the top.
Deep Sandstone		St. Peter		Sandstone, fine to medium texture, well sorted and poorly cemented. Exceptionally pure quartz sand.
		Prairie Du Chien		Interbedded dolomites and sandstones.
	Cambrian	Eminence-Potosi		Dolomite, white, fine-grained, but typically sandy at its base. (Lower unit known as St. Lawrence in Wisconsin.)
		Franconia		Sandstone, dolomitic with thin shale partings.
		Ironton-Galesville		Sandstone, coarse to fine-grained, well sorted. May be dolomitic in the upper part.
		Eau Claire		Shale and siltstone. Contains a sandy dolomite member in northeastern Illinois. Entire formation becomes essentially a fine-grained sandstone in Milwaukee.
		Mt. Simon		Sandstone, coarse-grained. Thickness estimated at 2,000 feet in Illinois.
	Precambrian			Crystalline rock, probably granite.

Figure 5.2 – Generalized Regional Geologic Section

5.2.1 Quaternary System

The unconsolidated deposits at the site that have not been removed through quarrying consist of the Henry Formation of the Mason Group on the west and the Yorkville

Member of the Lemont Formation of the Wedron Group (Willman 1971; Curry 2001) along the east boundary. The Henry Formation consists of stratified sand and gravel that contains localized lenses of silt, clay and organic debris (Hansel and Johnson 1996). The Yorkville Member of the Lemont Formation consists of calcareous, gray, silty clay to silty clay loam diamicton (poorly sorted, poorly stratified sediment) that contains lenses of gravel, sand, silt and clay. The weathered surface of Yorkville diamicton commonly contains a concentration of small dolomitic pebbles, giving it the appearance of gravel (Hansel and Johnson 1996).

5.2.2 Silurian System

The Silurian System in northeast Illinois is comprised of marine reef deposits and is almost entirely dolomite in the region. During Silurian time, approximately 395 to 440 million years before present (mybp), Illinois was continuously beneath the ocean and the Silurian System in the state can include limestone, siltstone and shale, in addition to dolomite. The Silurian System in northeast Illinois includes the bottom portion of the Niagaran Series and most of the Alexandrian Series.

In the area of the site, the Silurian System is approximately 50 feet thick and is comprised of the Joliet, Kankakee, Elwood and Wilhelmi Formations. The Joliet and Kankakee Formations tend to be undifferentiated and are comprised of white, grey to greenish grey dolomite with some chert and minor amounts of shale. The beds can be wavy, with some minor clay partings between the beds. The Elwood Formation is a slightly argillaceous, brownish grey fine-grained dolomite that can contain dense layers of chert up to 4-inches thick. The Wilhelmi Formation is comprised of a medium grey, argillaceous dolomite that at its base can contain reworked shaly sediments from the underlying Brainard Formation shales of the Maquoketa Group (Mikulic et al. 1985). Thus, the Wilhelmi represents an infilling of eroded areas in the underlying Maquoketa; therefore its thickness depends on the thickness of the underlying Brainard, the combined thickness of the two units being approximately constant.

The basal area of the Silurian System dolomite is fractured and comprises an aquifer unit in the region at the contact of the basal Whilhelmi Formation with the Brainard Formation shale. Water is held within the secondary porosity created by the laminae, partings, bedding planes and fractures of the formation. There are several producing wells in the area that are screened at this depth interval.

5.2.3 Ordovician System

The Ordovician System (approximately 440 to 500 mybp) in northeast Illinois consists of marine deposits, showing multiple transgression and regression sequences. Much of the upper portion of the system was deposited in a broad shallow sea and is predominantly comprised of fine-grained carbonates and shales, with little to no clastic deposits. The lower portions of the system are characterized by massive deposits of sand that were created by large deltas which formed at the time. The system is bounded by unconformities above and below and is approximately 900 feet thick in the vicinity of the site.

In northeast Illinois the units comprising the Ordovician System are the Maquoketa Group, the Galena and Platteville Groups (which are commonly combined together as the Galena-Platteville Group), the Ancell Group and the Prairie du Chien Group. These units are discussed in more detail below.

Maquoketa Group

The Maquoketa Group consists of an upper shale unit called the Brainard Formation, an intermediate limestone unit called the Ft. Atkinson Formation and a lower shale unit called the Scales Formation and has a total thick of approximately 150 feet in the vicinity of the site. The Brainard Formation is approximately 80 to 100 feet thick and is characterized as a greenish grey to green dolomitic shale. It can be fossiliferous and can include interbeds of siltstone and limestone or dolomite. The Ft. Atkinson formation is a grey, argillaceous limestone that is less than 5 feet thick in the area of the site. The Scales Formation ranges from 50 to 80 feet thick in the Aurora area and is an olive-gray to dark-gray, massive shale. The Maquoketa Group acts as the confining unit for groundwater flow in the Cambro-Ordovician Aquifer in the region.

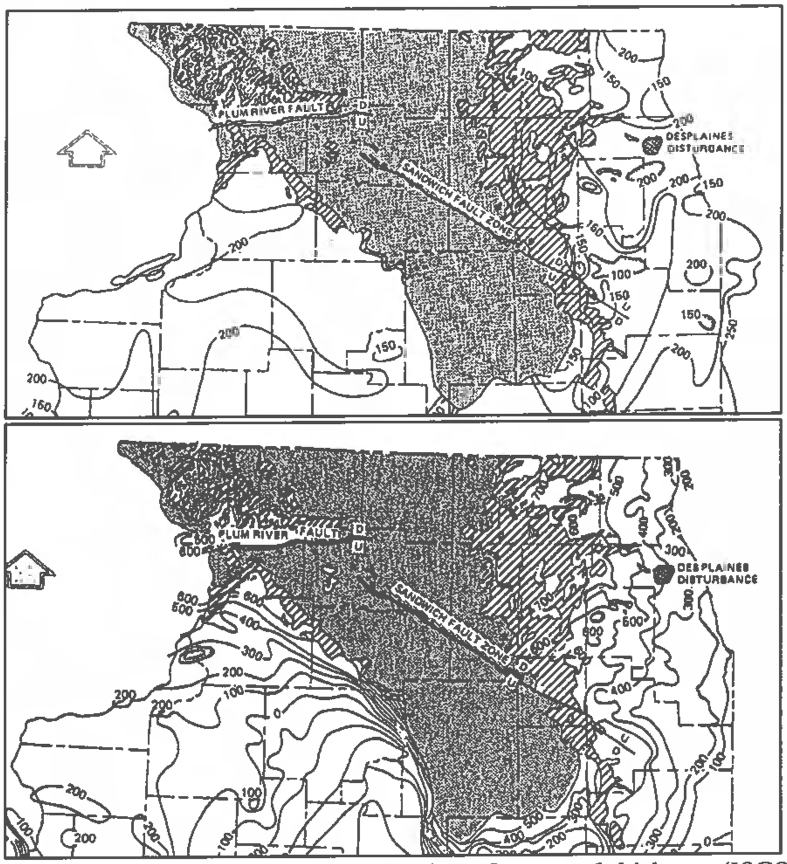


Figure 5.3 – Elevation of top of Maquoketa Group and thickness (ISGS/ISWS, 1985)

Galena Group

The Galena Group, which is often combined with the underlying Platteville Group as the Galena-Platteville Group, is widely mined for mineral resources in the region and ranges from 150 to 200 feet thick. It generally consists of limestone and dolomite. In northeast Illinois it is generally comprised of the Wise Lake, Dunleith and Guttenberg Formations. The Wise Lake formation consists of relatively pure, massive, light brown, vesicular to vuggy limestone and dolomite. The Dunleith Formation is a mottled gray to light brown limestone/dolomite unit that contains vugs filled with calcite and pyrite crystals. The Guttenberg Formation is a medium grained, typically reddish brown shaly dolomite that is a distinct marker bed and ranges in thickness from about 1.5 to 4 feet in the Chicago area.

Platteville Group

The Platteville Group ranges from 100 to 150 feet thick and, as with the Galena Group, is widely mined in the region for crushed stone. It overlies the Ancell group and is comprised of dolomite or dolomitic limestone. Regionally, it is consists of the Quimby's Mill, Nachusa, Grand Detour, Mifflin and Pecatonica Formations. The Quimby's Mill formation is a thin, light brown argillaceous dolomite characterized by chert nodules and some clay partings. The Nachusa Formation is fine-grained, pure to slightly argillaceous, thick bedded dolomite. The Grand Detour Formation is a thick-bedded to massive, light brown to gray dolomite unit that often has a distinct blue-gray color on fresh, unoxidized surfaces. The Mifflin Formation is a fossiliferous, fine-grained to microcrystalline dolomite with distinct shale partings. The Pecatonica Formation is the basal unit of the Platteville Group and overlies the Ancell Group. It is a light brown to light gray, microcrystalline, thinly bedded dolomite that becomes increasingly siliceous and vuggy at the bottom.

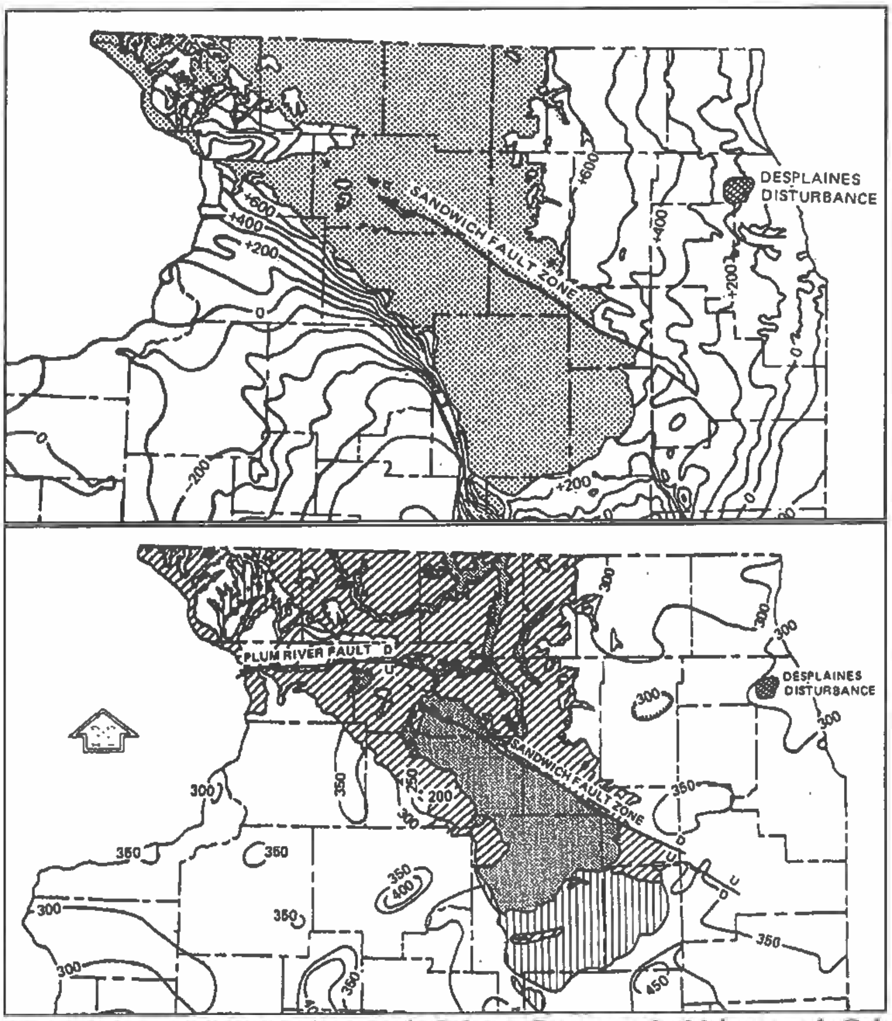


Figure 5.4 – Elevation of top of Galena Group and thickness of Galena-Platteville Groups (ISGS/ISWS, 1985)

Ancell Group

The Ancell Group is a major aquifer in the Midwest, ranges from 200 to 250 feet thick and consists of the Glenwood and St. Peter Formations. The Glenwood Formation, which is comprised of impure dolomite, shale and poorly sorted sandstone, is typically thin to absent in the Aurora area and often undifferentiated from the St. Peter.

The St. Peter Formation (also called the St. Peter Sandstone) is about 220 feet thick in the area of the site and is a massive, white sandstone that is friable or weakly cemented, fine- to medium-grained, well rounded, frosted and predominantly quartz. It outcrops across northern Illinois, notably along the Fox and Illinois River valleys in the Ottawa to Starved Rock area and is widely quarried for silica sand. The St. Peter Formation is a Class I aquifer and is an USDW. Most of the COA municipal wells are screened in the St. Peter and as the shallowest USDW below proposed lime sludge storage area, it will be discussed in greater detail later in this narrative.

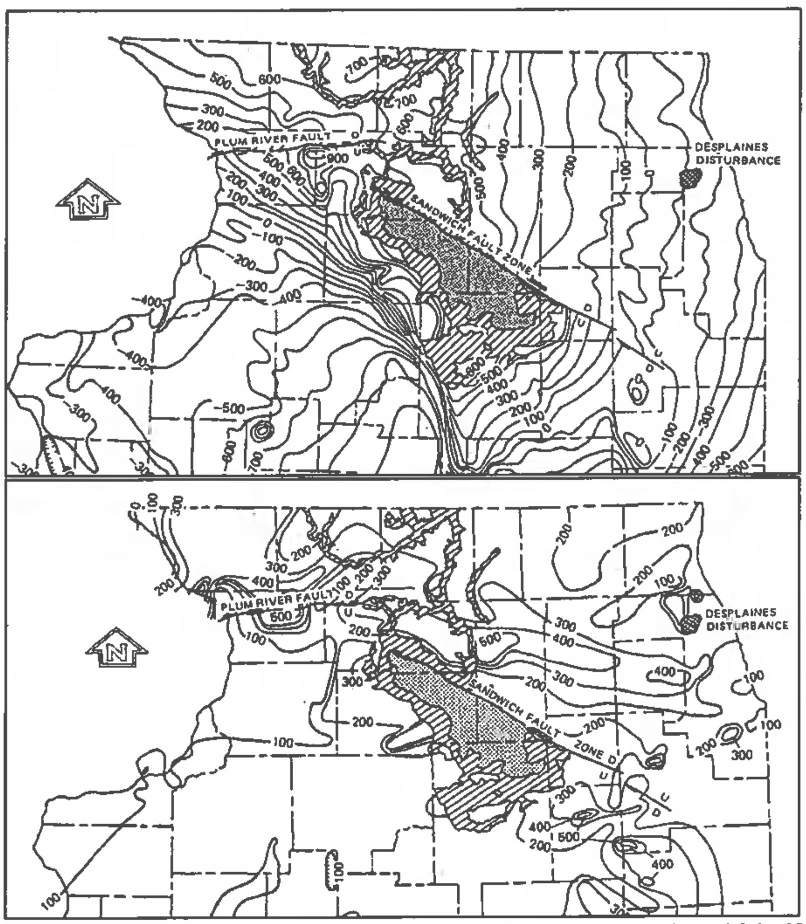


Figure 5.5 – Elevation of top of Ancell Group and thickness (ISGS/ISWS, 1985)

Prairie du Chien Group

The Prairie du Chien Group consists of alternating, dolomite and sandstone formations. The sandstone formations tend to be thin in the region and are typically not used as an USDW. In Illinois it consists of the Shakopee Dolomite, the New Richmond Sandstone and Oneota Dolomite and the Gunter Sandstone. However, the Shakopee and New Richmond Formations are absent in the Aurora area and the Gunter Sandstone, where identified in wells in the Aurora area, ranges from 10 to 50 feet in thickness. The Oneota Dolomite is typically approximately 100 feet thick but is not considered a major groundwater source (Woller and Sanderson 1978).

5.2.4 Cambrian System

The Cambrian System (approximately 500 to 570 mybp) in northern Illinois ranges from 3,000 to 3,500 feet thick and is comprised primarily of clastic marine sediments. These sediments were deposited in a shallow marine embayment and include sandstones, sandy dolomites, dolostones and siltstones. Mineralogical evaluation indicates that most of the sediments were derived from Precambrian and possibly early Cambrian sandstones, with possibly several cycles of erosion, transportation and deposition. Fossils are scarce in the Cambrian System, which and the lower portion is comprised of the Potsdam Sandstone Megagroup and the upper portion is comprised of the Knox Dolomite Megagroup, which extends upward into the Ordovician dolomite formations. The Cambrian System includes the Eminence-Potosi, Franconia, Ironton-Galesville, Eau Claire and Mt. Simon Formations.

Knox Dolomite Megagroup (Eminence-Potosi and Franconia Formations)

The boring logs reviewed as part of this assessment refer to the Eminence-Potosi and Franconia Formations as the Knox Dolomite Megagroup and the formations are generally not differentiated. The Eminence Formation is a light grey to brown, sandy, fine- to medium-grained dolomite that contains oolitic chert and thin beds of sandstone. The Potosi Formation is a microcrystalline, brownish gray, pure to slightly argillaceous dolomite. In the Aurora area, the Eminence and Potosi Formations have a combined thickness ranging from 120 to 170 feet (Woller and Sanderson 1978). The Franconia Formation is a glauconitic, argillaceous sandstone and dolomite that is approximately 75 feet thick in the Aurora area (Buschbach 1964). The Franconia Formation is the basal unit in the Knox Dolomite Megagroup, which also includes the overlying Ordovician age Prairie du Chien Group (Buschbach 1964).

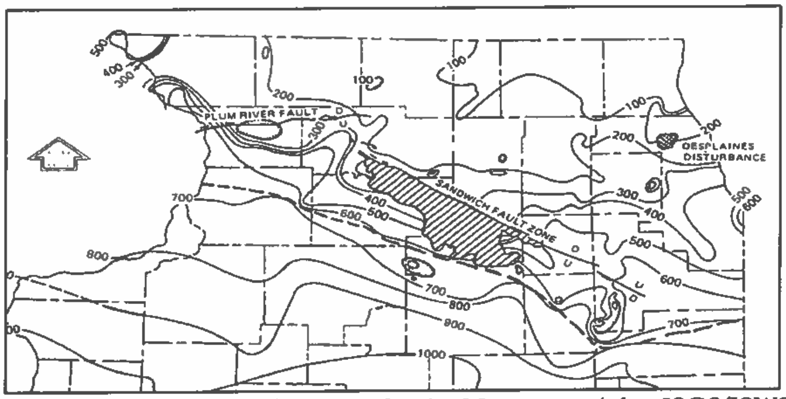


Figure 5.6 – Thickness of Knox Dolomite Megagroup (after ISGS/ISWS, 1985)

Ironton-Galesville Formations

The Ironton and Galesville Formations are generally not differentiated in boring logs and are referred to as the Ironton-Galesville Sandstone. Both formations are sandstones and comprise a major aquifer and primary USDW in the region. Most of the City of Aurora municipal wells draw water from these formations. The Ironton Formation is a coarse-grained, poorly sorted white dolomitic sandstone and the Galesville Formation is a white, clean, locally silty, well sorted, friable sandstone and is generally not dolomitic. The combined thickness of the Ironton-Galesville is approximately 175 feet in the Aurora Area (Buschbach 1964). As a USDW, the Ironton-Galesville Formations are described in more detail later in this narrative.

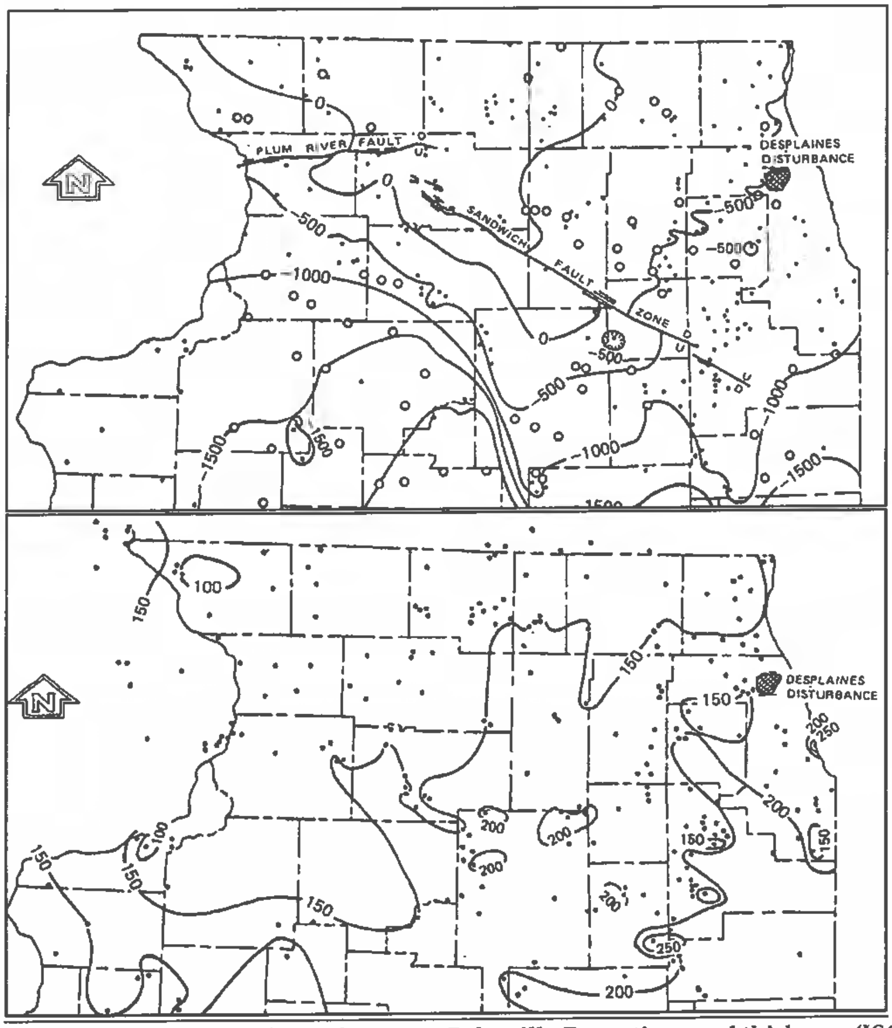


Figure 5.7 – Elevation of top of Ironton-Galesville Formations and thickness (ISGS/ISWS, 1985)

Eau Claire Formation

The Eau Claire Formation acts as a confining unit separating the Ironton-Galesville Formation from the Mt. Simon Formation. It consists of alternating beds of dolomite, dolomitic sandstone, siltstone and shale with a total thickness of approximately 375 feet (Buschbach 1964).

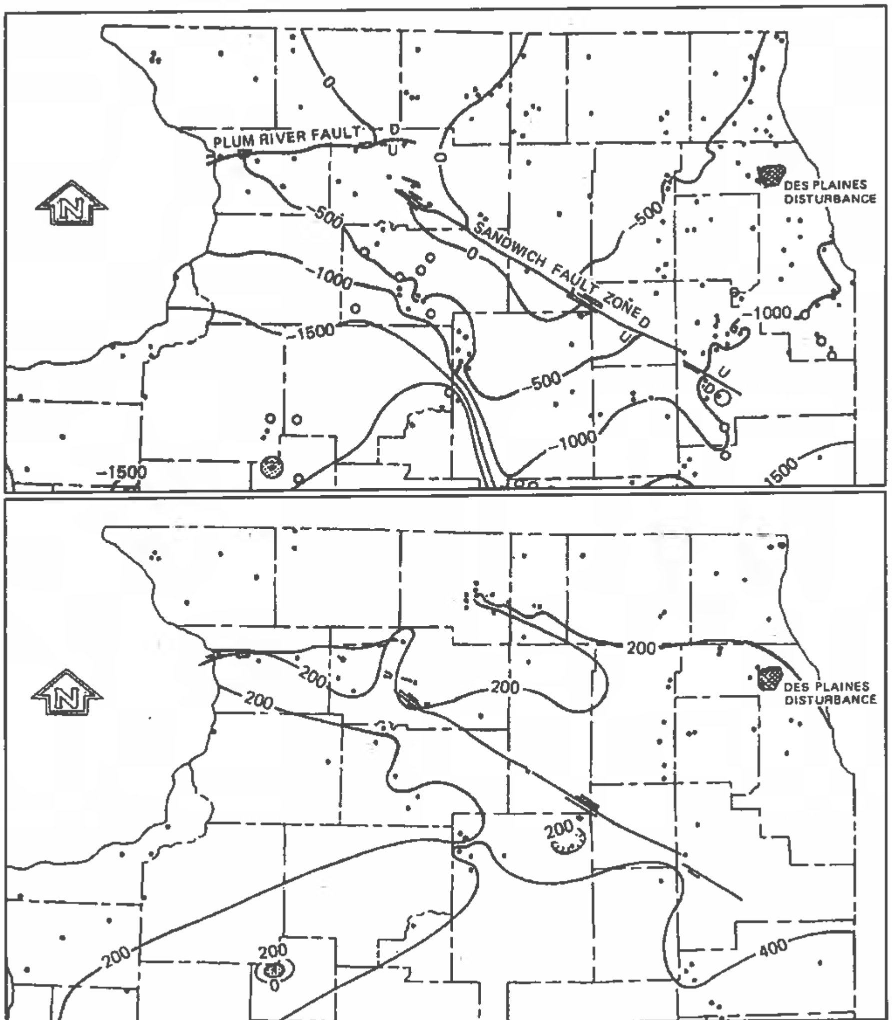


Figure 5.8 – Elevation of top of Eau Claire Formation and thickness (ISGS/ISWS, 1985)

Mt. Simon Formation

The Mt. Simon Formation is over 2,600-feet thick in the region (Buschbach 1964) and is a fine- to coarse-grained, partly pebbly, friable, quartz-rich sandstone. It is a Class I aquifer unit and is a USDW. In the past, a few of the COA municipal wells were screened in this unit, but have since been abandoned.

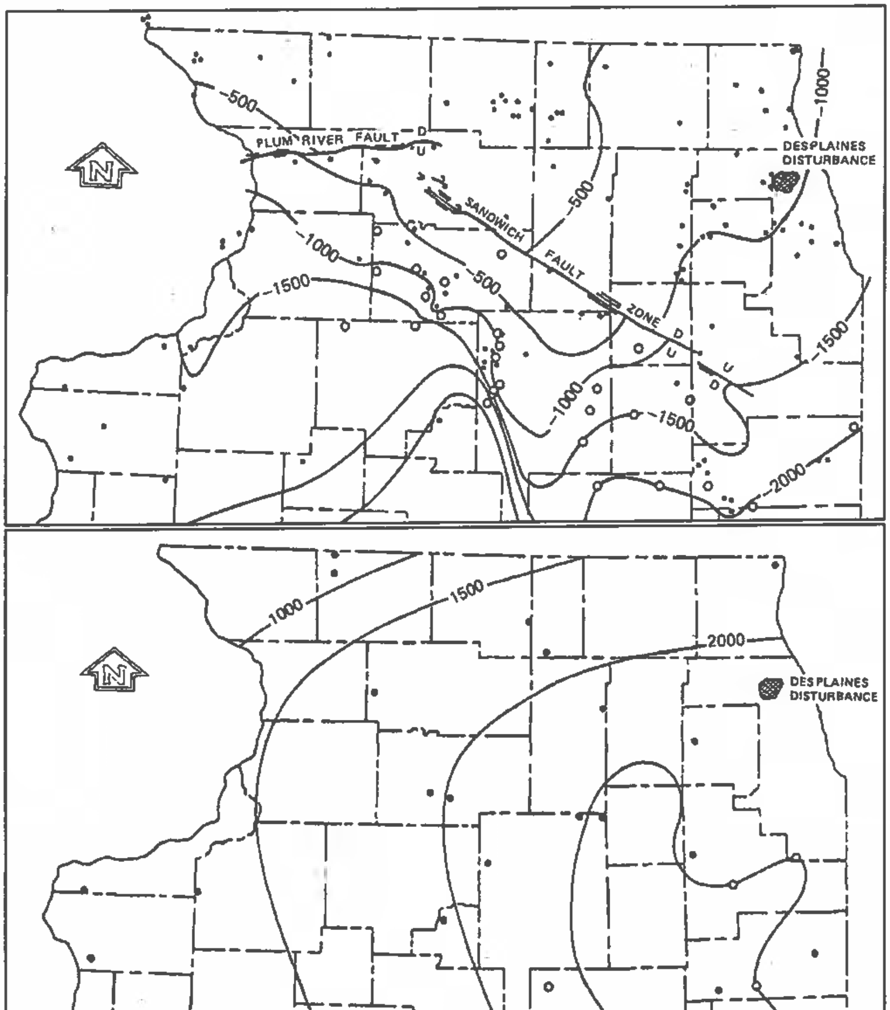


Figure 5.9 – Elevation of the top of Mt. Simon Formation and thickness (ISGS/ISWS, 1985)

Precambrian Basement

The Precambrian Basement rocks are anticipated to occur approximately 3,000 to 3,500 feet bgs in the vicinity of the site. The buried surface of the Precambrian rocks in Illinois is irregular and in the western part of the state, the basal Mt. Simon Formation is thin or absent. The rock is part of the granite-rhyolite terrane extending across the Midwest United States.

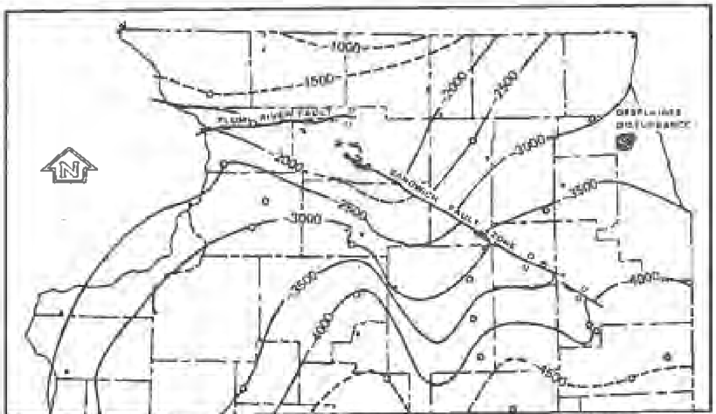


Figure 5.10 - Elevation of top of Precambrian rocks (ISGS/ISWS, 1985)

5.3 *Regional Geologic Logs and Cross Sections*

The ISGS Circular 547 (1991) presented two cross sections (**Figures 5.11 through 5.13**) that are in fairly close proximity to the AOR and are presented below.

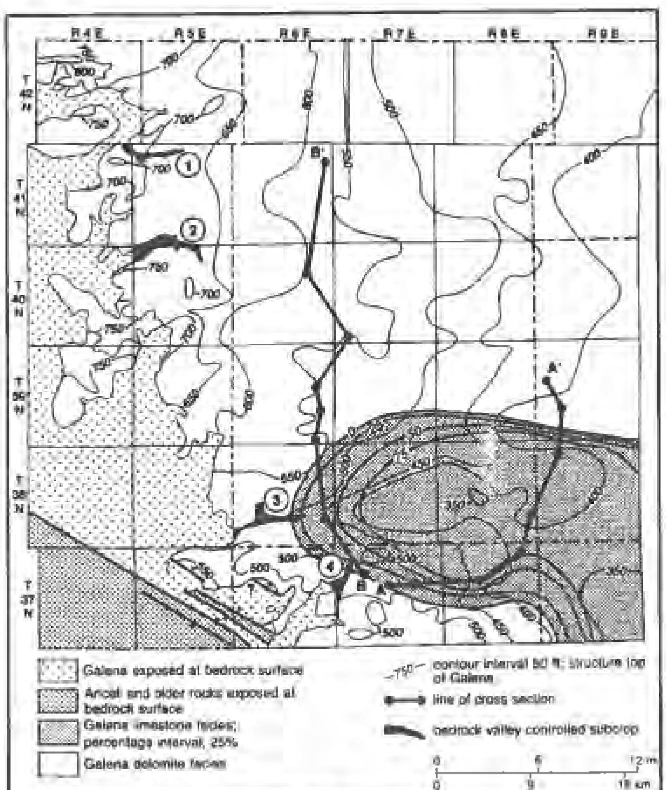


Figure 5.11 - Geologic map and section lines A-A' and B-B'

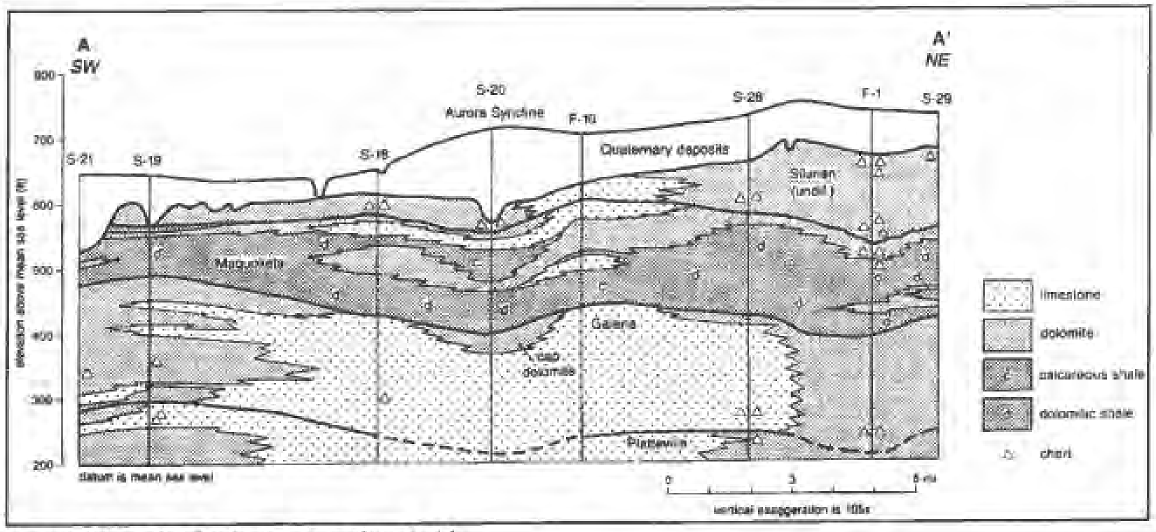


Figure 5.12 - Geologic cross section A-A'

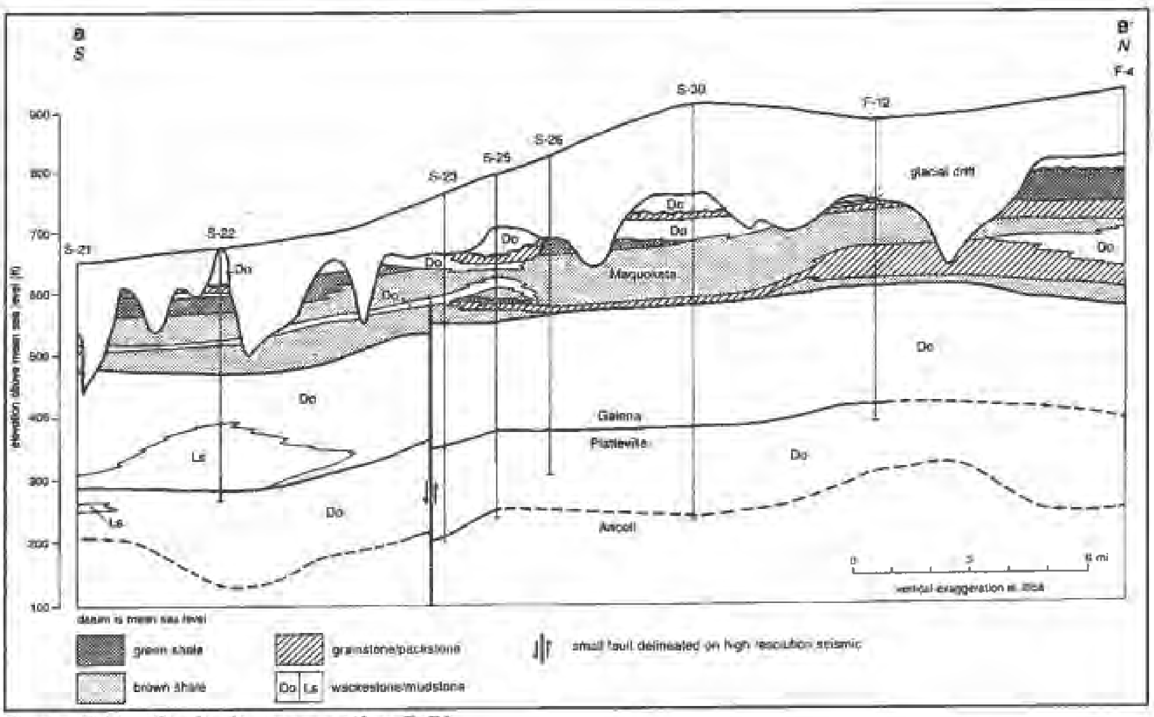


Figure 5.13 - Geologic cross section B-B'

In addition to the evaluation of geologic interpretation presented in the literature, the COA a total of 37 boring logs obtained from the ISGS database were reviewed in detail and are included in **Appendix H** of this permit application. From these boring logs, three geologic cross sections were created, A-A' (north-south), B-B' (east-west) and C-C' (east-west). The cross section map and the cross sections themselves are presented in

Appendix I.

The boring logs indicate that the wells generally terminated in the Eau Claire Formation, with some extending into the Mt. Simon Formation. There is good correlation between the borings, and the borings showing the best correlation being used for the cross sections. All of the cross sections are constructed through the site and the units show good lateral correlation.

It should be noted that the borings/wells were constructed by different entities for differing purposes and there is no guarantee of the accuracy of the interpretations provided by the persons logging the holes. The vertical datum(s) used and the locations of the benchmarks used to well collar elevations are not known.

DEI believes that the elevations provided are fairly accurate as they were checked using GIS from the general vicinity of the boring locations. Due to the ages of the boring logs, the elevations were probably not tied to the North American Vertical Datum of 1988 ("NAVD 88") as the monitoring well constructed at the site by the COA was. Nonetheless, due to the good lateral continuity of the geologic units, the good correlation between the units and the vertical distance evaluated (650 to 1617 feet), any inaccuracy in the surface elevations is negligible and doesn't impact the interpretation of the geology of the area.

Based upon review of the boring logs, the following average thicknesses of geologic units was determined to be:

- Silurian System: 80 feet
- Maquoketa Group: 156 feet
- Galena – Platteville Groups: 333 feet;
- St. Peter Formation: 231 feet;
- Knox Dolomite: 367 feet;
- Ironton – Galesville Formations: 164 feet; and
- Eau Claire Formation: 379 feet.

5.4 *Site Geology*

The COA constructed a monitoring well into the St. Peter Formation for the purpose of evaluating the geology of the site and to assist in evaluating the feasibility of the lime sludge disposal project. The well was constructed from July to October 2008 and is located in the northwestern corner of the site as depicted on **Figures 2.2, 4.1, 4.6, 12.7 and 12.8.**

The following information was collected:

- Detailed geologic logging by a professional geologist of the continuous core retrieved from the borehole;
- Packer testing at 20-foot intervals within the Galena-Platteville Groups;
- Geophysical testing of the borehole that included acoustic televiewer, caliper, natural gamma ray, normal resistivity, spontaneous potential and single point resistance;
- Surveyed well location in the Illinois State Plane Coordinate System and elevation using NAVD 88;
- Ground water elevation data based upon the above; and
- Ground water chemistry data by laboratory analysis.

Raimonde Drilling Corporation, Inc. ("RDC") of Addison, Illinois was contracted by the COA to provide drilling services to core, create and interpret boring logs and to construct the monitoring well. The following roles and subcontractors were employed for the project:

- RDC: Primary Contractor and coring services;
- GZA Environmental, Inc. ("GZA") of Waukesha, Wisconsin, subcontractor for geological logging and packer testing services;
- Hager-Richter Geoscience, Inc. (Hager-Richter) of Fords, New Jersey for geophysical testing services; and
- Albrecht Well Drilling, Inc. ("AWD") of Ohio, Illinois, subcontractor for monitoring well construction.

5.4.1 Coring and Site Geologic Log

A report was prepared by GZA that included a detailed geological description of the core obtained from the borehole, the geophysics report and the packer test results. This report is included in **Appendix B**.

RDC mobilized to the site and drilling, coring and monitoring well construction activities were conducted from July 16, 2008 to October 8, 2008. Daily field summary sheets are included in Appendix B of the GZA report.

Photograph 5.1 – CME-75 Drill rig used for drilling and coring

Initial drilling was conducted on July 16, 2008. RDC used an 8-inch diameter tricone bit to drill to a depth of 19 feet bgs through the unconsolidated glacial soils and fill material. A 6-inch outside diameter ("OD") steel casing was installed into the borehole to this depth to protect the borehole and to prevent sloughing of the unconsolidated overburden material.

Coring of the bedrock was then conducted using a wireline system for retrieval of a continuous core sample throughout the entire length of the borehole (from 19 feet bgs to the end of the borehole). RDC advanced a PQ-size hole (4.8-inch OD coring bit; 3.345-inch core diameter) to a depth of 48 feet bgs. At this depth, the hole size was reduced to HQ (3.8-inch OD coring bit and 2.500-inch core diameter) and the hole was advanced to a depth of 518 feet bgs. At this depth, the hole size was reduced to NQ (3.0-inch hole diameter and 1.875-inch core diameter) and the hole was advanced to full depth at 545.7 feet bgs.

Photographs 5.2 and 5.3 – Wireline coring system

Wireline coring uses a diamond tipped bit attached to and the drill string. The coring barrel is located inside of the drill casing and is connected to a winch on the surface by means of a wireline. In this manner, the coring barrel can be retrieved when full of core from the borehole without removing the drill string and bit from the hole. As the drill bit is advanced and rotated, a continuous core sample is forced into the sampler. Water is pumped through the drill rods to exit at the face of the bit to cool it and then forced up the annulus between the rods and the hole wall to the surface.

The stainless steel core barrels were 10-feet long and of varying diameters as described above. Rods of 10-feet in length are attached to the top end of the drill string to advance the sampler into the ground. The following general information was recorded:

- Borehole/monitoring well ID;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Geologist's name;
- Drill rig type;
- Drilling methods used including core diameter(s);
- Total depth of borehole/core;

- Water level(s) at the time of drilling; and
- Water level at the time of completion of drilling.

Photograph 5.4 – Rock core prior to retrieval from core barrel

The continuous core was placed into a wooden core box and labeled with the following information:

- The number of the core box;
- The project name;
- The date(s) and time(s) of coring;
- Geologist's name; and
- The depth interval contained within each core box.

Photographs 5.5 and 5.6 – Geologists table and Core Box

Care was taken to place the core sample into the wooden core box so that the uppermost (shallow) end of the core was placed into the upper left hand corner of the box and the lowest end of the core sample was at the lower right hand corner of the box (with the lid of the box opening to the left). The core was mechanically broken in order to fit the sample into the box and core blocks were placed into the box to indicate the drilling depths for the ends of each coring segment (equal to the length of the core sampler).

Photographs 5.7 and 5.8 – (Left) Limestone with chert nodule; (Right) upper St. Peter Formation

After each 10-foot segment, the core barrel was retracted from the borehole and the core sample was extruded from the core barrel. GZA inspected and logged the core samples in real time and recorded the following technical information:

- Depth interval (scaled in feet bgs) of the core interval;
- Graphical and written description of the rock type;
- Rock Quality Designation ("RQD");
- Rock type and correlation to the regional geology (System, Group, Formation, Member);
- Lithologic description of the rock encountered to differentiate into proper geologic unit as well as to distinguish between rock types;
- Description of the physical appearance of the rock (color, hardness, competency, weathering, texture, partings, remineralization, etc.);
- Detailed description of the rock structure including foliation, bedding, joints, fractures, voids, etc.
- Rod drops or water loss; and
- Daily water level measurements (once at the beginning of the drilling day and once at the end of the drilling day).

Please refer to the GZA report for a detailed description of the geology, which is summarized in the following table for ease of review:

Table 5.2 – Summary of Site Geology

DEPTH TO TOP OF UNIT (feet)	ELEV. (ft above MSL)	UNIT	SYSTEM	GROUP	ROCK TYPE	THICKNESS (feet)
0	670.24	Glacial Sediment /fill	Quaternary	None	Soil	12
12	658.24	Joliet& Kankakee Fms	Silurian	None	Dolomite	36
48	622.24	Elwood Fm	Silurian	None	Dolomite	5.1
53.1	617.17	Wilhelmi Fm.	Silurian	None	Dolomite	10.4
63.5	606.74	Brainard Fm.	Ordovician	Maquoketa	Shale	97.3
138	532.24	Ft. Atkinson Fm.	Ordovician	Maquoketa	Limestone	1.9

DEPTH TO TOP OF UNIT (feet)	ELEV. (ft above MSL)	UNIT	SYSTEM	GROUP	ROCK TYPE	THICKNESS (feet)
139.9	530.84	Scales Fm.	Ordovician	Maquoketa	Shale	67.2
207	463.24	Wise Lake Fm.	Ordovician	Galena	Limestone	83
290	380.24	Dunleith Fm.	Ordovician	Galena	Limestone trans to Dolomite	103.6
393.6	276.64	Guttenberg Fm.	Ordovician	Galena	Dolomite	0.7
394.3	275.94	Quimby's Mill Fm.	Ordovician	Platteville	Dolomite	9.1
403.4	266.84	Nachusa Fm.	Ordovician	Platteville	Dolomite	41
444.4	225.84	Grand Detour Fm.	Ordovician	Platteville	Dolomite	36.7
481.1	189.14	Mifflin Fm.	Ordovician	Platteville	Dolomite	22
503.1	167.14	Pecatonica Fm.	Ordovician	Platteville	Dolomite	36.5
539.6	130.64	Glenwood Fm.	Ordovician	Ancell	Dolomitic Sandstone	4.3
543.9	126.34	St. Peter Fm.	Ordovician	Ancell	Sandstone	231*
604.5	65.74	End of Boring				

* Average thickness of St. Peter Formation from regional boring logs

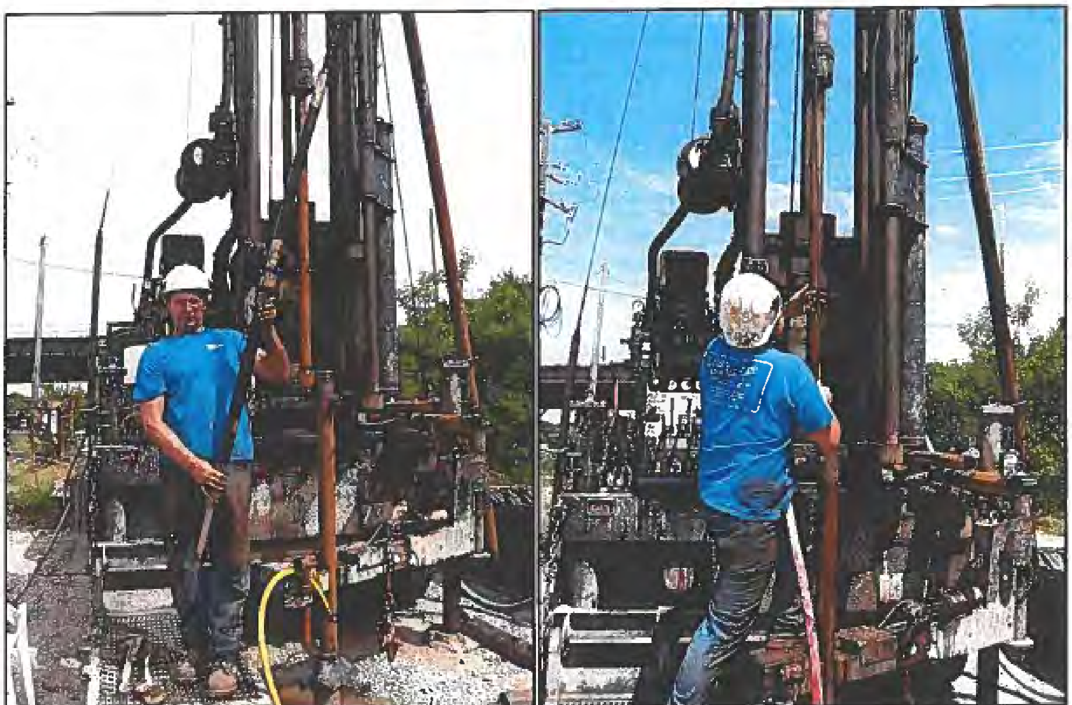
Upon review of the core log by a DEI geologist, and consultation with colleagues, some changes were made to the interpretation of the boring log as follows:

- The Silurian Wilhelmi Formation was added to the log replacing the Ft. Atkinson Formation of the Ordovician Maquoketa Group (53.1 to 63.5 feet bgs); and
- The contact for the Ordovician Brainard Formation moved from 57.7 feet bgs to 63.5 feet bgs and the dolomite previously identified as the upper part of the Brainard Formation was moved into the lower part of the Wilhelmi Formation.

The remainder of the log below 63.5 feet bgs is unchanged from GZA's interpretation.

5.5 *Borehole Water Pressure Testing*

Water pressure tests (packer tests were conducted by GZA in accordance with the COA project specifications in order to evaluate the hydrogeologic properties of the formations within and below which the lime sludge will be stored. The project specifications for the pressure testing were in general accordance with ASTM Standard D4630-96, *"Standard Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test."* This ASTM standard is included in **Appendix J** for reference.



Photographs 5.9 and 5.10 – Inflatable packer assembly and attachment to wireline

Based upon the geologic log of the continuous core samples and the configuration of Levels 1 and 2 of the mine, lime sludge storage will occur within the Dunleith Formation of the Galena Group for Level 2 of the mine and within the Wise Lake Formation of the Galena Group for Level 1 of the mine.

Photographs 5.11 and 5.12 – Pressure gauge and packer assembly attachment to well

Packer tests were conducted at 20-foot intervals, beginning at a depth of 208 feet bgs, and continuing to a depth of 518 feet bgs (the last testing interval was 10 feet long, from 508 feet bgs to 518 feet bgs). A detailed description of the testing process is included on page 3, Section 3.2 of the GZA report. Additionally, a discussion of the packer test results and interpretation of the data is included on page 16, Section 4.3.2 and the packer test data is presented in Appendix D of the same report.

A total of 16 packer tests were conducted in the borehole using a sliding-head, inflatable packer assembly suspended by the wireline for the coring system. Please refer to Figure 3 of the GZA report for a depiction of the packer test assembly. The packer tests were conducted as the core hole was advanced. For each test interval, the rock was first cored using the HQ bit. After coring was completed to the target depth, the core sample was retrieved for logging. Then the HQ casing was raised from the bottom of the borehole to expose the desired interval to be pressure tested. The packer assembly was then lowered into the borehole and it rested on the drill bit at the lower terminus of the casing.

The packer assembly had two inflatable packers. The lower packer and the assembly center tube extended below the HQ casing and the lower packer was inflated to seal off of the top of the exposed rock interval. The upper packer was inflated within the HQ casing, sealing the casing. The top of the HQ casing was fitted with a threaded steel cap and rubber gasket. The cap contained openings for the steel cable that suspends the packer assembly, the air line that inflates and pressurizes the packers and a high-pressure water hose.

To begin a particular test, the HQ casing was filled with pressurized water, which then enters the test zone through the center tube of the packer assembly. The duration of each test ranged from approximately 5 to 20 minutes. Water pressure was applied in increments of approximately 10 pounds per square inch ("psi"). Pressures applied ranged from 20 to 40 psi shallow and from 40 to 60 psi deep. A pressure gauge was attached to the assembly and pressures were continuously recorded during the test. Pressure was increased in 10 psi increments and the test continued until the pressure reading on the gauge stabilized. The data was recorded and an average conductivity value was calculated for each test interval.

The packer tests measure the horizontal flow characteristics of the geologic formations for which lime sludge disposal is proposed. The conductivity values ranges from a high of 5.92 x 10^{-5} cm/sec in the test interval from 208 to 228 feet bgs (Wise Lake Formation) to a low of 9.89 x 10^{-8} cm/sec in the test interval from 248 to 268 feet bgs (also Wise Lake Formation). The weighted geometric mean of the data (allowing for the different thickness of the deepest test) was 4.75 x 10^{-6} cm/s. (The geometric mean is used because hydraulic conductivity data are log-normally distributed and the geometric mean corresponds to the arithmetic mean of the base-10 logarithms of the data.)

The 3 test results from the 308 to 368 feet bgs depth interval (all within the Dunleith Formation) at which the lime sludge disposal is proposed were as follows:

- 308 to 328 feet bgs: 1.26 x 10^{-6} cm/sec;
- 328 to 348 feet bgs: 2.05 x 10^{-6} cm/sec;
- 348 to 368 feet bgs: 4.89 x 10^{-7} cm/sec; and
- Average: 1.08 x 10^{-6} cm/sec.

The 8 test results from the depth intervals between 368 to 518 feet bgs (see composite log for geologic formations) below the level at which the lime sludge disposal is proposed were as follows:

- 368 to 388 feet bgs: 1.02 x 10^{-6} cm/sec;
- 388 to 408 feet bgs: 1.98 x 10^{-5} cm/sec;
- 408 to 428 feet bgs: 1.23 x 10^{-5} cm/sec;
- 428 to 448 feet bgs: 8.57 x 10^{-6} cm/sec;
- 448 to 468 feet bgs: 6.95 x 10^{-6} cm/sec;
- 468 to 488 feet bgs: 6.46 x 10^{-6} cm/sec;
- 488 to 508 feet bgs: 8.90 x 10^{-7} cm/sec;
- 508 to 518 feet bgs: 1.87 x 10^{-5} cm/sec:
- Average: 5.95 x 10^{-6} cm/sec.

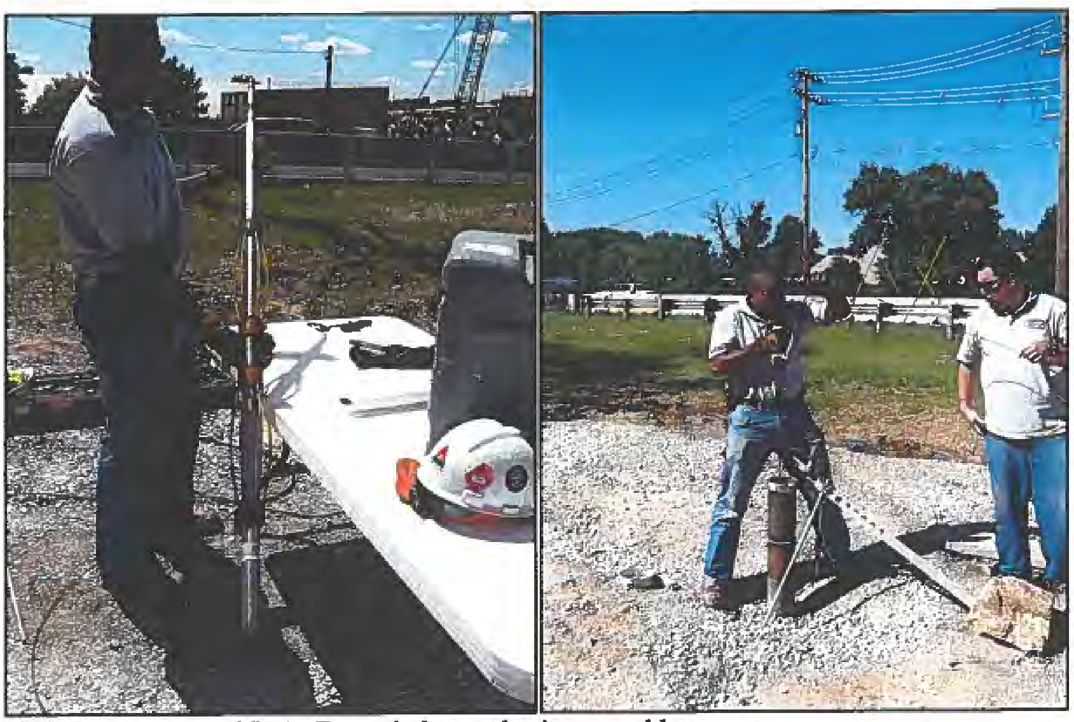
These hydraulic conductivity values are incorporated into the hydrogeologic modeling that was conducted for the site and discussed in **Section 10.0** of this narrative.

5.6 Borehole Geophysics

RDC contracted with Hager-Richter to conduct borehole geophysics under their contract with the COA. Hager-Richter performed the following down-hole geophysical tests to the borehole on July 23, 2008:

- Acoustic Caliper: measures borehole diameter;
- Acoustic televiewer ("ATV") to identify the depth and orientation of structures intersected by the borehole such as fractures, voids, bedding planes, etc.;
- Natural gamma ray ("GR"), spontaneous potential ("SP"), electrical resistivity and single-point resistance ("SPR") to determine lithology, lithologic changes, bedding planes, bedding thickness, and other information such as water quality, occurrence of factures, voids, etc. ; and
- Verticality of the borehole (borehole deviation) via an inclination survey.

Hager-Richter drafted a summary report providing a detailed description of the methodologies employed and interpretation of the results. This report is included in **Appendix C** of this narrative.



Photographs 5.13 and 5.14 – Down-hole geophysics assembly

5.6.1 Data Acquisition and Presentation

The geophysics equipment was contained within probes that were lowered into the borehole via a winch. The data were automatically logged to a PC using a portable digital logger and were displayed in real time in the field. According to the Hager-Richter report, adequate tension was maintained on the logging cable during the borehole geophysical logging and the depth encoder was cleaned after each logging run in order to maintain accurate depth measurements. Repeat sections were acquired to verify depth consistency. In addition, at the beginning and end of the logging run, a fiducial depth (ground surface) was measured and checked for consistency.

The ATV and acoustic caliper used a sampling interval of 0.01 feet whereas the natural gamma ray, normal resistivity, SP and SPR probes used a sampling interval of 0.1 feet. The logging speed was 8 to 11 feet per minute.

5.6.2 Data Output, Data Interpretation and Results

The Hager-Richter report includes two sets of logs. The first set of logs (image logs) consist of lithologic interpretation, ATV amplitude and travel time image logs, structure projection plot, acoustic caliper log, tadpole plot and the ATV virtual core. The virtual core takes the ATV image logs and wraps them around so that the ends meet, creating a virtual core of the borehole.

The second set of logs consist of lithology, natural GR log, SPR log, SP log, normal resistivity logs and the borehole deviation logs.

Fractures can be identified from the ATV images based on interpretation of the images by person logging the borehole. Some bedrock features such as bedding, foliation, veins and other planar features in the rock may appear similar to fractures in the geophysical data. Therefore, the fracture data from geophysical logging must be combined with the physical logging of the core samples to get a truer interpretation of the data.

Fractures are categorized as Ranks 1 through 3 and bedding planes. Rank 1 fractures are minor, Rank 2 are intermediate and Rank 3 are fractures that are distinct and continuous around the borehole with an apparent aperture. The ranks of the fractures and bedding planes and other planar structures are identified on the log, along with the azimuth and dip of the structures (in the form of tadpole plots). Borehole deviation data are reported as northing and easting logs.

All lithologic logs provided in the Hager-Richter report are based upon interpretation of the geophysical data together with the physical log descriptions provided by GZA. The

GZA log was used when the geophysical data was inadequate to define the lithology encountered in the borehole.

A total of 141 fractures were identified in the logged portion of the borehole (between 48 and 517 feet bgs) with the predominant azimuth of west-southwest and dips ranging between 0 and 10 degrees. Of the fractures logged, 79 (56%) occurred from 48 to 85 feet bgs and 62 (44%) from 85 to 517 feet bgs. The fracturing between 48 and 85 feet bgs is considered to be moderate; the fracture density for the remainder of the borehole is considered to be low.

In addition, a total of 67 bedding planes were interpreted to exist in the borehole with a north and west orientation and a dip of less than 5 degrees. The average angle of borehole deviation was less than 0.5 degrees from vertical (less than 3 feet south and less than one foot east over the entire length of the borehole).

6.0 REGIONAL AQUIFERS AND NEAREST USDW

There are four groundwater aquifers in northeast Illinois (Visocky et al. 1985), as follows (in order of increasing depth):

- Prairie Aquigroup (Quaternary Aquifer): includes unconsolidated glacial outwash and buried sand deposits as the aquifer unit with interbedded clayey diamicton units as aquitards;
- Upper Bedrock Aquigroup (Silurian Dolomite Aquifer): includes the Silurian-age dolomite formations as the aquifer unit and the Maquoketa Group as the basal confining unit and in northeastern Illinois is continuous with the Prairie Aquigroup;
- The Midwest Bedrock Aquigroup (Cambro-Ordovician Aquifer): includes the Ancell Group (Glenwood-St. Peter Formation) and the Ironton-Galesville Formations as the aquifer units with the Knox Dolomite Megagroup (Prairie du Chien, Eminence-Potosi and Franconia Formations) as the confining unit between the two aquifer units; and
- The Basal Bedrock Aquigroup (Mt. Simon Aquifer): includes the Mt. Simon Formation and, where differentiated, the basal Elmhurst Member (sandstone) of the Eau Claire Formation as the aquifer unit and the remainder of the Eau Claire Formation as the overlying confining unit between the Mt. Simon and Ironton-Galesville Formations.

The underlying Precambrian basement complex is considered impervious.

A water well search was conducted within the AOR to determine the ground water use characteristics of the area surrounding the site. This information in conjunction with the regional geology and the COA municipal water supply well information gives a good picture of the use of ground water surrounding the site and the relationship of that use to the proposed lime sludge storage outlined in this permit application.

The results of the well survey conducted indicate that 29 water supply wells exist within a ½ mile radius of the site. Based upon the data reviewed, the following table summarizes ground water use and the aquifers immediately below the site, between the ground surface and the Precambrian basement rock:

Table 6.1 – Summary of USDW's and Confining Units

GW/Aquifer Unit	Anticipated Depth (ft.)	Unit Thickness (ft.)	Contact/Confining Unit	Position Relative to Lime Sludge Placement	Comment
Quaternary Sediments	12	12	Silurian Joliet/Kankakee Formation Dolomite	Above	Class II aquifer; generally not used for industrial or potable purposes in the AOR
Silurian Wilhelmi Formation Dolomite	53	10	Ordovician Brainard Formation Shale	Above	Class I aquifer used for industrial and potable purposes
Ordovician St. Peter Formation Sandstone	540	231	Knox Dolomite Megagroup	Below	Class I aquifer used for industrial and potable purposes
Cambrian Ironton-Galesville Formation Sandstone	900	160	Eau Claire Formation Dolomite/Shale	Below	Class I aquifer used for industrial and potable purposes
Cambrian Mt. Simon Formation Sandstone	1280	2000+	Pre-Cambrian Granite Basement Rock	Below	Class I aquifer used for industrial and potable purposes

Each of the ground water units listed in this table are discussed in more detail in the subsections below.

6.1 *Prairie Aquigroup (Quaternary Aquifer)*

In the vicinity of the site, ground water is generally encountered the sandy outwash unit at the contact between the unconsolidated sediments and the Silurian Dolomite bedrock. The upper units of Silurian bedrock beneath the site are the undifferentiated Joliet and Kankakee Formations. Although these bedrock formations are fractured, their hydraulic conductivities are significantly less than those of the sand unit within the sediments and form the confining unit to this shallow ground water unit.

The ground water within the AOR is typically ***Class I*** in accordance with 35 IAC 620, Sections 210 and 220 and is not generally used for industrial or potable purposes. According to the well survey conducted by DEI, there are no water use wells screened in this ground water unit within the AOR for the site.

West of the AOR in the Sugar Grove, Illinois area a paleovalley system exists that contains significant thicknesses of Quaternary sand and gravel. The thickness of this system is up to 200 feet and it acts as a high yield/high specific capacity unit and is used as a source of drinking water in the area. The Village of Sugar Grove utilizes this unit as part of their municipal water system, as well as 4 of the active COA water supply wells.

The yield and specific capacity of this unit within the AOR is minimal (0.1 gpm/foot) and the quality of the water is poor. In the Sugar Grove area the water quality is generally good and the yield can be up to 3,000 GPM with specific capacity of up to 5,000 GPM/foot.

No production wells screened in this unit exist within the AOR. This ground water unit is stratigraphically above the proposed lime sludge storage elevation, and due to the low injection pressure, is not considered to be potentially impacted by the system.

6.2 *Upper Bedrock Aquigroup (Silurian Dolomite Aquifer)*

The Silurian-age dolomite formations (beneath the site primarily the Wilhelmi Formation) contain fractures and other secondary porosity features that allow the units to hold water. The Brainard Formation shale, the uppermost unit of the Ordovician Maquoketa Group, acts as the basal confining unit for this ground water unit. The ground water is generally Class I and is used for both potable and industrial purposes.

Across northern Illinois the yields from this unit are variable; in the area of the site, it can yield up to 1000 gpm. The quality of the water is generally good, but the total dissolved solids ("TDS"; usually between 350 and 1,000 mg/L) and hardness (usually between 200 and 400 mg/L) tend to be high. (Given that this is a carbonate aquifer, elevated hardness is expected; moreover, the hardness in the Silurian aquifer is one reason that the suburbs east of Aurora abandoned the use of water wells and switched to Lake Michigan water in the late 1980's.)

A total of 25 water wells are screened in this unit as identified in **Table 6.2** below (boring logs are supplied in **Appendix G**). This ground water unit is stratigraphically above the proposed lime sludge storage elevation and separated from it by the Maquoketa Group confining unit. For these reasons and because the injection pressure for the sludge will not be sufficient to reverse the downward hydraulic gradient through the confining unit, the Upper bedrock Aquigroup is unlikely to be impacted by the proposed sludge injection.

Illinois EPA FOIA Exemption Reference Sheet

SID: 33134

Agency ID: 170000614271 Media File Type: LAND
Bureau ID: 0894075971
Site Name: Aurora, City Of
Site Address1: Rte 25
Site Address2:
Site City: Aurora State: IL Zip: 60507-

This record has been determined to be partially or wholly exempt from public disclosure

Exemption Type:

Redaction

Exempt Doc #: 3 **Document Date:** 2 /26/2013 **Staff:** MED

Document Description: TABLE 6.2 AOR WELLS PP.6-4 AND 6-5

Category ID: 23A **Category Description:** UIC/ADMIN REC - UNDERGROUND INJECTION CONTROL **Exempt Type:** Redaction

Permit ID: UIC-147 **Date of Determination:** 5 /21/2015

Table 6.2 – AOR Wells Screened in the Upper Bedrock and Prairie Aquigroups

MAP REF. #	OWNER	Distance From Site (feet)	Direction From Site	Depth (feet)	LIKELY UNIT	TYPE
L43	Thorton Oil Co.	2240'	West	28	Prairie Aquigroup	Monitoring Well
51	[redacted]	2454'	West	80	Silurian	Private
21	[redacted]	1185'	West	83	Silurian	Private
C8/G27	[redacted]	1255'	Northeast	92	Silurian	Private
L40	[redacted]	2030'	West	100	Silurian	Private
E17/E23	Chicago Title and Trust	1006'	Southeast	111	Silurian	Industrial
36	Jim Popp Builders	1883'	East	115	Silurian	Commercial
H28/ N64	Weldstar Company/Chapple Co.	2662'	East	120	Silurian	Commercial
C7/G26	[redacted]	1255'	Northeast	133	Silurian	Private
I30/M41	[redacted]	2088'	East	135	Silurian	Private
M48/O58	[redacted]	2688'	East	135	Silurian	Private
M48/O65	[redacted]	2746'	East	135	Silurian	Private
M50/O57	[redacted]	2654'	East	140	Silurian	Private
I37	[redacted]	1107'	East	140	Silurian	Private
M47/O53	[redacted]	2580'	East	145	Silurian	Private
M46/M49	[redacted]	2820'	East	145	Silurian	Private
N52/54	[redacted]	2540'	East	152	Silurian	Private
81/S83	[redacted]y	2826'	Southeast	160	Silurian	Private
M44/M45	[redacted]	2240'	East	165	Silurian	Private
D9/D10	[redacted]	1248'	East	190	Silurian	Private
H29/H34	[redacted]	1904'	East	190	Silurian	Private
F24/I31	[redacted]	1476'	East	200	Silurian	Private
B5/B6	Ill. Toll Highway Comm. EP-1	564'	East	215	Silurian	Private
I38	[redacted]	2630'	East	300	Silurian and Galena-Platteville	Private
E11/E18	[redacted]	854'	Southeast	341	Silurian and Galena-Platteville	Private

6.3 *Midwest Bedrock Aquigroup (Cambro-Ordovician Aquifer)*

The St. Peter and Ironton-Galesville Formations of the Midwest Bedrock Aquigroup or Cambro-Ordovician Aquifer are the principal aquifers used for private and public drinking water supplies within the AOR. Most of the COA municipal wells are screened in these units. The yield and specific capacity of these units is moderate to high and the quality of the water is good. **Table 6.3** below lists the wells within the AOR that are screened in these units (boring logs provided in **Appendix G**).

Table 6.3 – Wells Screened in the Midwest Bedrock Aquigroup

MAP REF. #	OWNER	Distance From Site (feet)	Direction From Site	Depth (feet)	LIKELY UNIT	TYPE
55	[redacted]	2154'	Northwest	610	St. Peter	Private
35/ E13/E14	[redacted]	1705'	Southwest	772	St. Peter	Private
F20	[redacted]	[redacted]	[redacted]	[redacted]	St. Peter and Ironton-Galesville	[redacted]

6.3.1 Regional Ground Water Use

The Midwest Bedrock Aquigroup is the primary hydrostratigraphic unit used in northeast Illinois for public and private drinking water supplies. The Midwest Bedrock Aquigroup has been widely used by municipalities starting in the 1870's and reached a peak withdrawal rate of just over 180 MGD in 1979 (Wehrmann and Knapp 2006). Over the next 13 to 14 years withdrawals from this hydrostratigraphic unit declined to just below 65 MGD, the sustainable yield estimated by studies in the 1950s and 1960s (Burch 2002), in about 1992 as more and more communities began using Lake Michigan water as the principal source for drinking water. However, more recently, water levels in the Joliet and Aurora areas are again declining (Burch 2008). The project site is at the northern edge of the Aurora area and based on measurements in a monitoring well at the site, the piezometric surface is approximately static.

The potentiometric surface of the Midwest Bedrock Aquigroup in northeastern Illinois rose into the 1980s and 1990s due to decreased pumping of the aquifer units as Lake Michigan water increased in use (Burch 2002). In the years between 2000 and 2007, the potentiometric surface began a slow decline as communities increased pumping from the aquigroup (Burch 2008). A pronounced decrease in water levels in the potentiometric surface has occurred in the area of the Aurora CWS, indicating increased pumping from the aquigroup.

6.3.2 Ironton-Galesville Formations

The Ironton and Galesville Formation are undifferentiated in the vicinity of the site and are often referred to collectively in published literature. The formations range from 150 to 200 feet thick (the average thickness from the boring logs reviewed as part of this project is about 163 feet) and consist of fine- to coarse-grained sandstone with varying dolomite content that increases to the south (Visocky et al. 1985).

The Ironton-Galesville Formations represent the most uniform and productive ground water unit in the region, representing over 50% of the yield of the Midwest Bedrock Aquigroup. Yields range from 500 to 1000 gpm of good to high quality water with transmissivity between 10,000 to 20,000 gallons per day ("GPD") per foot. The elevation of the potentiometric surface of the units ranges between 100 and 200 feet above MSL (its elevation at the site since 2008 has ranged from 177 to 197 feet above MSL as measured in the on-site monitoring well). Walton and Csallany (1962) found specific capacities in the Ironton-Galesville in the wells studied in the Aurora area to be approximately 3 GPM/foot.

6.3.3 Nearest USDW – St. Peter Formation (Ancell Group)

The Ancell Group, which consists primarily of the St. Peter Formation within the AOR, averages 225 feet thick in the vicinity of the site and unconformably underlies the Platteville Group and unconformably overlies the Knox Dolomite Megagroup. The Glenwood Formation, as determined by the on-site core, is a very thin, dolomitic sandstone and is hydraulically connected to the St. Peter Formation.

According to Visocky et al. (1985), the St. Peter Formation is a white, fine- to coarse-grained, pure quartz sand that is friable. It produces moderate amounts of water and accounts for approximately 15% of the yield of the Midwest Bedrock Aquigroup.

Walton and Csallany (1962) studied pump test data from more the 200 wells in northern Illinois screened into the Ancell Group and found that in areas where the Maquoketa Group shales are present (the Brainard and Scales Formations) and the Ancell is 200 feet or greater in thickness, the yields range from 1.2 to 1.5 GPM/foot (1,728 to 2,160 GPD/foot). The literature reviewed indicated that average pumping rates of the Ancell Group range between 100 to 500 GPM and that the pumping rate doesn't increase dramatically with increased thickness of the formation.

6.4 *Mt. Simon Sandstone (Basal Bedrock Aquigroup)*

The Cambrian Mt. Simon Formation is a massive, fine- to coarse-grained sandstone with locally occurring lenticular shale beds. The shale beds are not laterally continuous

Illinois EPA FOIA Exemption Reference Sheet

SID: 33134

Agency ID: 170000614271 | Media File Type: LAND
Bureau ID: 0894075971
Site Name: Aurora, City Of
Site Address1: Rte 25
Site Address2:
Site City: Aurora | State: IL | Zip: 60507-

This record has been determined to be partially or wholly exempt from public disclosure

Exemption Type:

Redaction

Exempt Doc #: 4 | **Document Date:** 2 /28/2013 | **Staff:** MED

Document Description: TABLE 6.4 AURORA CWS MUNICIPAL WELL DATA PP.6-7 AND 6-8

Category ID: 23A | **Category Description:** UIC/ADMIN REC - UNDERGROUND INJECTION CONTROL | **Exempt Type:** Redaction

Permit ID: UIC-147 | **Date of Determination:** 5 /21/2015

WELL #	YEAR CONSTRUCTED	DEPTH	WELL CAPACITY (GPM; 2005)	MAXIMUM CAPACITY (GPM)	GEOLOGIC UNITS
15	1958	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
17	1958	[redacted]	[redacted]	[redacted]	Ironton-Galesville
19	1962	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
20	1967	[redacted]	[redacted]	[redacted]	Ironton-Galesville
21	1972	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
23	1973	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
24	2002	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
25	1974	[redacted]	[redacted]	[redacted]	Ironton-Galesville
26	2004	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
27	2005	[redacted]	[redacted]	[redacted]	St. Peter, Ironton-Galesville
28	2008	[redacted]	NA	[redacted]	St. Peter, Ironton-Galesville
29	2010	[redacted]	NA	[redacted]	St. Peter, Ironton-Galesville

In addition to the data supplied by the COA Water Production Division, historical production rates from pump tests conducted on COA wells was reviewed by Walton and Csallany (1962). Pump tests on 10 wells having pumping rates ranging from 400 to 1400 gpm were documented that had observed specific capacity ranging from 2.5 to 11.1 GPM/foot.

Two (Well #15 and Well #17) of the wells evaluated by Walton and Csallany (1962) are still active. The report gives the test pumping rates in wells 15 and 17 as 1115 gpm and 1016 GPM, respectively resulting in an observed specific capacity of 7.6 GPM/foot for each well. These data are consistent with the more recent data in the table above.

Copies of the Illinois EPA's Source Water Assessment Program ("SWAP") Fact Sheet for 2003 and 2012 are provided in **Appendix L**.

6.6 Regional Potentiometric Surface

Burch (2008) compared the ground water elevations in 330 deep wells (800 to 1700 feet deep) over a seven year period. The results of this study indicate that water levels in the deep sandstone aquifers in northeastern Illinois have dropped 25 to 50 feet over the study period.

and generally don't affect the hydraulic properties of the formation. The lower portion of the formation is well-cemented and therefore has a relatively low hydraulic conductivity (Visocky, et al, 1985). The upper portion of the formation (the upper 300 to 600 feet) is more friable, less cemented and produces most of the water from the formation. It is similar in hydrogeologic properties to the St. Peter Formation.

Due to the depth of the formation and the fact that the stratigraphically higher Midwest Bedrock Aquigroup produces high quality water, there are fewer data available regarding the Mt. Simon Formation. Low to moderate yield and salinity issues limit the use of this aquifer for water supply purposes.

The specific capacity and yield of the aquifer are similar to those of the Ancell Group. Due to the lack of wells screened solely within the aquifer, Walton and Csallany (1962) subtracted the theoretical yield of wells that were open only to the Midwest bedrock Aquigroup from yields in wells open to both the Midwest Bedrock Aquigroup and the Basal Bedrock Aquigroup. The difference was considered to represent the yield of wells open only to the Basal bedrock Aquigroup (Mt. Simon). Despite considerable scatter, the specific capacity was found to be directly proportional to the thickness of the aquifer.

6.5 *City of Aurora Municipal Water System*

The COA wells produce water from the Quaternary System, the Ancell Group (Glenwood-St. Peter) and the Ironton-Galesville Formation. **Table 6.4** below lists the active COA wells that are screened in these units. Eighteen active wells in the Aurora CWS produce up to approximately 18 MGD. One active well (Well #17) is constructed into the Mt. Simon Formation, but doesn't draw water from this unit.

Since there are no shallow Quaternary System wells within the AOR, the discussion in this subsection will focus on the wells that are open to the Midwest Bedrock Aquigroup (the St. Peter and the Ironton-Galesville formations).

Table 6.4 – Aurora CWS Municipal Well Data

WELL #	YEAR CONSTRUCTED	DEPTH	WELL CAPACITY (GPM; 2005)	MAXIMUM CAPACITY (GPM)	GEOLOGIC UNITS
101	1970	[redacted]	[redacted]	[redacted]	Quaternary
103	1989	[redacted]	[redacted]	[redacted]	Quaternary
115	1989	[redacted]	NA	NA	Quaternary
119	1989	[redacted]	[redacted]	[redacted]	Quaternary
127	2005	[redacted]	[redacted]	[redacted]	Quaternary
129	2011	[redacted]	NA	[redacted]	Quaternary

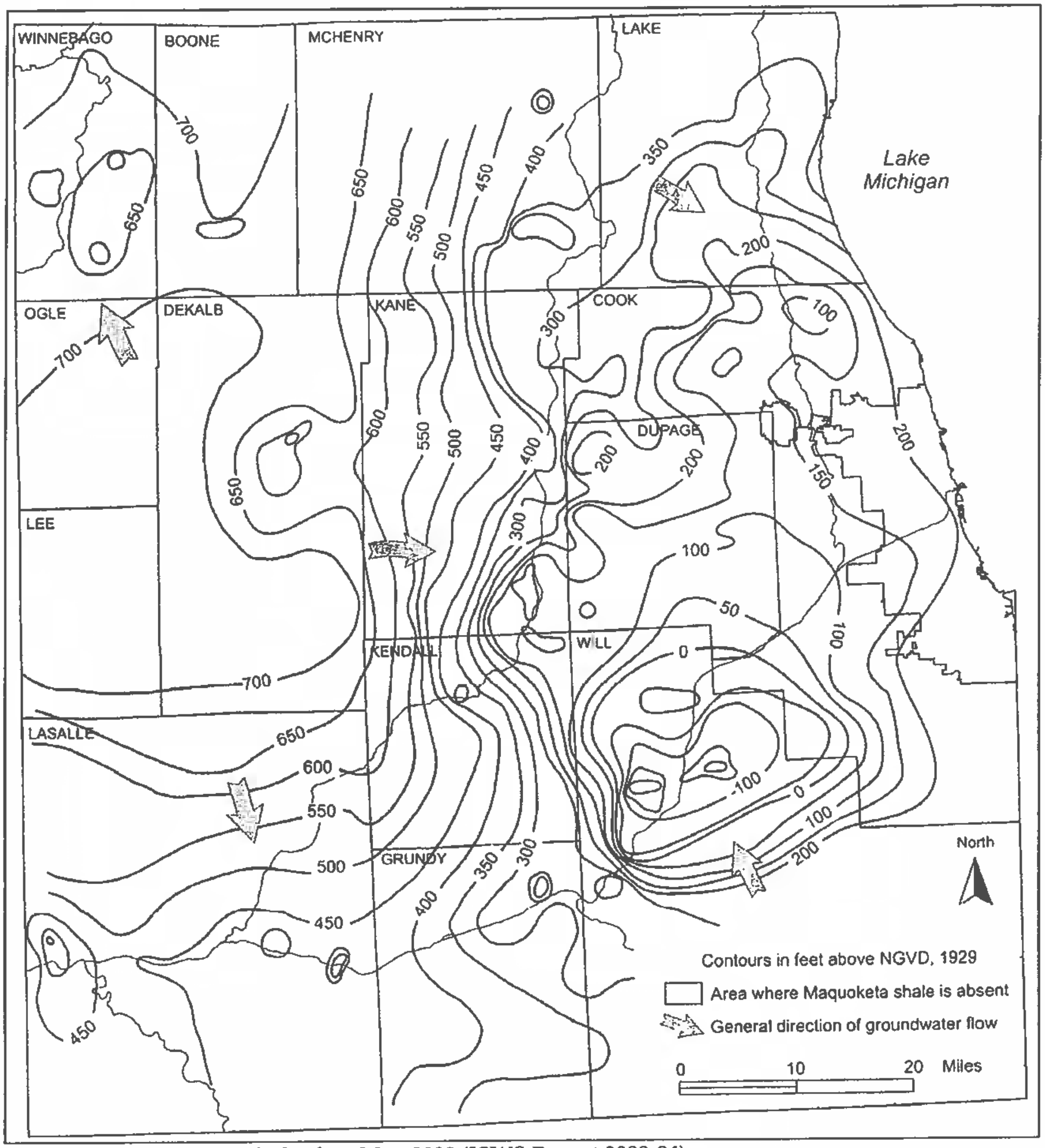


Figure 6.1 – Potentiometric Surface Map 2000 (ISWS Report 2008-04)

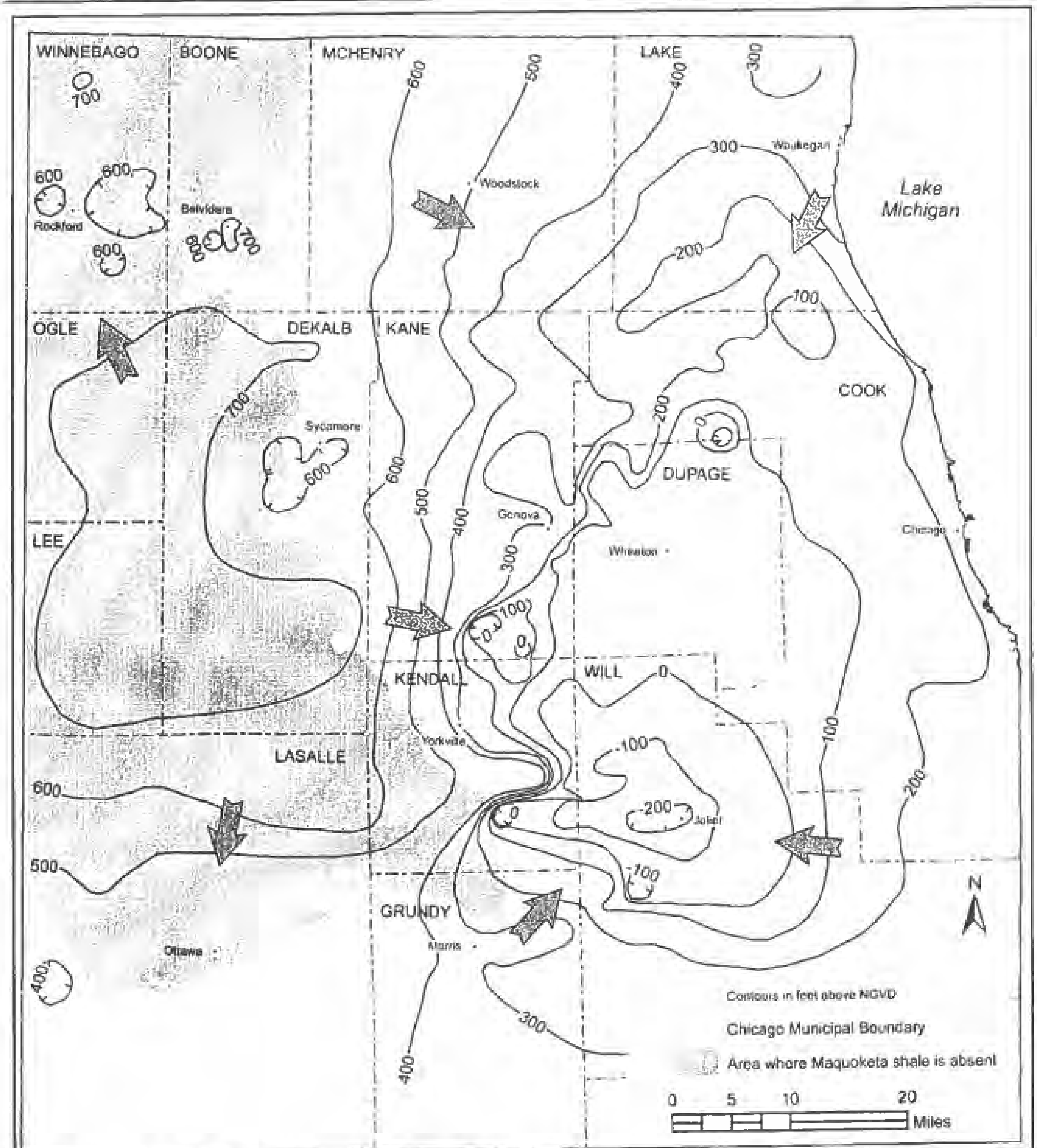


Figure 6.2 – Potentiometric Surface Map 2007 (ISWS Report 2008-04)

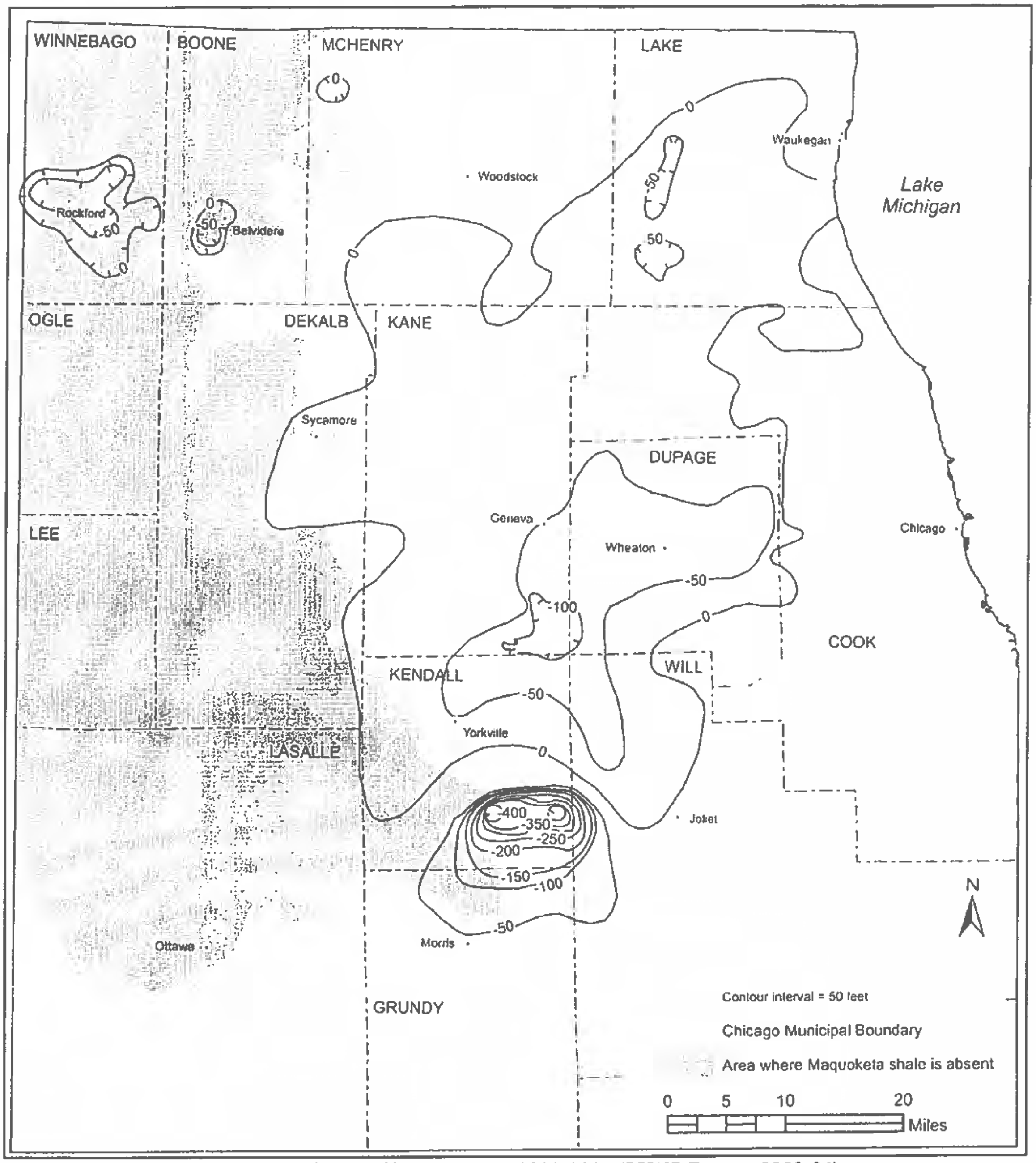


Figure 6.3 – Potentiometric Surface Difference Map 2000-2007 (ISWS Report 2008-04)

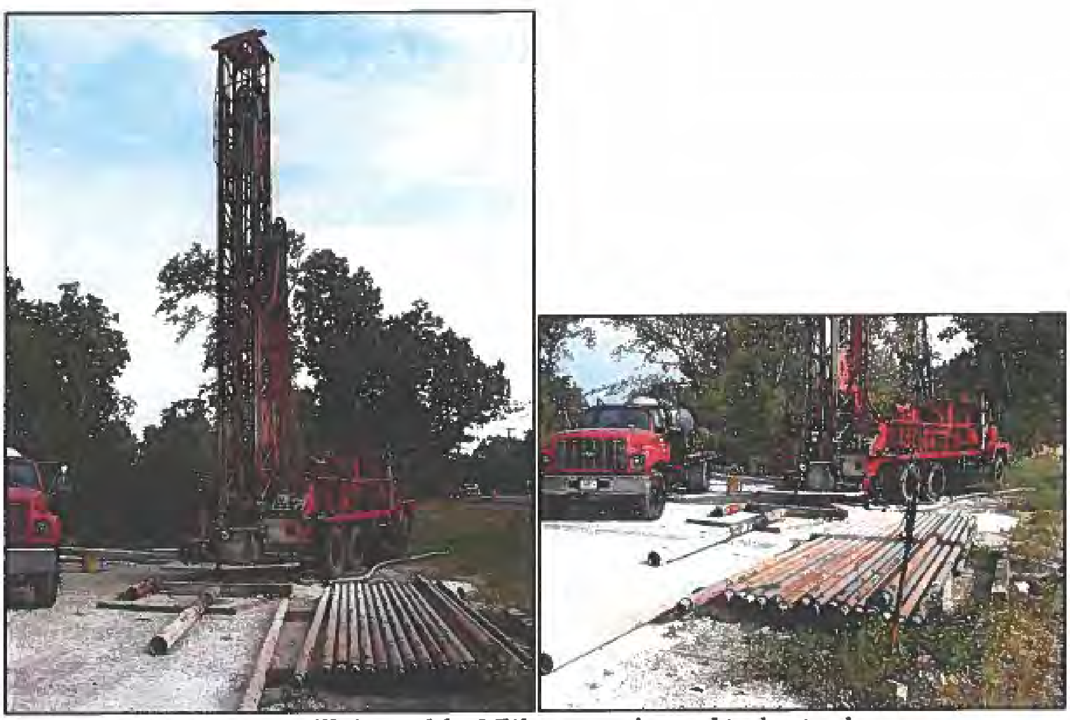
7.0 MONITORING WELL CONSTRUCTION

As part of the feasibility evaluation of the project, a permanent monitoring well was installed in the northwest corner of the site as depicted on **Figures 2.2, 4.1, 4.6, 12.7 and 12.8.** The purpose of the monitoring well is to determine the ground water quality and characteristics of the St. Peter Formation, the nearest USDW.

After the continuous core was retrieved from the borehole and the geophysical logging was completed, the monitoring well was constructed from August to October 2008. RDC contracted with AWD for the drilling and monitoring well construction. This process included the following:

- Over-drilling the borehole to a diameter of 10-inches and to a depth of 606 feet bgs, or approximately 62 feet into the St. Peter Formation;
- Installation of a 4-inch ID PVC well in the borehole;
- Sealing the annulus between the borehole and the PVC well casing; and
- Development of the monitoring well upon completion of construction.

A detailed summary of the monitoring well construction activities is included in Section 3.4, page 4 of the GZA report.



Photographs 7.1 and 7.2- Drill rig used for MW construction and tanker truck

The first step in constructing the monitoring well was to over-drill (ream) the borehole in order to construct the well. The drill rig was centered over the borehole and it was over-drilled to a diameter of 10-inches. Water levels were measured prior to over-drilling the core hole using a Solinst Model 101 water level indicator with a 650-foot tape. During over-drilling activities, the water level in the hole was measured daily through completion of the monitoring well construction activities. The water level indicator makes an audible sound when the probe comes in contact with water. The water level is measured by slightly moving the probe up and down until the sound becomes constant. The tape is held steady against the point of measurement and the depth to the tip of the probe is measured off of the measuring tape.

7.1 Specifications and Pipe Installation

Upon completion of over-drilling the borehole to a diameter of 10 inches, the monitoring casing and screen were installed to depth on September 29, 2008. The casing consisted of 4-inch ID, schedule 80 PVC pipe. The pipe was installed in 10-foot sections and all sections were threaded together with nitrile o-rings (no solvents or glue were used to connect the sections of pipe together). Stainless steel couplers were placed over the joint where the sections of pipe connected to add strength to the joint. The screen is 20-feet long with 0.010-inch machined slots. The bottom section of well screen included a factory supplied threaded end cap at the bottom.

As the sections of pipe were connected to the well screen and to each other, the well assembly was lowered into the borehole. In order to keep the casing centered in the borehole, stainless steel centralizers were attached to the screen and casing (from the bottom up) at the following depth intervals (in feet bgs): 604, 594, 584, 554, 534 and 504. Centralizers were added in 30-foot increments from 504 feet to 24 feet. Centralizers were attached to the pipe across the couplings between the pipe sections.

7.2 Placement of Annular Materials

In order to seal the monitoring well casing to the borehole and to allow the free flow of formation water through the well screen and into the monitoring well, annular materials were installed on September 30 and October 1, 2008. All annular materials were installed using a 1.25-inch PVC tremie pipe. All sections of the tremie pipe were 20-feet long and were joined by threaded connections with rubber o-rings and steel couplers. The tremie pipe also served as a sounding rod for determining the depth of the materials placed in the well annulus.

Annular materials were fed into the tremie pipe through a hopper and streaming water was used to convey the materials from the hopper, into the tremie pipe and then into the annulus of the well. The water was stored in an on-site tanker truck which was filled from a COA hydrant in close proximity to the site.

All annular materials were placed in lifts so as to avoid bridging. The following materials were placed in the annulus (from bottom to top), with the thickness and depth interval of each layer provided:

- Filter sand (Washed silica, #10/20): 603 to 575.5 feet (27.5 feet thick);
- Fine sand: 575.5 to 574.5 feet (2 feet thick);
- Bentonite Well Seal (Cetco 3/8 inch coated bentonite tablets) : 574.5 to 570 feet (4.5 feet thick);
- Bentonite Grout (Cetco Volclay high solids bentonite powder): 570 to 20 feet (550 feet thick);
- Bentonite Chips: 20 to 7 feet (13 feet thick); and
- Portland cement: 7 feet to surface.

Photographs 7.3 and 7.4– Hopper used for placement of annular materials

Please refer to the monitoring well construction diagram located in Appendix F of the GZA report.

The filter sand was chosen and sized to be compatible with the well screen slot size to allow for the free flow of formation water into the well and to minimize the introduction of formation sediment into the well. The well seal and grout were mixed at the ratios recommended by the manufacturer. Coated bentonite tablets were used for the well seal. The coated tablets were used in order to allow the seal materials to be placed at depth prior to the initiation of hydration and expansion of the clay. Additionally, the time-release characteristics of the coated tablets allow for the uniform hydration of the clay which minimizes the possibility of bridging. The seal was placed into the well on September 30th and October 1, 2008. The well driller didn't initially have enough bentonite tablets on-site, so the seal was completed over two days. The first lift of tablets likely at least partially hydrated over night, and that may account for the difference between the theoretical and actual amount of material used as noted by GZA in their report.

Photographs 7.5 and 7.6- Coated bentonite well seal tablets

Photographs 7.7 and 7.8– Hopper attached to tremie pipe; well casing on left

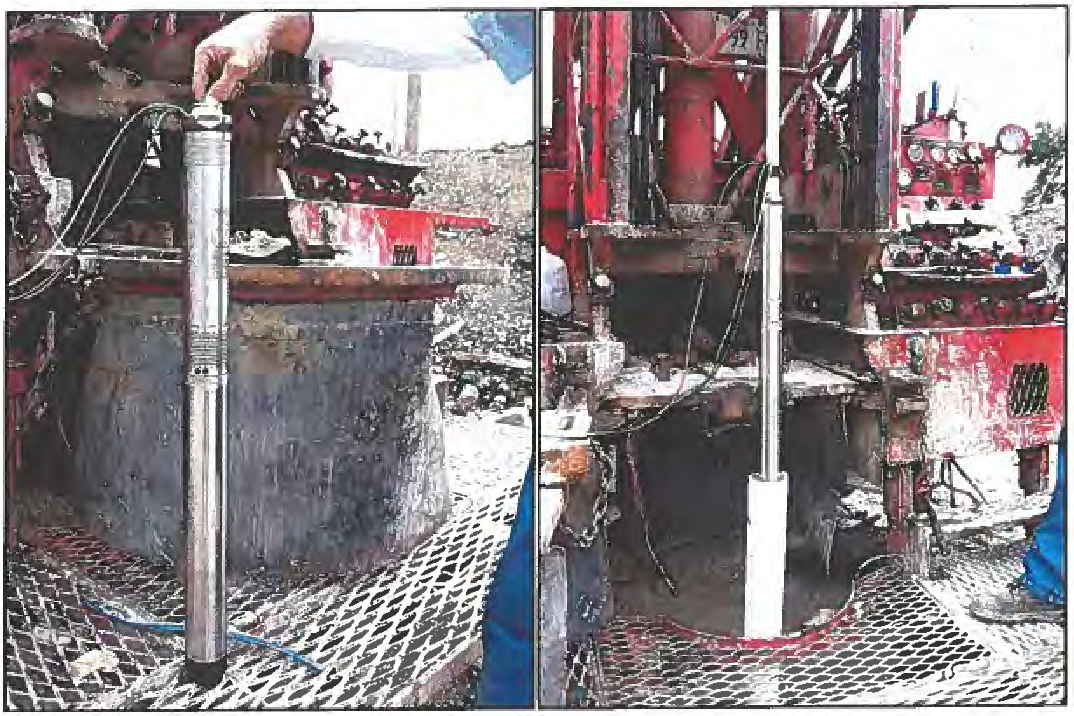
Photographs 7.9 and 7.10– Bentonite grout and mixing tank

After placement of the seal, Albrecht advanced a 3.25-inch diameter plug into the well casing and no constrictions in the pipe were noted. Additionally, the COA contracted with Municipal Well and Pump, Inc. (Waupun, Wisconsin) to advance a down-hole camera into the monitoring well casing to assess the integrity of the pipe. The resulting video determined that the pipe is sound with no evidence of physical defects in the walls of the casing or at the joints between pipe segments.

Once the well seal was allowed to fully hydrate, the high solids bentonite grout was placed in the annulus on October 3 and October 6, 2008. The grout was pumped into the annulus using the tremie pipe. A mixing tank was used and the grout was prepared in 75-gallon batches and a total of 25 batches of grout were placed in the annulus when it appeared at the ground surface. In order to maintain the integrity of the pipe against the force of the hydrating grout, the well was filled with water from the tanker truck.

7.3 *Pump Installation and Well Development*

On October 7, 2008 Albrecht installed a 3-inch diameter Grundfos submersible pump into the well. The pump was attached to a threaded, 1-inch diameter, schedule 80 PVC discharge pipe. The discharge pipe was connected in 20-foot segments using PVC couplers at the pipe joints and the threads were wrapped with Teflon thread tape. The pump was initially set at an approximate depth of 440 feet bgs in order to evacuate the well of the water that was emplaced to maintain pipe integrity during the grout curing process. The pump discharge was diverted away from the wellhead and the pumping rate was initially 5.5 to 6.0 gallons per minute ("GPM") and decreased gradually to a rate of 3.5 GPM. At this point, discharged ceased and the water level in the well was measured at 439 feet bgs. Approximately 15 minutes later the water level was measured at 440 feet bgs.



Photographs 7.11 and 7.12– Grundfos submersible pump

At this point, the pump was lowered to a depth of approximately 480 feet bgs, and the pump was turned on. The discharge rate started at 3 GPM and decreased to 2.5 GPM whereupon discharge ceased. Further pumping was suspended for the remainder of the day. On October 8, 2012, the initial water level was measured at 484.8 feet bgs, and the pump was lowered in the well to a depth of approximately 588 feet bgs, which is within the screened interval of the well. Pumping was initiated and after approximately 16 minutes of pumping at 1.7 GPM the discharge from the well became cloudy, indicating that formation water was being drawn into the well.

Well development was initiated by pumping a minimum total of three well volumes while measuring the depth to water, pumping rate, temperature and turbidity. The pumping rate was 1.7 GPM and the well was pumped for a total of 2 hours and 40 minutes with an estimated 270 gallons of water removed from the well (three well volumes at a water depth of 485 feet bgs is equal to approximately 234 gallons).

Photographs 7.13 and 7.14– Wellhead with pump discharge line

7.4 *Surface Completion*

The grout was placed to the ground surface on October 6, 2008 and gradually settled to a depth of approximately 20 feet bgs by October 8, 2008 as determined through the use of the sounding rod. On the same date, Albrecht placed bentonite chips above the grout to a depth of approximately 7 feet bgs.

Photographs 7.15 and 7.16– Wellhead and GW sampling port (right)

The well head and surface protection structures were completed on October 9 and

October 10, 2008. The well casing was cut to approximately 2 feet above the ground surface and an expandable steel cap was installed at the top of the casing. The cap has a port for the pump's electrical cable. A 10-foot long, 6-inch diameter protective steel casing was installed to a depth of 7 feet bgs, leaving 3-feet above the ground for protection and well access. The steel casing has a lid and is padlocked for security. The steel casing was set in concrete from the ground surface to 7 feet bgs.

The wellhead was completed by construction of a 2-foot square concrete pad which was graded away from the wellhead. Four concrete-filled steel bollards were installed surrounding the pad and rise approximately 4 feet above the ground.

7.5 *Well Surveying*

The monitoring well was surveyed by a Illinois Registered Land Surveyor in the Illinois State Plane Coordinates system. The elevations of the following were also surveyed using the NAVD 88:

- Ground surface elevation: 670.24 (location staked prior to drilling);
- PVC casing rim elevation: 673.05
- PVC ground water sampling port: 673.21 (used for determination of ground water elevation

8.0 GROUND WATER MONITORING RESULTS

In order to establish the background ground water quality of the nearest USDW prior to waste placement in the mine, quarterly sampling of the on-site monitoring well was conducted. Except for the 1st quarter 2010, the monitoring well at the site has been sampled quarterly since the 1st quarter of 2009 through the 4th quarter 2012 for a total of 15 sampling events. The following subsections discuss the sampling procedures, the information gathered, the ground water elevation, the laboratory analysis methods employed and a summary of the results of the laboratory analyses conducted.

8.1 Monitoring Well Sampling Procedures

During ground water sampling events, the static depth to water was measured using an audible electronic water level indicator prior to purging. The measured depth to water from the well was then recorded. The wells were purged using the submersible Grundfos pump. The well was then purged to remove the stagnant water from the well column, to remove any turbidity from the well and to allow for the free flow of formation water into the well for the acquisition of a representative ground water sample. Wells were purged until stabilized readings were recorded for temperature, pH, dissolved oxygen and specific conductivity, but until no fewer than three well volumes of water were removed.

Ground water samples were obtained directly from the pump discharge line directly into discrete, sterile sample containers provided by the laboratory. All sample containers were supplied with the proper preservatives by the laboratory. For organic parameter samples, the sample vial was held at a 45 degree angle and the water was filled to the top of the vial such that a meniscus formed to insure that there was no head space remaining in the vial. The vial was then sealed with the cap, and checked to insure that no air bubbles were present in the sample.

Once the containers were sealed, the sample labels were completed and the samples were placed in a cooler filled with ice for transport to the laboratory at a constant temperature of 4°C. The samples were not filtered in the field or by the laboratory.

Once the samples were placed in the cooler, they were immediately transported (in no instance longer than 24-hours after collection) under strict chain-of-custody procedures to the laboratory for analysis. First Environmental Laboratories, Inc. ("First") of Naperville, Illinois (Accreditation #100292) was used for all laboratory analyses conducted at the site.

All monitoring well materials and reusable ground water sampling equipment were decontaminated prior to use and handled in such a way so as to prevent introducing contamination into the samples. Sampling personnel wore disposable gloves and used sterile/decontaminated sample containers and equipment. Materials were decontaminated by washing with Alconox or similar product and triple rinsed.

8.2 *Field Information Recorded*

The following information was recorded in the field for each sampling event:

- The total depth of the well;
- The depth to ground water (all measurements taken from a location marked on the PVC rim to insure precision between sampling events);
- pH;
- Temperature;
- Specific conductivity; and
- Dissolved oxygen.

8.3 *Ground Water Elevations*

The ground water elevation was determined as follows:

GW Elevation = TOC Elevation – {DTW – (TOC – Ground Elevation)}
Where: GW = Ground Water
TOC = Top of Casing Elevation
DTW = Depth to Water

Ground water elevations are presented on a table in **Appendix M** and are also presented below:

- 4th quarter 2008: 183.23
- 2nd quarter 2009: 199.58
- 3rd quarter 2009: 198.68
- 3rd quarter 2010: 198.56
- 1st quarter 2011: 179.46
- 3rd quarter 2011: 183.36
- 4th quarter 2011: 198.55
- 1st quarter 2012: 188.28
- 2nd quarter 2012: 200.86
- Average: 192.28

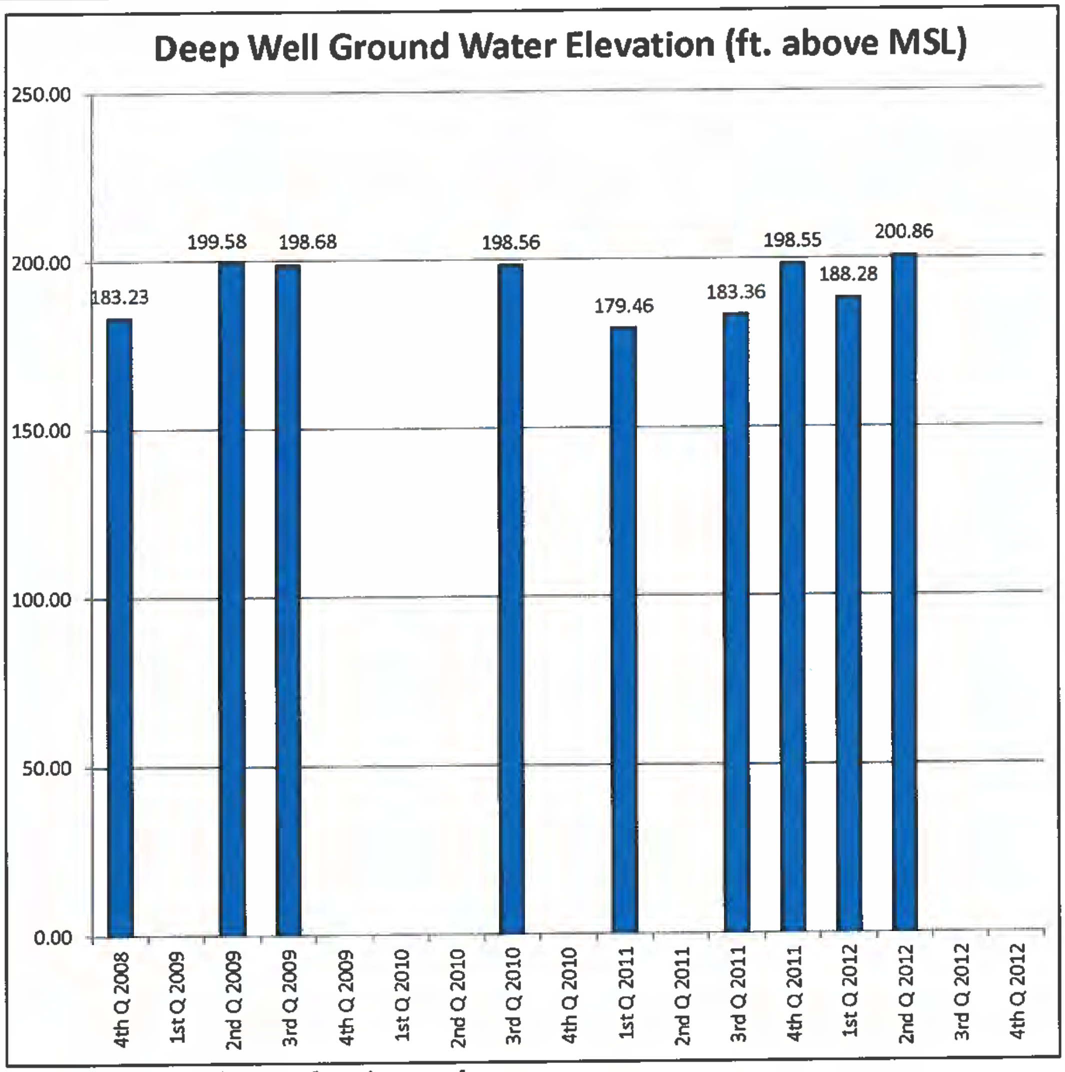


Figure 8.1 – Ground water elevation graph

8.4 *Monitoring Parameters and Analysis Methods*

The following monitoring parameters and laboratory analysis methods were employed on the ground water samples:

- Volatile Organic Compounds ("VOC's"): 5030B/8260B;
- VOC's: Method 8011;
- Semi-volatile Organic Compounds ("SVOC's"): 3510C/8270C;
- Polynuclear Aromatic Hydrocarbons ("PAH's"): 3510C/8270C;
- Semi-volatile Pesticides: 3510C/8270C;
- Pesticides and Polychlorinated Biphenyls ("PCB's"): 3510C/8081A/8082;

- Herbicides: 8321A;
- Metals: 3010A/6010B;
- Mercury: 7470A;
- Gross Alpha and Gross Beta: 900.0;
- Radium 226 and 228: 903.1/Ra-05;
- Cyanide: 335.4R1;
- Phenols: 9066;
- Nitrate, as N: 353.2R2.0;
- Nitrite, as N: 4500NO2, B;
- Sulfate: 375.2R2.0;
- Acidity: 2310B;
- Alkalinity: 2320B;
- BOD, 5 day: 5210B;
- TOX: 9020B;
- Total Dissolved Solids: 2540C;
- Ammonia: 350.1R2.0;
- Total Kjeldahl Nitrogen: 351.2R2.0;
- Phosphorous
- TOC: 5310C;
- Sulfide: 4500s2C, D;
- Conductivity: 2510B;
- pH: 4500H+, B;
- Chloride: 4500Cl, E; and
- Fluoride: 4500F, C

8.5 *Ground Water Analysis Results*

In all of the sampling events conducted, no VOC's, SVOC's, PAH's, Semi-volatile pesticides, pesticides, PCB's and herbicides were detected above the laboratory reporting limit.

Additionally, no parameter exceeded the Class I ground water standards as outlined in 35 IAC 620, except for the following:

- Manganese in the 1st quarter 2009; and
- Nickel in the 1st and 2nd quarter 2009.

These two parameters were below the Class I standards in all sampling events subsequent to the most recent exceedence.

All ground water sampling results and laboratory analysis reports are presented in

Appendix M.

The results of the analysis of the ground water from the on-site monitoring well indicate that the Ancell Group aquifer meets all of the ground water quality standards as outlined 35 IAC 620 for Class I aquifers.

9.0 WASTE CHARACTERIZATION AND COMPATIBILITY

In order to establish the chemical and physical characteristics of the waste stream associated with this permit application, the following information is provided:

- Chemical and physical properties of the lime powder used at the WTP;
- Raw source water and finished water chemistry; and
- Chemical and physical properties of the lime sludge.

The purpose of this evaluation is to determine the compatibility of the lime sludge with the geologic units in the disposal area within the mine and to demonstrate compliance with all regulatory requirements for the disposal of the lime sludge as proposed.

The lime sludge that is generated by the WTP blowdowns develops two types of wastes that will be managed by the proposed disposal system. As described in **Section 3.2** of this narrative, the lime sludge is delivered from the claricones as a slurry that averages 6% solids and 94% water. When the sludge is placed in the disposal area of the mine, it will quickly cover the floor and the solids will settle out of suspension. As the solids settle out of suspension, water is forced to the top of the settled solids (called decant water or supernatant) to a depth of approximately 5 feet. The two types of waste that will be managed will be the lime sludge solids and the lime sludge supernatant. Each of these two types of waste has been tested separately, as described in the subsections below.

9.1 *WTP Lime Powder Characterization*

The lime used at the WTP has the following chemical and physical characteristics:

- Total CaO: 97%
- MgO: 0.75%
- Al_2O_3: 0.11%
- SiO_2: 0.70%
- S: 0.05%
- P_2O_5: 80 parts per million ("ppm")
- MnO: 23 ppm
- Acid insoluble substances: 0.60%
- Specific Gravity: 3.3
- pH: 12.4
- Loose Bulk Density: 40 lbs/cf
- Packed Bulk Density: 60 lbs/cf

The Technical Data Sheet for the WTP lime is provided in **Appendix K**.

9.2 *Raw and Finished Water Chemistry*

The COA regularly tests the raw and finished water quality under their operating permit. The raw well water and raw river water are tested separately and the finished water is tested after treatment. The results of this testing is provided in **Appendix N**. According to the monitoring data supplied by the COA, the raw and finished water doesn't exceed any of the Maximum Contaminant Level Goals ("MCLG's") or MCL's listed in 35 IAC 611, *"Drinking Water Standards"*.

9.3 *Lime Sludge Solids Characterization*

The lime sludge solids are routinely sampled from the dewatering lagoons at the WTP by the COA as part of their operating permit from the Illinois EPA Bureau of Water. Additionally, DEI, on behalf of the COA, obtained and analyzed lime sludge solids samples specifically for waste characterization for this permit application.

9.3.1 COA Routine WTP Operating Permit Sampling

The following parameters are analyzed annually by the COA as part of their permit and lime sludge management procedures:

- Toxicity Characteristic Leaching Procedure ("TCLP") VOC's (Method 1311/5030B/8260B)
  - Benzene
  - 2-Butanone
  - Carbon Tetrachloride
  - Chlorobenzene
  - Chloroform
  - 1,2-dichloroethane
  - 1,1-dichlororethene
  - Tetrachloroethene
  - Trichloroethene
  - Vinyl Chloride
- TCLP SVOC's (Method 1311/3510C/8270C)
  - 1,4-dichlorobenzene
  - 2,1-dinitrotoluene
  - Hexachlorobenzene
  - Hexachlorobutadiene
  - Hexachloroethane
  - 2-methylphenol

- 3&4-methylphenol
- Nitrobenzene
- Pentachlorophenol
- Pyridine
- 2,4,5-trichlorophenol
- 2.4.6-trichlorophenolTCLP Pesticides (Method 1311/3510C/80581A)
- Endrin
- Gamma-BHC
- Heptachlor
- Heptachlor epoxide
- Methoxychlor
- Toxaphene
- Chlordane

- TCLP Herbicides (Method 1311/515.1R4.0)
  - 2,4-D
  - Silvex (2,4,5-TP)

- Total PCB's (Method 3540C/8082)

- TCLP Metals (Method 1311/3010A/6010B)
  - Arsenic
  - Barium
  - Cadmium
  - Chromium
  - Lead
  - Mercury (Method 7470A)
  - Selenium
  - Silver

- Inorganics
  - Alkalinity as $CaCO_3$
  - Ammonia
  - Ash, percent
  - $CaCO_3$ equivalent
  - Chromium, hexavalent
  - COD
  - Cyanide, total and reactive
  - Extractable Organic Halogens
  - Flash point
  - FOC
  - Oil and grease
  - pH

- Paint filter test
- Phenols
- Phosphorus
- Sulfate
- Sulfide, total and reactive
- Sulfur
- Total volatile solids
- Total Kjeldahl Nitrogen

- Total Metals (Method 3050B/6010B)
  - Aluminum
  - Arsenic
  - Barium
  - Cadmium
  - Chromium
  - Cobalt
  - Copper
  - Iron
  - Lead
  - Manganese
  - Mercury (7470A)
  - Molybdenum
  - Nickel
  - Potassium
  - Selenium
  - Silver
  - Sodium
  - Thallium
  - Vanadium
  - Radium 226 and 228

For this permit application, the analysis results for a total of 12 annual sampling events from 1999 to 2012 are provided. Copies of the laboratory analysis reports and the tabulated results are provided in **Appendix O**.

9.3.2 Permit Application Waste Characterization Sampling

In order to more fully characterize the lime sludge solids, DEI collected 4 additional samples for analysis by a more expansive list of parameters. The following is the list of parameters and analysis methods used as part of this sampling:

- VOC's: 5035A/8260B;

- VOC's: Method 8011;
- SVOC's: 3540C/8270C;
- Semi-volatile Pesticides: 3540C/8270C;
- Pesticides and PCB's: 3540C/8081A/8082;
- Carbamate Pesticides: 8318;
- Herbicides: 8321A;
- Metals (antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc): 3050B/6010B;
- Mercury: 7470A;
- Gross Alpha and Gross Beta: 900.0;
- Radium 226 and 228: 901.1M;
- Cyanide: 4500CN,C,E;
- Nitrate, as N: 353.2R1.0;
- Nitrite, as N: 4500NO2, B;
- Sulfate: 9038;
- Acidity: 2310B;
- Alkalinity: 2320B;
- BOD, 5 day: 5210B;
- COD: 5220D;
- EOX: 9023;
- TOX: 9020B;
- Total Volatile Solids: 2540G
- Total Solids: 2540B
- FOC: D2974-00;
- Ammonia: 350.1R2.0;
- Phosphorous: 4500P,B,E
- TOC: 6060M;
- Sulfide: 4500S2C, D;
- pH: 9045C;
- Chloride: 4500Cl, E; and
- Fluoride: 4500F, C

Samples of the lime sludge solids were obtained on October 20, 2008, April 24, 2012, July 3, 2012 and July 19, 2012. Copies of the laboratory analysis sheets and tabulated results are provided in **Appendix O**.

9.4 *Lime Sludge Supernatant Characterization*

Since the lime sludge will separate into solids and supernatant inside of the mine after injection from the WTP and since the supernatant will be extracted from the mine and discharged to the sanitary sewer, sampling to characterize the supernatant was conducted. The following is the list of parameters and analysis methodologies used as part of this sampling:

- VOC's: 5030B/8260B;
- VOC's: Method 8011;
- SVOC's: 3510C/8270C;
- PAH's: 3510C/8270C;
- Semi-volatile Pesticides: 3510C/8270C;
- Pesticides and PCB's: 3510C/8081A/8082;
- Herbicides: 8321A;
- Metals: 3010A/6010B;
- Mercury: 7470A;
- Gross Alpha and Gross Beta: 900.0;
- Radium 226 and 228: 903.1/Ra-05;
- Cyanide: 4500CN,C,E;
- Phenols: 9066;
- Nitrate, as N: 353.2R2.0;
- Nitrite, as N: 4500NO2,B;
- Sulfate: 4500SO4,E;
- Acidity: 2310B;
- Alkalinity: 2320B;
- BOD, 5 day: 5210B;
- COD: 5220D;
- TOX: 9020B;
- Total Dissolved Solids: 2540C;
- Ammonia: 350.1R2.0;
- Total Kjeldahl Nitrogen: 351.2R2.0;
- Phosphorous 4500P,B,E;
- TOC: 5310C;
- Total Suspended Solids: 2540B;
- Sulfide: 4500S2C,D;
- Sulfide, Reactive: 7.3.4.2;
- Conductivity: 2510B;
- pH: 4500H+, B;
- Chloride: 4500Cl,C; and
- Fluoride: 4500F, C

Samples of the lime sludge supernatant were obtained on August 28, 2002, June 13, 2005, July 15, 2005, July 14, 2008, December 15, 2011, April 24, 2012 and July 3, 2012. Copies of the laboratory analysis reports and tabulated results are provided in

Appendix P.

9.5 *Summary of Waste Characterization Analysis Results*

The characterization of the lime sludge includes evaluation of the following:

- The lime powder used as part of the water treatment process;
- The raw well and river water that is treated at the WTP;
- The lime sludge solids that will be injected and permanently stored in the Conco South mine; and
- The lime sludge supernatant that will be extracted from the mine and disposed via a sanitary sewer.

Based upon the characterization of the waste stream, the lime sludge that will be injected is chemically compatible with the rock formations in the mine as evidenced by the analysis results and by the fact that a lime powder slurry will be placed into a limestone mine.

Each of the above is discussed in the subsections below.

9.5.1 Lime Powder Characterization

Based upon the technical data sheet, the lime powder used in the water treatment process will not impart organic, metal or inorganic contamination to the lime sludge waste proposed to be injected and stored in the mine. The pH of the lime powder is 12.4.

9.5.2 Raw Well and River Water Characterization

The raw well and river water that is treated prior to distribution in the Aurora CWS demonstrates no organic, metal or inorganic contamination that will be imparted to the lime sludge solids and supernatant prior to its injection and storing in the mine. The results of the sampling indicate that the raw water doesn't exceed any of the standards as outlined in 35 IAC 620 for Class I ground water for any of the parameters tested. Additionally, the raw water doesn't exceed any of the maximum contamination limits MCL's as outlined in 35 IAC 611, *"Primary Drinking Water Standards"*.

9.5.3 Lime Sludge Solids Characterization

The results of the sampling conducted by the COA indicate that none of the parameters analyzed for TCLP existed above the laboratory reporting limit in any of the 12 annual sampling events conducted. Additionally, the lime sludge is not a listed hazardous waste as per 35 IAC 721, *"Identification and Listing of Hazardous Waste"*, nor does it exhibit characteristics of hazardous waste as per Subpart C, Sections 721.120 through 721.124.

The lime sludge solids have been tested a total of 15 times between June 1999 and July 2012 as outlined in **Section 9.3** above. In that time, the following organic parameters were detected above the laboratory reporting limit:

- Benzene in the April 24, 2012 sample;
- cis-1,2 Dichloroethene in the April 24, 2012 sample;
- MTBE in the April 24, 2012 sample; and
- Phenol in the October 20, 2008, April 24, 2012, July 3, 2012 and July 19, 2012 samples.

There are no sources in the waste stream generation process that have been identified (raw river/well water or the lime powder) that can introduce these chemicals into the lime sludge. The lime sludge is stored outside of the WTP in the dewatering lagoons for several weeks at a time and these chemicals were likely imparted to the sludge from a surface source outside of the WTP or could be representative of cross contamination either in the field sampling or at the laboratory.

All other parameters for VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's were below the laboratory reporting limit in every sampling event.

The lime sludge solids testing yielded the following average concentrations for non-organic parameters (in mg/kg unless otherwise noted):

- Aluminum: 1,064.92
- Antimony: <R.L.
- Arsenic: 1.99
- Barium: 246.28
- Beryllium: <R.L.
- Boron: 262.57
- Cadmium: 0.42
- Calcium: 63,150
- Chromium: 5.68
- Chromium, hexavalent (7196A): 0.89
- Cobalt: 0.59
- Copper: 8.07
- Iron: 3,803.13
- Lead: 1.91
- Magnesium: 11,000

- Manganese: 260.51
- Mercury (7470A): 0.09
- Molybdenum: <R.L.
- Nickel: 4.11
- Potassium: 350.53
- Selenium: <R.L.
- Silver: 2.80
- Sodium: 623.54
- Thallium: <R.L.
- Vanadium: 3.78
- Zinc: 34.77
- Gross Alpha (pCi/g): 18.69
- Gross Beta (pCi/g): 12.44
- Radium 226 (pCi/g): 4.26
- Radium 228 (pCi/g): 3.55
- Total Radium (pCi/g): 7.81
- Cyanide, total: 1.45
- Cyanide, reactive: <R.L.
- Phenols: 7.39
- Sulfate: 512.38
- Sulfide: 9.40
- Sulfide, reactive: 20.0
- Sulfur, %: 0.10
- pH: 9.98
- Nitrate as N: <R.L.
- Total Kjeldahl Nitrogen: 755.08
- Ammonia, as N: 99.91
- Phosphorous, as P: 228.46
- Acidity, total: <R.L.
- Alkalinity, total as CaCO3: 3,438.13
- Ash, %: 75.65
- Calcium Carbonate, %: 68.03
- BOD, 5 day: 1,810
- COD: 2,871.36
- Conductivity, MHOS: 2,224.25
- EOX: <R.L.
- Total Volatile Solids, %: 6.10
- Total Solids, %: 38.01
- FOC, (0.58 conv. factor), %: 2.12
- FOC, organic matter @ 440°C, %: 3.65
- TOC: 25,077.14

- Chloride: 448.33
- Fluoride: <R.L.

The lime sludge solids have also been tested for density, grain size and permeability. Copies of the laboratory analysis reports for these tests are included in **Appendix Q** of this permit application. The results of this testing are as follows:

- Bulk Density:
  - November 1997: 1.64 g/cc
  - May 2009: 1.24 g/cc, 1.16 g/cc and 1.21 g/cc (from three different locations)
  - Average: 1.31 g/cc
- Hydraulic Conductivity (May 2009):
  - 1.10×10^{-5} cm/sec
  - 8.79×10^{-6} cm/sec
- Grain size (D_{50}):
  - 0.0152 mm
  - 0.0131 mm
  - 0.0105 mm
  - Average D_{50}: 0.0129 mm

9.5.4 Lime Sludge Supernatant Characterization

The supernatant that forms on top of the limes sludge will be characteristic of the water that would be available for potential flow from the lime sludge detention area in the mine. Therefore, its chemical characteristics are important to quantify when evaluating the potential environmental impacts of the proposed injection system.

The supernatant has been tested a total of 7 times between August 2002 and July 2012 as outlined in **Section 9.4** above. In that time, the following organic parameters were detected above the laboratory reporting limit:

- Chloroform in the April 24, 2012 sample; and
- 2,4-D in the July 3, 2012 sample.

All other parameters for VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's were below the laboratory reporting limit in every sampling event.

As with the lime sludge solids, there are no sources in the waste stream generation process that have been identified (raw source water or the lime powder) that can introduce these chemicals into the supernatant and is likely from a surface source while the sludge was in the dewatering lagoon.

The supernatant testing yielded the following average concentrations for non-organic parameters (in mg/L unless otherwise noted):

- pH: 10.45
- Cyanide, total: <R.L.
- Phenols: 0.02
- Nitrate, as N: 0.67
- Nitrite, as N: 0.06
- Nitrate + Nitrite, as N: 0.30
- Sulfate: 42.0
- Sulfide: <R.L.
- Sulfide, reactive: <R.L.
- Acidity, total: <R.L.
- Alkalinity, total: 92.0
- BOD, 5 day: 5.0
- COD: 17.5
- TOX: 0.02
- Ammonia, as N: 11.36
- Total Kjeldahl Nitrogen: <R.L.
- Phosphorous: 0.04
- TOC: 4.15
- TDS: 243.0
- TSS: 137.0
- Conductivity, umhos/cm: 2,494.33
- Chloride: 98.75
- Fluoride: 0.33
- Aluminum: <R.L.
- Antimony: <R.L.
- Arsenic: <R.L.
- Barium: 0.02
- Beryllium: <R.L.
- Boron: 0.22
- Cadmium: <R.L.
- Chromium: 0.003
- Chromium, hexavalent: <R.L.
- Cobalt: <R.L.
- Copper: 0.004
- Iron: 0.07
- Lead: <R.L.
- Manganese: 0.003
- Mercury: <R.L.
- Molybdenum: <R.L.

- Nickel: 0.002
- Potassium: 8.6
- Selenium: <R.L.
- Silver: <R.L.
- Sodium: 41.10
- Thallium: <R.L.
- Vanadium: <R.L.
- Zinc: <R.L.
- Gross Alpha (pCi/L): 1.11
- Gross Beta (pCi/L): 5.53
- Radium 226 (pCi/L): 0.90
- Radium 228 (pCi/L): 1.52
- Total Radium (pCi/L): 1.91

The supernatant testing results indicate the following:

- Although some parameters were detected above the laboratory reporting limit, they are all well below both the 620 Class I ground water standards and the 611 MCL's and MCLG's;
- The levels detected for some of the supernatant parameters are lower than the levels of the same parameters detected in the ground water sampling results (for instance, the average total radium levels in the supernatant was 1.91 pCi/L and the average for the ground water samples from the deep monitoring well was 4.54 pCi/L); and
- Even if there is some flow of water out of the lime sludge detention area in the mine, it will not impart contamination to the ground water in the nearest USDW above either the 620 or 611 standards and therefore, the prohibition against fluid movement into a USDW above the 611 standards will be met.

10.0 FEASIBILITY EVALUATION

DEI contracted with Agapito Associates, Inc. ("AAI") of Golden, Colorado to conduct a series of feasibility evaluations regarding the proposed lime sludge storage in the Conco South Mine. The purpose of these evaluations was to:

- Determine the physical layout of the mine;
- Determine the physical properties of the rock remaining in place within the mine;
- Identify and map geologic structures within the mine including folds, discontinuities (faults, joints, fractures, shear zones), bedding planes and dissolution features;
- Conduct rock stability calculations;
- Conduct hydrogeologic flow modeling based upon the data collected from the mine;
- Evaluate the potential wetting and drying effects on pillar stability; and
- Evaluate the potential chemical effects on the rock based upon the characteristics of the lime sludge proposed to be stored.

The results of these evaluations are summarized in AAI's report dated December 2012 which is included in **Appendix A** of this permit application.

The evaluation conducted by DEI and AAI included the following tasks:

- Field mapping of the mine;
- Conducting compressive strength tests on drill cores retrieved from the site that are representative of the geologic formations that comprise the mine;
- Collecting joint infilling samples and estimating hydraulic conductivity values from laboratory falling-head tests on the samples;
- Conducting hydrogeologic flow modeling; and
- Interpretation of results.

10.1 Mine Configuration

The Conco South Mine has a standard room and pillar design. The mine was originally developed by Conco Western Stone Company, Inc. in the 1980's and 1990's by driving a decline (an inclined tunnel) within the Conco North Mine, approximately 200 feet below the existing surface quarry floor. Mining was advanced by blasting in two different cuts. The first cut, or breast cut was 23-feet high (from floor to ceiling). The second cut, or bench cut, developed a full vertical dimension of 50-feet high.

50-foot square pillars were left in place and 45- to 47-foot square rooms and crosscuts were mined. A second level was mined approximately 25-feet below the first level (meaning a sill of rock ranging from 23- to 25-feet thick was left in place between Levels 1 and 2 of the mine). The pillars on Level 2 of the mine lie directly underneath the pillars on Level 1 in order to enhance rock stability. Roof bolts were used to secure the mine from rock falls that could potentially occur and an air vent was constructed in the northern portion of the Conco South Mine to supply air to the mine. According to Lafarge, the mine is categorized as a dry mine by the State of Illinois as little to no water is present within the mine.

After their acquisition of Conco Western in 2007, Lafarge Aggregates North America, Inc. continued mining in the same configuration. Mining on Level 1 has been completed and Lafarge is currently completing the mining of Level 2. At the time when the construction of the disposal system begins, all of Level 2 will have a full bench cut. Part of Level 1 was mined on the top heading only and not benched to full height. Maps of the configuration of Levels 1 and 2 of the mine are depicted on **Figures 12.7 and 12.8** respectively.

Mining was conducted under an operating permit issued by the State of Illinois and in accordance with all Illinois Department of Natural Resources ("IDNR") and Illinois Mine Safety and Health Administration ("MSHA") statutes and regulations.

10.2 Field Mapping of the Mine

Field mapping of the Conco South Mine was conducted by DEI and AAI from July to October 2008 and from March to July 2009. Mapping activities were conducted around the perimeter of the mine and within accessible areas in the interior of the mine on Levels 1 and 2. The results of this field mapping indicated the following:

- No faulting with vertical or horizontal offsets or folding of the rock was identified within either of the existing levels of the mine (Level 1 or Level 2);
- Bedding planes for the carbonate rocks were found to be near-horizontal but the inclinations were not measured with a compass. Visual inspection and literature identified that the bedding planes dip to the south at 1° to 2°; and
- The rock mass within the mine exhibited four sets of through-going joints identified as J1 (northeast-southwest), J2 (northwest-southeast), J3 (east-west) and J4 (north-south).

Some areas in the interior of Level 2 of the mine were inaccessible during the time of field mapping due to active mining operations and the existence of air flow diversion structures.

10.3 Identified Rock Joint Sets

The rock within the mine is intersected with through-going fractures called joints. Joints are a universal feature of rocks near the earth's surface that are generally tectonic in origin. The joints are either a result of compressive and shearing forces in the earth's crust or are a manifestation of relief of compressive forces and consequent tensile fracturing. The joints separate the rock into blocks and result in rock mass strengths that are typically less than those of "intact" rock masses and provide pathways for potential fluid movement. Therefore, the strength of the rock and the potential for fluid movement were further evaluated as part of the feasibility study conducted at the site.

The joints were mapped by AAI and are presented on Figure 3-4 (mine Level 1) and Figure 3-5 (mine Level 2) on pages 3-5 and 3-6 respectively in AAI's report.

The primary joint sets were J1 (northeast-southwest) and J2 (northwest-southeast). Two sets of complimentary, secondary joint sets were also identified as J3 (east-west) and J4 (north-south). The complimentary joint sets were minor and localized and appear to be related to anomalous local structures.

The primary joint sets J1 and J2 had an average length of 70 feet on Level 1 and 80 feet on Level 2. The maximum observed joint length on both levels of the mine was approximately 200 feet. The spacing of the joints (as measured perpendicular to the joint faces) averages approximately 120 feet on Level 1 and 110 feet on Level 2, with the maximum observed joint spacing ranging from 350 to over 500 feet on both levels of the mine. AAI noted that the joint lengths and spacing observed in the Conco South Mine are consistent with the lengths and spacings for other locations in northeast Illinois for both the Silurian System dolomite and the Galena and Platteville Groups.

10.4 Mechanisms of Potential Fluid Flow Through the Rock Mass

Based upon the proposed lime sludge storage within the mine, the mechanisms of potential fluid movement were evaluated. In geologic formations such as the Galena and Platteville Groups, the rocks are formed by the lithification of unconsolidated, very fine grained marine sediment. Lithification occurs by a combination of processes (compaction, cementation, desiccation and crystallization) either concurrent with, soon after, or long after deposition.

The sediment was deposited in beds of various thicknesses, the contacts between which are delineated by bedding planes. In competent (unfractured/undissolved) limestone or dolomite, no fluid movement can occur within a bed. Potential fluid movement within these types of rocks can only occur along bedding planes and along post-lithification secondary porosity features (fractures/joints and dissolution features).

Dolomite is formed by the post-deposition, pre-lithification replacement of calcium with iron and/or magnesium in the chemical structure of the sediment. Consequently, limestone can grade laterally into dolomite and limestone and dolomite can be interbedded.

Limestone and dolomite have a naturally high pH and are sparingly soluble in deionized water but will dissolve in weak acids. (Fizzing upon contact with dilute hydrochloric acid is a characteristic test for identifying limestone and dolomite.) Dissolution features such as vugs, voids, cavities and caverns form post-lithification and typically form along fracture/joint faces.

The overall hydraulic conductivity of the Galena-Platteville Groups is dependent upon the porosity and permeability of the rock matrix together with the permeability and spacing of rock joints and other secondary permeability features. As noted in the AAI report, the hydraulic conductivity values for the unfractured Galena-Platteville Group rock is typically less than 10^{-8} cm/s, which is too small to measure using normal field methods and insignificant compared to the hydraulic conductivity of fractures.

Various packer tests in borings conducted by the ISGS for the Superconducting Supercollider Project ranged from 10^{-5} to 10^{-6} cm/s, which is comparable to the results of the packer tests conducted in the on-site bore hole by GZA. The hydraulic conductivity values obtained from packer tests is a combination of the values from the rock matrix and from bedding planes and secondary porosity structures. DEI and AAI evaluated the potential for fluid movement within the rocks along with the associated hydraulic conductivity, the results of which are discussed below.

10.5 *Identification of Joint Types, Joint Infillings and Joint Aperture Size*

DEI and AAI carefully inspected the joints within the mine and collected samples of joint infilling material for examination and testing. As part of the inspection, it was observed that the joints have either:

- A tightly healed, small aperture with no infillings; or
- Infilling materials of various types with various apertures.

The term aperture is used to describe the open space in the joint between the two rock faces. The physical appearance and characteristics of all the non-infilled joints were very consistent. All such joints were well-healed with very small aperture size. The aperture size of these joints was measured at 15 different locations within the mine with a feeler gauge. In all instances, the aperture size was smaller than the 0.0015-inch thickness of the thinnest feeler gauge.

10.5.1 Joint Infilling Material Types

Three distinct types of materials were identified in the joints containing infilling materials:

- Calcite- and sulfide-filled breccia or shear zones;
- Simple clay infillings; and
- Expanded oval pods of clay.

The breccia or shear zones are characterized by fractured wall rock and are filled with calcite and sulfides. The joints with simple clay infillings consist of green to gray, moldable clay. The joints with expanded oval pods are filled with green, moldable clay. The pods are lenticular in shape and range in size from 3 to 9 inches with lengths proportional to the widths.

Open, unfilled joints with a measurable aperture were not observed in the mine; all joints with measurable apertures were completely filled with clay or calcite or a combination of the two. The apertures of the clay-filled joints measured from 0.06 to 6 inches.

10.5.2 Population of Joints by Type of Infilling

AAI categorized and counted the occurrence of joints by type of infilling present. A total of 301 joints were inspected and categorized in the mine (119 on Level 1 and 182 on Level 2). This data is presented in Table 3-1, on page 3-4 of their report and is summarized below for convenience:

- Closed Joints with small aperture and no infilling: 69 total (23%);
- Simple clay infilling: 227 total (75.4%);
- Clay pods: 2 total (0.60%); and
- Breccia/shear zones: 3 total (1.0%).

10.6 Sampling and Analysis of Joint Infilling Materials

AAI collected a total of 15 samples of the various types of joint infilling materials for analysis. The infilling materials were identified using stereo microscope, X-ray Diffraction ("XRD") and X-ray Fluorescence ("XRF"). Samples were also collected for determination of hydraulic conductivity and estimation of compressive strength.

Approximately 6 ounces of infilling material was collected from joints at each sampling location (as depicted on Figures 3-4 and 3-5 of the AAI report). Each sample was placed in a double Ziploc® bag and was labeled with the date and the sample location (referenced to the grid system used by Lafarge).

The mineral composition of each sample was qualitatively evaluated by AAI personnel using a stereo microscope. Further compositional testing was conducted by laboratories contracted by AAI to confirm the evaluation. The purpose for evaluating the mineralogy of the samples was to determine the specific type of clay present, because different clay minerals react differently to the presence of water – for example, kaolin is not expansive, illite is mildly expansive and montmorillonite/smectite is highly expansive. Since the lime sludge has high water content, the type of clay was considered important by AAI in their evaluation of the proposed method of lime sludge disposal.

10.6.1 Compressive Strength Tests

A total of 4 samples were tested for compressive strength using a Pocket Penetrometer. Each of the samples were from joints with simple clay infillings and the results of the testing are presented in Table 3-2, page 3-7 of the AAI report and ranged from 17 to 58 psi.

10.6.2 X-Ray Diffraction Analysis Results

A total of 12 samples were submitted to The Mineral Lab, Inc. of Boulder, Colorado for identification of clay mineralogy by XRD/XRF analysis. The results of these analyses are presented on Table 3-3, page 3-9 of the AAI report. A total of 8 of the samples were predominately illite (a mildly expansive clay) and 4 samples were predominately calcite. The illite samples were obtained from joints with simple clay infilling and clay pods and the calcite samples were obtained from the breccia/shear zones.

10.6.3 Hydraulic Conductivity Analysis Results

A total of 8 samples were submitted to Wang Engineering, Inc. of Lombard, Illinois for determination of hydraulic conductivity using the falling head method (ASTM Method D5084). The results of this analysis are presented on Table 3-4, page 3-9 of the AAI report, and are summarized below for convenience:

- Samples that were predominately clay had a mean hydraulic conductivity of 2.7×10^{-8} cm/s; and
- Samples with clay with dolomite and calcite fragments had a mean hydraulic conductivity of 2.5×10^{-7} cm/s.

One sample consisted of mostly calcite and dolomite wasn't suitable for this type of analysis and one sample had an anomalously high value of 1.95×10^{-5} cm/s. This value was considered an outlier due to an anomalously high percentage of sand-sized particles that wasn't representative of the infillings from the other joints in the mine and was not used in calculating the mean hydraulic conductivity values.

10.7 Rock Strength Tests and Pillar Stability Calculations

In evaluating the feasibility of the project, the stability of the mine was evaluated considering its room and pillar configuration and the ability of the unmined rock to support the dead load that will be exerted by the lime sludge. To provide data for the necessary calculations, the unconfined compressive strength of the rock was estimated from tests conducted on core samples obtained from the mine by AAI for other projects and on core sample retrieved by GZA as part of this project.

The calculations were conducted to determine the stability of the 50-foot square pillars in the mine, the existing 25-foot thick rock sill between Levels 1 and 2 and the proposed 25-foot thick sill between Levels 2 and 3. Once the lime sludge disposal facility has been constructed, it is proposed that Lafarge mine a new Level 3 below existing Level 2. The evaluation conducted by AAI takes this into account to determine if this mining would have any potential impact to the stability of the lime sludge storage area on Level 2.

The results of this testing are presented on Table 4-1, page 4-1 of the AAI report and are summarized below for convenience:

- The bulk density ranged from 158.8 to 171.8 pounds/cubic foot ("pcf");
- The unconfined compressive strength ("UCS") ranged from 9,205 to 22,020 psi;
- The Young's Modulus (a measure of the material's deformation response to an applied load or stress) ranged from 5.70×10^6 to 8.31×10^6 psi;
- The Poisson's Ratio (a measure of the lateral deformation in reaction to an applied axial load) ranged from 0.36 to 0.17; and
- The Brazilian Tensile Strength ranged from 540 to 1,380 psi.

Using these values, AAI calculated the pillar and sill safety factors. For the sill pillar, uniformly distributed, vertical loads of 50 psi and 100 psi were assumed, which are equivalent to 50 and 100 foot thicknesses of compacted lime sludge at a density of 144 pcf, which represent one and both levels being completely filled with dewatered lime sludge. However, the density of uncemented backfills is more typically 100 pcf to 125 pcf, so that the assumed loads are greater than would occur in reality. In addition, it is not possible to completely fill the openings. Thus, assuming a filling efficiency factor of between 50% and 70% of the total air space available in the mine as discussed in **Section 14.0** of this permit application, the amount of sludge will be considerably less than what was assumed by AAI for their calculations. Hence, the assumed loads are a worse case assumption.

AAI's calculations are presented in Section 4.0 of their report. The calculated safety factor of the pillars on all three levels of the mine exceeds 1.79 and AAI states that the pillars will be stable and will support the dead load of the lime sludge. In addition, the estimated safety factor for the 25-foot sills between Levels 1 and 2, and 2 and 3 exceeds 7.7. The calculations do not account for the effect that water will have on the stability of the sills; therefore, further evaluation was conducted using a numeric model. The results of this modeling are presented in the following section.

10.8 Numerical Hydromechanical Modeling

In order to assess the potential for fluid movement out of the lime sludge storage area and in order to assess the overall stability of the storage area, AAI conducted numerical hydromechanical flow modeling using UDEC 4.0 (Itasca 2004). Section 5.0 of the AAI report, which discusses the model, the assumptions and the results in detail, is summarized in the subsections below.

10.8.1 Description and Purpose of the UDEC model

UDEC 4.0 is a commercially available two-dimensional numeric program based upon the distinct element method for discontinuum modeling. The UDEC model was chosen because the potential flow of fluids out of the storage area in the mine will be along bedding planes and secondary porosity features and not through the rock matrix itself. This is consistent with field studies of the Galena-Platteville Groups, which have found the hydraulic conductivity of the units to be attributable to secondary porosity features, with the intact rock matrix typically characterized as an aquitard within the Midwest Bedrock Aquigroup (referred to as the Cambro-Ordovician Aquifer in the AAI report).

Because, as discussed in **Section 9.0** of this permit application narrative, the lime sludge contains no contaminants, fate and transport modeling was determined to not be necessary in order to evaluate the feasibility of the project. Therefore, the primary purposes of the modeling were to characterize and predict:

- Potential fluid flow through a solid rock matrix with secondary porosity features;
- The overall stability of the rock system in the presence of the stored lime sludge.

UDEC simulates the response of discontinuous media, in this case a jointed rock mass, which is subjected to either static or dynamic loading (i.e., the storage of the lime sludge in the mine). The discontinuous media represented in the model are the joint-bounded, discrete blocks that were mapped within the mine. The model subdivides these deformable blocks into a mesh of finite-difference elements and each element responds according to a prescribed linear or nonlinear stress-strain relationship. UDEC models fluid flow through the joints and bedding planes within the system of impermeable blocks. The model takes into account the measured or assumed hydraulic conductivity of the pathways of fluid movement (joints and bedding planes) using the results of packer testing, the measured conductivity values of the joint infilling materials, the joint aperture size, etc. A fully coupled mechanical-hydraulic analysis was performed in which the conductivity of the potential pathways of fluid movement was dependent on the mechanical deformation of the blocks bounding the joints as well as the joint water pressure's effect on the mechanical load on the blocks.

10.8.2 Model Assumptions and boundary conditions

The UDEC model uses a series of assumptions that are based upon directly and indirectly defined variables in order to conduct the distinct element computations. The variables and assumptions are as follows:

- Sludge disposal to occur concurrent with the mining of the proposed Level 3 of the mine, beneath the lime storage area on Level 2 of the mine;
- An assumed sill thickness of 25 feet;
- Lime sludge to be injected into the mine via 4 injection wells as depicted in **Figures 12.7 and 12.8** of this narrative;
- An assumed maximum supernatant head elevation of 6 feet above the settled lime sludge solids within the mine;
- A blanket of lime sludge solids will be allowed to deposit across the floor of the mine by alternating the injection from the four IW's;
- A hydraulic conductivity of the lime sludge solids of 1.0×10^{-5} cm/s (based upon measured conductivity values from lime sludge solids samples ranging from 8.79 $\times 10^{-6}$ cm/s to 1.10×10^{-5} cm/s);
- Lime sludge solids assumed to eventually reach a 50-foot thickness;
- The lime sludge assumed to have a bulk density of 144 pcf;
- No fluid flow within the rock matrix, which is assumed to be impermeable, consistent with field observations and measurements conducted on the Galena-Platteville Groups;
- Fluid flow along bedding planes using an average hydraulic conductivity of 9.26 $\times 10^{-6}$ cm/s (the mean value of the on-site packer tests conducted; see **Section 5.5** of this narrative) for untested horizons within the geometry of the model and the actual measured packer test values for those horizons within the geometry of the model;
- Bedding planes repeated at 20-foot vertical intervals corresponding with the spacing of the packer tests at the average measured hydraulic conductivity of the packer tests;
- Joints assumed to be vertical;

- Based upon field mapping, assumed lateral joint spacings of 120-feet and joint lengths of 200-feet;
- Joints assumed to repeat in the same vertical plane separated by 100-feet between joint ends;
- Fluid flow along joints, taking into account the populational breakdown and hydraulic conductivity of the 3 different joint types mapped in the mine as follows:
  - 27.2 % of the total number of joints modeled were the unfilled, but tight open joints (Type 1) with an assumed aperture of 0.0015-inches and a hydraulic conductivity value of 6.16×10^{-2} cm/s. The hydraulic conductivity value assumed for these types of joints was calculated as an arithmetic mean using the aperture measured in the mine and the cubic law (discussed in detail on pages 5-5 and 5-6 in AAI's report).
  - The remainder of the joints modeled were clay filled or calcite filled (Types 2 and 3) as mapped in the mine. The assumed hydraulic conductivities were 2.66×10^{-8} cm/s for clay-filled joints and 2.59×10^{-7} cm/s for calcite-filled joints, the median values measured by laboratory testing of the infilling materials from the mine).
- An assumed potentiometric surface elevation of 180.40 feet above MSL;
- An assumed in situ vertical stress gradient of 1.09 psi/foot of depth; and
- Assumed maximum in situ horizontal stress gradients of 3.51 psi/foot of depth and 2.11 psi/foot of depth, respectively.

The hydraulic conductivities assumed in the model for the bedding planes and various joint types correlated very well with the published literature values for the Galena-Platteville groups reviewed by AAI and DEI. These values and sources are presented in Table 5-3, page 5-6 of the AAI report.

The physical modifications made within the mine related to decreasing the potential for fluid movement (lime sludge solids filling joints present in the floor, physical sealing of joints within the floor and perimeter of the mine, etc. as described in **Section 11.0** of this narrative) were not considered by the model.

10.9 Model Results and Discussion

The UDEC model predicted results for both fluid flow and rock stability. The following subsections summarize the results of the UDEC modeling.

10.9.1 Fluid Flow Modeling Results

Fluid movement within the system was modeled to consist of two potential flow pathways: 1) vertically downward through vertical joints and 2) horizontally through joints and bedding planes. The model predicted that most of the potential fluid movement will occur vertically and be intercepted by the water table, or by Level 3 of the mine after it has been excavated.

The model also predicted that the vertical fluid flow will decrease over time due to the presence of lime sludge solids along the floor of Level 2 of the mine. The lime sludge solids will provide increasing resistance with time against downward fluid movement due to its increasing thickness over time and to its inherently low permeability. To model this behavior, fluid flow was modeled at 6 different time intervals, T0 to T5, representing the various stages of lime solid deposition and decant water head levels throughout the operation of the disposal system. Additionally, a worst case scenario of a 50 foot supernatant head with no deposited solids was also modeled as a worst case under which vertical fluid flow could occur at the beginning of operation of the system.

Once the excavation of Level 3 of the mine occurs, it will intercept some or all of the fluid that could potentially flow from the lime sludge storage area depending on its extent compared to that of Level 2. This fluid can be collected and pumped out of the mine to the surface, if need be. Thus, the maximum potential for fluid movement to the water table occurs before the onset of construction of Level 3.

Under the worst case scenario, the model predicted a maximum potential vertical flow rate of 0.9 to 1.5 GPM (1,300 to 2,160 GPD) across the entire 43-acre lime sludge detention area over the life of system operation. Once lime sludge solids have covered the floor of the mine and Level 3 has been completed, negligible flow, on the order of a few gallons per day, could potentially reach the water table.

To put this in perspective, if the amount of flow predicted by the model is taken as a function of the total surface area of the floor of the mine (assuming a floor surface area of 43 acres), the worst case flow would be approximately 0.021 to 0.035 GPM/acre.

The model predicted very minor flow horizontally through vertical joints and bedding planes that could potentially reach the water table due to the circuitous flow path and comparatively low hydraulic conductivity values.

Additionally, the AAI model was conducted to characterize and predict the potential fluid flow through the rock mass as it naturally exists and didn't account for the following:

- The unfilled joints on the floors and perimeter of Levels 1 and 2 will be sealed; and
- The lime sludge particle size is smaller than the smallest aperture size of the unfilled joints and the sludge will therefore infill the joints near the surface of the

floor of the mine.

Please refer to the following in the AAI report:

- Section 5.2 for a detailed discussion of the model fluid flow results;
- Figure 5-2, page 5-5 for a conceptualized diagram of the system and model geometry; and
- Figure 5-3, page 5-10 for a diagram depicting the fluid flow pathways.

10.9.2 Rock Stability Modeling Results

The rock mass stability of the model system was assessed for the worst case scenario (no settled lime sludge solids and a supernatant head of 50 feet). Rock stability is a function of the strength of the solid rock and natural joints compared to the stresses induced by mining (of Level 3) and the force exerted on the 25-foot sill between Levels 2 and 3 by the dead load of the sludge emplaced on Level 2. The model accounted for effective stresses in joints caused by fluid pressurization and for plastic yielding where the rock mass strength is exceeded.

The rock stability was quantified by the model in terms of a critical or global minimum stability factor. The stability factor was calculated using a strength reduction method where the strength parameters (cohesion and friction angle) of the rock mass and joints were incrementally reduced from their estimated values until uncontrollable plastic failure was induced somewhere in the model.

Using this approach, the weakest part of the mine was identified, whether it was an individual pillar, sill, roof span, floor or a combination of these components. The ratio of the actual strength to the reduced strength represents the factor of safety in the system, where larger reduction factors imply greater system stability.

The model calculated a safety factor of 1.89 under the worst case scenario, indicating the mine will be stable under those conditions. This value suggests that rock with pressurized joints, on average, is slightly less than twice as strong as the loads that will be imposed on the system by mining and lime sludge emplacement. It also suggests that joint pressurization from fluid flow will have a minor impact on the global stability of the system.

10.10 Wetting, Drying and Chemical Effects

The work performed for this project also included an evaluation of the effects of wetting and drying and of the chemistry of the lime sludge on the stability of the mine.
AAI contacted representatives from the Metropolitan Water Reclamation District of

Greater Chicago ("MWRDGC") and reviewed information from the Milwaukee Metropolitan Sewage District ("MMSD") to gather information regarding the effects of alternating wetting and drying in limestone and dolomite tunnels. Based upon this research, it was concluded that alternating wetting and drying of limestone and dolomite surfaces did not affect the stability of rocks similar to those found at the site where the lime sludge is proposed to be disposed.

With regard to chemical effects, the Aurora CWS water has an average pH that ranges from 9.1 to 9.3 and an average hardness of 120 to 140 mg/L. These values are typical of water that has been in contact with carbonate rocks such as the Galena-Platteville Groups and consequently, few if any adverse chemical interactions can be expected to the chemistry of the water and of the lime sludge (average pH of 9.98).

10.11 Summary and Conclusions of Modeling and Feasibility Evaluation

The modeling conducted revealed the following:

- Mining has not and will not in the future have a significant influence on the hydraulic conductivity of the natural system or on the stability of the rock mass of the mine;
- Rock stability calculations conducted by AAI indicate that a safety factor of 2.0 will be exceeded in all cases for the pillars and 1.89 will be exceeded in all cases for the sills between mine levels;
- Potential fluid flow out of the lime sludge disposal area is predicted to be very low, even under the worst case scenario. The worst case flow rate was estimated to be 0.9 to 1.5 GPM (0.021 to 0.035 GPM/acre) over the life of the operation of the system;
- Furthermore, considering the fact that the unfilled joints on the floors and perimeter of Levels 1 and 2 of the mine will be sealed and the fact that the lime sludge solids are small enough to fill the joint apertures, it is unlikely that the worst case conditions will exist within the mine and it is highly unlikely that flows approaching the worst case model prediction will occur.
- Once Level 3 of the mine is excavated, if any flow of water occurs from the lime sludge detention area, it will be captured within Level 3 and negligible flow is predicted to reach the St. Peter Aquifer; and
- Considering the chemistry of the Aurora CWS water, lime sludge solids and lime sludge supernatant, there will be no adverse impacts to the stability of the mine due to lime sludge disposal given that the injection fluid is chemically compatible with the rock formations within the mine.

11.0 MINE CHARACTERISTICS AND PREPARATION

As previously discussed, the WTP lime sludge will be transported and retained within the Lafarge Conco South Mine which is constructed within the Galena and Platteville Groups (limestone and dolomite deposits). These rock formations have naturally occurring secondary porosity structures such as joints, bedding planes and dissolution features. The rock mass itself is essentially impermeable; therefore, the only pathways for potential water movement are through the identified and characterized secondary porosity structures.

The results of the feasibility evaluation and hydromechanical flow model indicate that in its current condition, very little water can potentially flow out of the lime sludge detention area. In order to enhance the water retention characteristics of the natural system, certain activities will be conducted in order to prepare the mine for disposal and meet the stated project goal of preventing or minimizing potential water movement and to create a clean, continuous self-contained storage area within the mine.

11.1 *Mine Configuration and Operations*

As stated in **Section 10.0** of this permit application narrative, the Lafarge Conco South Mine is a standard room and pillar design. As mining is conducted, pillars of solid rock are left in place in order to impart sufficient stability to the rock mass left in place. The pillars are approximately 50-feet square and rooms are mined to the approximate dimensions of 47-feet by 47-feet.

Photographs 11.1 and 11.2 – Typical configuration of pillars and rooms

The South Mine currently has two levels and will include a third level in the future. The ceiling of Level 1 is located approximately 241 feet bgs (approximate elevation is 429 feet above MSL). The deepest floor depth is approximately 50 feet below the ceiling and there is a sill of rock 25-feet thick between Levels 1 and 2. The elevation of the floor of Level 2 is approximately 307 feet above MSL and using the same mine configuration

(25-foot sill between Levels 2 and 3 and a 50-foot bench cut) the floor elevation of the proposed Level 3 will be 231 feet above MSL.

Photographs 11.3 and 11.4 – Pillar and ceiling with yellow air flow diversion blanket

The pillars in Level 2 line up directly below the pillars on Level 1 to enhance the stability of the rock mass. Level 3 of the mine will be constructed with the identical configuration and mining methods as Levels 1 and 2. Most of Levels 1 and 2 have been benched (50-feet floor to ceiling), with some areas having a breast cut only (23-feet floor to ceiling). Please refer to **Figures 12.7 and 12.8** for a depiction of the mine layout for Levels 1 and 2 respectively.

Photographs 11.5 and 11.6 – (left): Ceiling showing J1 and J2 joint sets and roof bolts

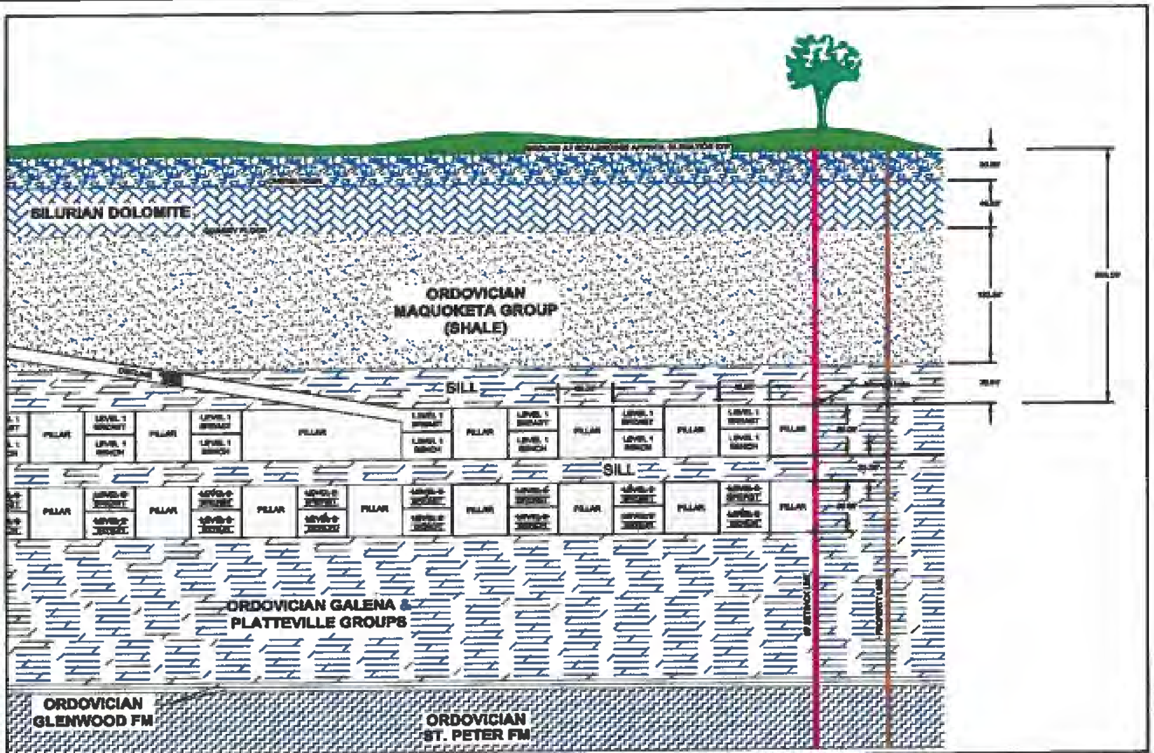
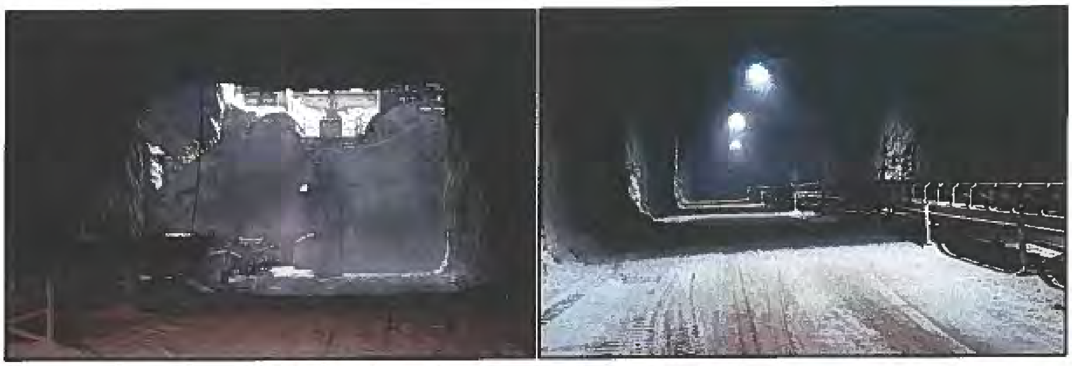


Figure 11.1 – Conceptualized mine configuration and general geology

Mining is conducted by blasting. Holes are drilled into the working face of the rock (called the heading) and filled with explosives. The explosives are detonated and the resulting rock pile (called shot rock) is excavated using heavy equipment and transported via dump trucks to the rock crusher located inside of the mine. The rock is dumped into the hopper and is crushed. The crushed rock is moved to the surface (the former quarry floor above the North mine, north of the I-88 tollway) via a system of conveyor belts and is stockpiled until sold. The rock faces are scaled to remove loose material and the roof is bolted with 60-inch roof bolts to prevent rock falls.

Photographs 11.7 and 11.8 – Loading shot rock into dump truck and rock crusher

Headings are advanced in two phases. The first phase is called the breast cut where a total of 23-feet of rock are removed. The second phase is called the bench cut where an additional 27-feet of rock are removed, making the total thickness of mining (and pillar/room height) approximately 50-feet. The headings are routinely surveyed to insure that the mining is limited to the property boundaries of the site.



Photographs 11.9 and 11.10 – Rock crusher chute and conveyor system

An air vent exists from the ground surface to Level 1 of the mine. A hole through the sill between Levels 1 and 2 exists beneath the air vent shaft to supply air to Level 2. The air vent shaft is 9-feet in diameter and is cased. At the ground surface, the blowers and MCC along with the intake ductwork and other ancillary equipment rests on a concrete pad and is surrounded by a security fence.

Photographs 11.11 – Air vent shaft as viewed from Level 2; vent shaft to surface seen through the hole

Photographs 11.12 and 11.13 – Air vent, duct work and MCC

The goal is to maintain a floor elevation of Level 3 no closer than 100 feet within the top of the Ancell Group (nearest USDW) and above the potentiometric surface of this aquifer unit. Based upon the core conducted at the site, the elevation of the top of the Ancell Group is 130.64 feet above MSL, which will provide a vertical separation of 100.36 feet to the floor of Level 3. The highest recorded ground water elevation in the monitoring well at the site is 200.86 feet above MSL which provides a 30.14 foot separation between the potentiometric surface of the nearest USDW and the floor of Level 3. There will be over 170 feet of rock between the floor of the lime sludge detention area on Level 2 of the mine and the top of the Ancell Group.

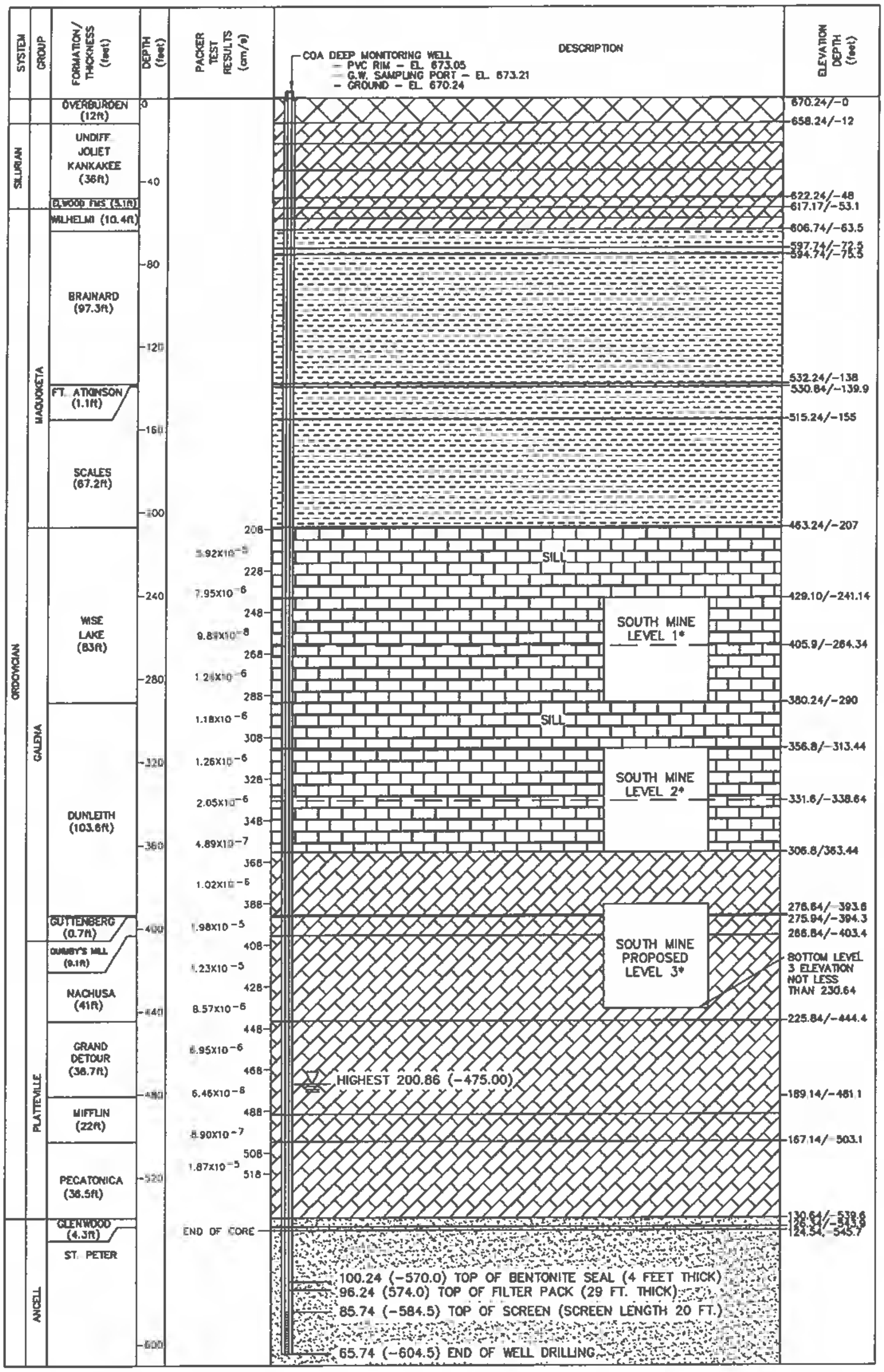


Figure 11.2 – Composite log and mine configuration with respect to geology

11.2 Mine Survey

It is critical to this project that the lime sludge injection well components project into the mine in the rooms as designed. Therefore, a detailed survey was conducted at the mine to determine the following:

- The location of the mine as it exists within the Illinois State Plane Coordinates System;
- The configuration and dimensions of the rooms and pillars in mine Levels 1 and 2 related to the State Plane Coordinates System;
- The elevations of the ceilings and floors of mine Levels 1 and 2;
- The location of the air vent shaft; and
- The topography of the floors of mine Level 1 in order to design the distribution piping system.

The survey was conducted by Hampton, Lenzini and Renwick, Inc. (Elgin, Illinois) in a contract through Lafarge on September 21, 2012. All of the mine diagrams have been placed within the State Plane Coordinates System and elevations determined as per NAVD 88.

Please refer to **Appendix R** for a copy of the survey maps of Levels 1 and 2 of the mine.

11.3 Sealing of Joints

A total of 3 lime sludge solids samples were obtained from a dewatering lagoon at the WTP on May 8, 2009 and shipped to First under chain-of-custody protocol. The samples were tested for grain size using ASTM D-422. The average D_{50} grain size was 0.0129 mm.

The aperture size of the unfilled joints in the mine was less than 0.038 mm, which is approximately 66% larger than the average grain size of the lime sludge solids. This indicates that as the lime sludge solids are deposited and compacted on the floor of the mine over time, the particles will infill any joints that may be present in the floor of mine Level 2. This will serve to aid in the reduction of the potential for water movement through these joints.

In addition to this intrinsic characteristic of the lime sludge solids and the unfilled joint system within the mine, all unfilled joints along the mine perimeter and floor of Levels 1 and 2 of the mine will be sealed by Lafarge. There are various methods that could potentially be used to seal the joints that would have similar effectiveness in their characteristics to retard water flow. Examples of these methods are:

- Pneumatically applied concrete (a.k.a., shotcrete): Shotcrete can be applied using the wet or dry method. In both methods, the material is applied at high pressure through a nozzle directly onto the surface to be treated. In the wet method, the concrete is premixed with water and fed into the hose and in the dry method the concrete is fed into the hose dry and water is mixed at the nozzle.
- Bentonite: The methods of application are similar to shotcrete and can use a dry or wet application method as described above but use bentonite instead of concrete.
- Pressure grouting: Direct injection of a mixture of sand and cement under high pressure directly into the joint openings (better for larger openings). Due to the small aperture of the unfilled joints mapped in the mine, this method may not be applicable.

11.4 *Removal of Mining Equipment and Mine Cleanup*

In order to provide a clean and unobstructed environment for the operation of the disposal system, all of the equipment and appurtenances associated with mining operations will eventually be removed from the mine prior to beginning the operation of the lime sludge injection and extraction systems. The equipment to be removed includes, but is not necessarily limited to:

- Rock crusher;
- MCC;
- Conveyor system;
- All safety fencing, barricades and cement barriers;
- Air flow diversion curtains;
- Electrical lines, lighting and control panels;
- All portable equipment;
- Portable toilets;
- Signage; and
- Miscellaneous tools and equipment.

In addition to the removal of equipment, the mine will be cleaned by Lafarge prior to system operation. Cleaning includes but is not necessarily limited to the removal of all mining related excavations, stockpiles, shot rock, impoundments, settling basins and all debris and waste materials (refuse, plastic, wood and any other material not naturally occurring in the subsurface in its natural condition). This will also include any material associated with the construction of the lime sludge disposal system.

The object of these activities is to remove all foreign objects from the mine to allow for the unobstructed operation of the system.

11.5 Bulkheads and Sealing of the Lime Sludge Detention Area

There are 4 openings into the South Mine from the North Mine under the I-88 tollway as follows:

- Three openings from Level 1 of the North Mine to Level 1 of the South Mine; and
- One opening from Level 1 of the North Mine to Level 2 of the South Mine.

These openings must be closed in order to seal and maintain the integrity of the lime sludge detention area and to protect Lafarge's mining operations in the North Mine. In accordance with an agreement between Lafarge and the COA, Lafarge is responsible for the design, construction, monitoring and maintenance of these bulkheads.

The COA and Lafarge agreed that a specially designed bulkhead using a combination of Kennedy NZL ("near zero leak") Stoppings ("stoppings") and a proprietary foamed cement manufactured by Minova, Inc. called Tekseal® will be used. Kennedy Stoppings are manufactured by Jack Kennedy Metal Products & Buildings, Inc. and they, along with the Tekseal® cement have been used in mines for years for a variety of applications including air flow diversion, fluid bulkheads and waste containment purposes.

The following subsections discuss these bulkheads.

11.5.1 Bulkhead Description and Design

Each of the bulkheads that will be constructed in the mine will consist of two stoppings sandwiching the Tekseal® material. The bulkheads will provide a water-tight, structurally sound barrier to keep the lime sludge in place and to protect Lafarge's mining operations to the north.

The Tekseal® material provides both the structural strength of the barrier as well as its water resistance, with the stoppings serving as the framework to hold the Tekseal® material in place. The stoppings are constructed out of a series of steel panels that are joined together using metal ties and a lattice of horizontal and vertical heavy duty metal braces. The stoppings are constructed in-place and are fitted to the rock opening by using side extensions that are cut to size. The braces of the stopping will be bolted to the floor, ceiling and sides (called ribs) of the rock using resin bolts.

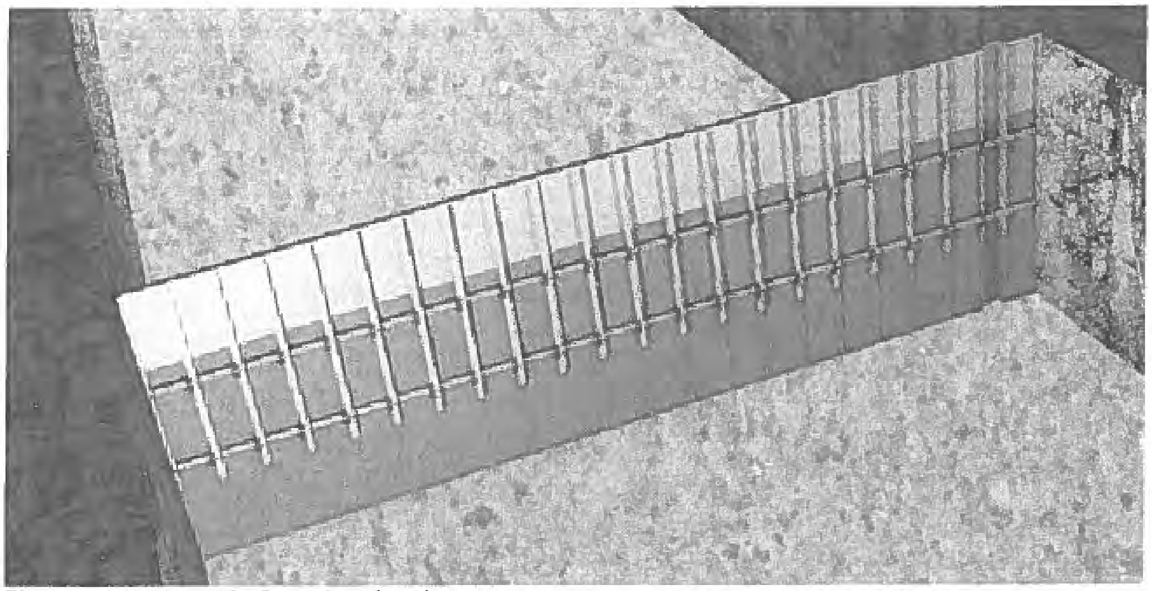
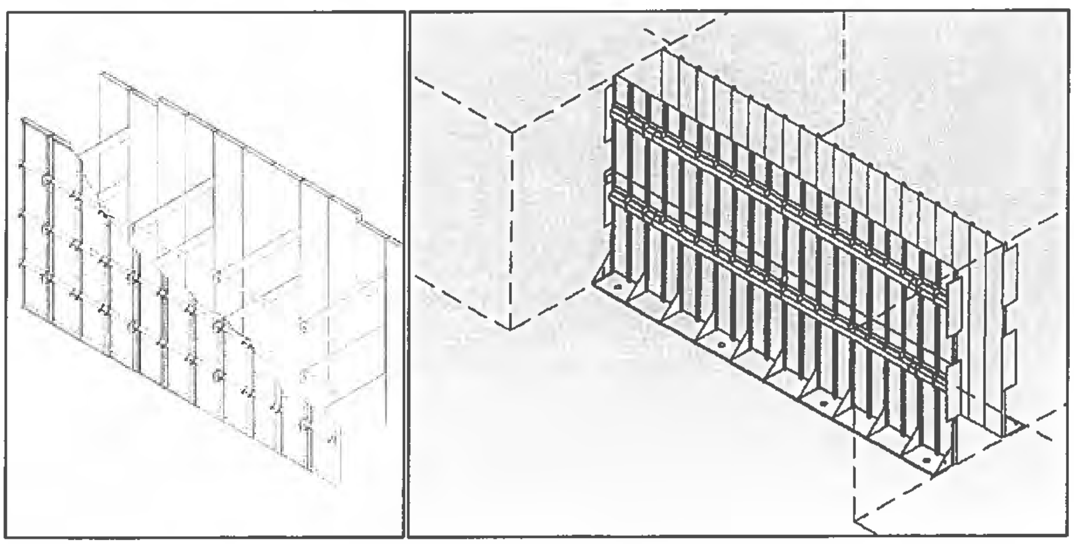
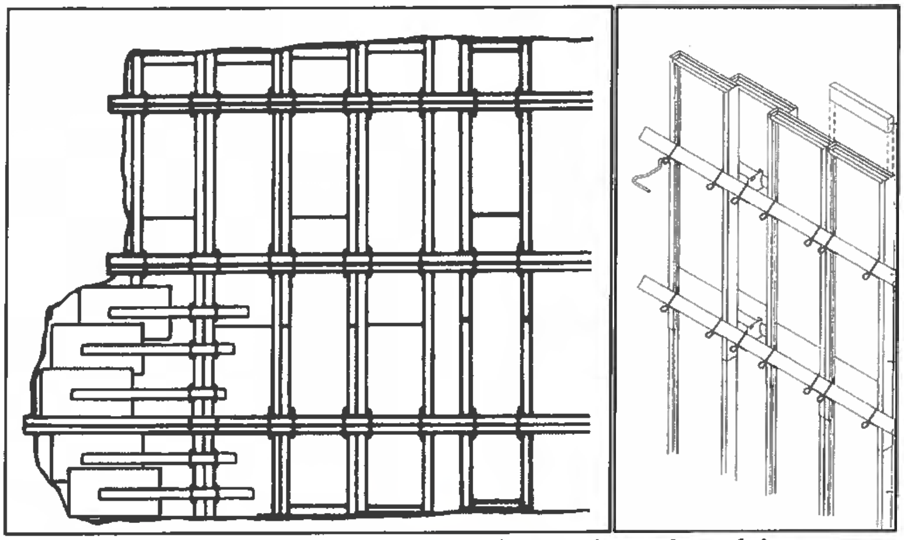


Figure 11.3 – Kennedy Stopping drawing



Figures 11.4 and 11.5 – Kennedy Stopping drawing showing braces



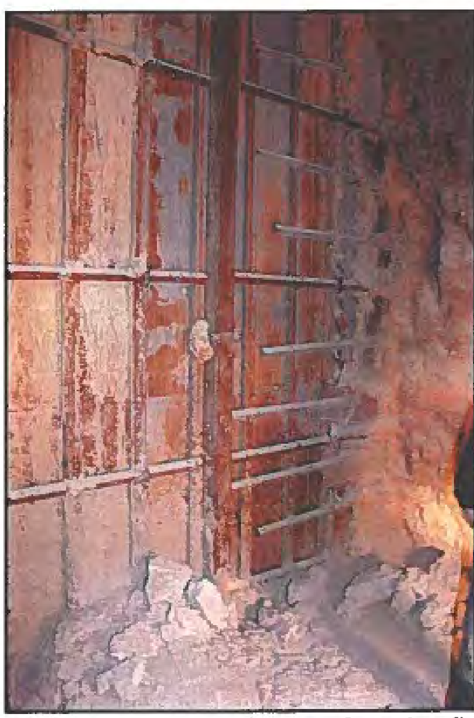
Figures 11.6 and 11.7 – Kennedy Stopping side extension and metal ties

Lafarge has constructed dozens of Kennedy Stoppings for use in a fly ash detention area in their Joliet, Illinois mine as depicted below.

Photographs 11.14 and 11.15 – Stoppings steel panels and heavy duty braces

Photographs 11.16 and 11.17 – Bracing showing floor bolts and connection to panels

Photographs 11.18 and 11.19 – Bracing ties and rib bolts



Photographs 11.20 and 11.21 – Stopping fitted to opening using side extensions and ceiling bolts

Photograph 11.22 – Completed stopping

Photographs 11.23 – Completed stopping

The flyash being stored in the Lafarge Joliet mine has similar physical properties as the lime sludge and Lafarge reports that there have been no issues with the stoppings in this application.

The Tekseal® material is a proprietary, low density (specific gravity of 0.5 to 0.7) foam cement that adheres to the undulating rock surfaces. It is a blend of inorganic cements and additives that forms a cellular material with closed cells. The Tekseal® material comes dry in 45-pound bags. It is mixed with air and water in a specially designed placer unit and the mixture will be pumped in the space between the steel stoppings. Once pumped between the stoppings, it gels in minutes forming a non-toxic, non-combustible product weighing approximately 1100 lbs/CY. The material will have a minimum shear strength of 72 psi for a 400 psi mixture.

The preliminary design of the bulkheads, based upon the bulk density of the lime sludge and the amount of anticipated head is as follows:

- The bulkheads on Level 1 will be 22 feet tall, 42 feet wide and 15 feet thick and will be designed to withstand approximately 25 feet of head for an 80 lb/CF fluid; and
- The bulkhead on Level 2 will be 27 feet tall, 42 feet wide and 24 feet thick and will be designed to withstand approximately 125 feet of head for an 80 lb/CF fluid.

The safety factor of this preliminary design is 3.06. The final design may change from the above based upon the final calculations conducted by Lafarge. The ability of the bulkheads to hold back the lime sludge comes from the shear strength of the Tekseal® material and it's characteristic of filling in all of the space in the rock opening and adhering to the undulations in the rock. This, in part, accounts for the overall thickness of the bulkheads. Lafarge has stated that bulkheads designed in this manner will be more than sufficient to hold the lime sludge in place and prevent any migration of water out of the lime sludge detention area. If Lafarge deems it to be necessary they will deform (create more undulations) the rock faces of the floor, ceiling and ribs to create a higher skid resistance in the contact with the foamed cement.

11.5.2 Piping Connecting to Extraction Pumping System

In order to connect to the supernatant extraction system, one of the bulkheads on Level 1 and the bulkhead on Level 2 will have a series of pipes constructed through them.

The piping will be constructed though the bulkhead at a spacing interval to keep the head level of the supernatant above the lime sludge solids to 5-feet or less and to allow for the efficient and effective extraction of the supernatant from the storage area to the surface. Lafarge has stated that the piping through the bulkhead will be incorporated as structural component of the design.

Please refer to <u>*Section 12.7*</u> of this narrative for additional description of the bulkhead and extraction system design.

11.5.3 Sealing of Host Rock

The bulkheads as proposed will provide a water-tight seal against the rock, and the rock mass itself is essentially impermeable. It is possible that the rock surrounding the bulkhead may contain pathways of fluid movement along secondary porosity features that could potentially flow around the bulkhead and through the rock from the side where the lime sludge will be stored to the "dry" side of the bulkhead. In order to prevent this from occurring, Lafarge has agreed to seal any secondary permeability structures identified in the host rock. The openings in the mine that will be sealed have been inspected and no visible dissolution features were identified, so the secondary porosity features that will be sealed would be large bedding planes, partings and joints.

Lafarge has stated that they will closely inspect the host rock in these areas to identify such features and seal them. Lafarge has also stated that the likely method of sealing will be pressure grouting, but other methods will be considered so that the entire system (the host rock and the bulkheads) together will be resistant to the flow of fluids from the storage side to the dry side of the stoppings.

11.5.4 Long-term Monitoring and Maintenance

Lafarge will be responsible for the long-term monitoring and maintenance of the bulkheads. The monitoring will include regular visual inspection of the bulkheads and monitoring for leakage. The bulkheads will include a series of pressure transducers to monitor the load on the bulkheads over time and will be equipped with alarms to warn against excessive loads.

11.6 Berms and Sedimentation Basins

The final aspect of the preparation of the mine for lime sludge disposal is to create three sedimentation basins on Level 2 of the mine. The purpose of these sedimentation basins is to:

- Decrease the energy and velocity of the lime sludge slurry in order to enhance the deposition of the lime sludge solids within the mine;
- Enhance the uniformity of the deposition of the lime sludge solids and to direct such deposition in the desired areas of the mine;
- Insure that the solids are taken out of suspension in the slurry prior to reaching

the supernatant extraction system; and

- Increase the filling efficiency of the system in order to use as much space in the mine as possible for solids deposition in order to increase the effective life of the disposal system.

11.6.1 Berm Composition

The berms will be include materials of various particle sizes in order to allow for the efficient capture of solids while maintaining the free flow of water through the berm and toward the extraction system. The berms will be constructed from materials that comprise existing safety berms from the mine and from mine screenings. Mine screenings are rock particles that are created from the blasting and crushing of the limestone and dolomite that are too small for commercial sale and use. The existing safety berms are a combination of screenings and larger pieces of shot rock that are created during the blasting process. The advantages of using these materials is that they are readily available, chemically compatible, have the optimal range of particle sizes and have the proper slope characteristics.

The combination of larger rock fragments (ranging in size from a few inches to tens of inches in diameter) and the smaller particle size mine screenings will provide an effective screen to capture the lime sludge solids.

11.6.2 Berm and Sedimentation Basin Configuration

The berms will be constructed as depicted in the diagrams below, with a 1:1 slope and with the following minimum dimensions:

- Level 1: 5-feet high, 5-feet across the top of the berm and 15-feet deep; and
- Level 2: 10-feet high, 5-feet across the top of the berm and 25-feet deep.

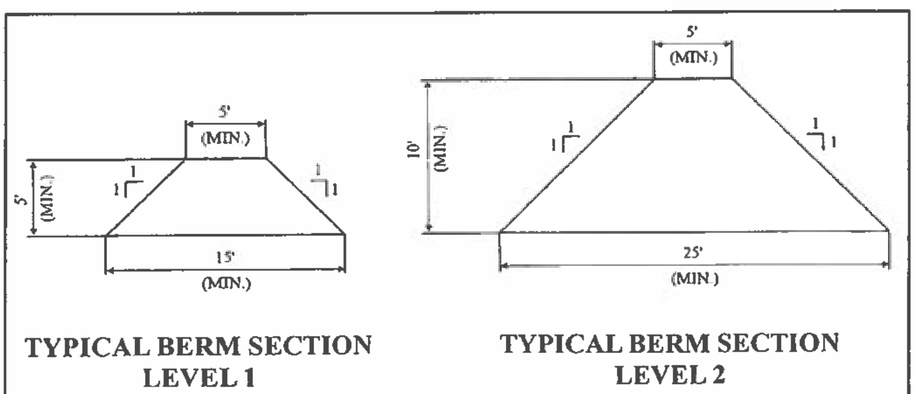


Figure 11.8 – Typical berm sections Levels 1 and 2

The berms will be constructed between selected pillars as depicted on **Figure 12.7**. By doing so, three separate sedimentation basins will be created as labeled on the diagram.

11.6.3 Timing of Construction and Sequence of Deposition

The construction of the berms on both levels of the mine will be timed to coincide with the construction of the rest of the disposal system, such that two points of access/egress to the southern portion of the mine will be maintained. Safety berms and/or concrete barricades will be maintained or placed between pillars in certain locations as determined to be necessary maintain worker safety during the construction of the system.

On both levels of the mine, the solids in the lime sludge will deposit behind the line of berms in Sedimentation Basin #1 over time and will eventually crest over the top of the berms and begin solids deposition in Sedimentation Basin #2. As deposition continues to occur in Basin #1, deposition will begin in Basin #2. This process will continue until all three basins are filled with lime sludge solids.

The deposition of the lime sludge will be controlled by the sequential operation of the injection wells and the associated distribution piping network that will be tied to each well. Please see **Section 12.7** of this narrative for a more detailed description of this process.

11.7 Mining Rock for Flow Pathways to Extraction System

The final element of mine preparation involves the mining conducted by Lafarge. Benching will be completed on Level 2 of the mine and certain rock walls and partitions will be removed on both levels of the mine prior to the start of system operation. This will be conducted in order to insure that the maximum numbers of mined rooms are connected continuously from the points of injection to the single point of extraction at the northern end of the mine.

This will maximize the efficiency of the deposition of solids within the mine and to insure that the maximum flow of water reaches the supernatant extraction system.

12.0 SYSTEM DESIGN SUMMARY

In order to determine the parameters, efficacy and feasibility of the project, DEI has completed a Memorandum of Design ("MOD") for the system which is included in **Appendix D** of this permit application. The MOD provides for the preliminary design of the system and system components. Upon approval of the Class V UIC permit application by the Illinois EPA, final design of the system will be conducted, permits to construct will be applied to the Illinois EPA and specifications for public bidding will be completed. Slight alterations of the design may occur between the MOD and the final design stages, but the major system concepts, features and components will likely remain the same. This section summarizes the MOD, broken out into the following elements:

- Delivery System – WTP improvements, pump station and forcemain;
- Injection System – IW's, distribution piping and injection points;
- Extraction System – Supernatant inlet pipes, pump system, EW, forcemain;
- Surface completion and power feed;
- Securing vent shaft.

The Piping and Instrument Diagram for the system has been included as Exhibit B to the PA.

12.1 *Lime Sludge Delivery System*

In order to deliver the lime sludge to the site, a lime sludge delivery system must be constructed. This system will include improvements made at the WTP along with the construction of an underground forcemain.

12.1.1 New Pump Station and Wet Well

A pump station will be constructed adjacent to the north of the existing WTP building. The pump station building will be constructed directly adjacent to and slightly overlapping existing dewatering lagoon #3. The pump station will house the pumping system for the forcemain, a wet well and all electrical and control systems.

The WTP claricones will be connected to the wet well via a gravity sewer. ***The sludge will first enter the coarse screen chamber by gravity prior to entering the wet well. The inclined screen with a 1-inch spacing will block any large deposits of lime scale from entering the wet well and potentially damaging the pumps. An overflow has been provided upstream of the bar screen so that, in the rare event the bar screen would be completely blocked, the flow would enter the wet well prior to screening.*** The wet well will provide a screening mechanism to remove solids from the sludge that could damage the pumps. This will allow for the more even and uniform pumping of the lime sludge to the site for injection and to eliminate the need to synchronize the pumps with the blowdowns at the WTP. The wet well will have enough storage capacity to accommodate the blowdown flow volume to be pumped to the site.

Blowdown data over a 2.5 year period (2010 through July 2012) was evaluated and modeled to determine the sizing of the system and to determine the volume of lime sludge that will be injected into the South Mine over time. This data is applicable for the basis of system design because of the drought that occurred in the summer of 2012, resulting in unprecedented water demand. These data are representative of historic maximum lime sludge generation at the WTP. Based upon these data, the average percent solids were approximately 6% by weight and the average flow rate during blowdowns is approximately 800 gpm.

The WTP claricones will be connected to the wet well in the pump station by an 8-inch underground, gravity fed blowdown line. This line will be connected to the wet well which will have a hopper design and plan dimensions of 20-feet by 15-feet to accommodate a blowdown flow rate of 800 gpm. The wet well provides approximately 2,240 gallons per foot of active storage or 9,632 gallons of volume available to be pumped to the site.

An emergency overflow structure has also been incorporated into the wet well design that will bypass the forcemain and divert flow directly into dewatering lagoon #3 in the event that a need would arise.

Additionally, a tap with a back flow preventer to a water transmission main will be connected to the wet well to flush the forcemain periodically for maintenance purposes.

12.1.2 Forcemain Pumping System

The basis of design for the forcemain pumps will be the Wilfley Model K solids-handling centrifugal pump. This pump was chosen because it is specifically designed for application with abrasive materials and is easier to maintain compared to other pumps. The preliminary design calls for two pumps to be installed, each having the following performance characteristics:

- Flow rate of 800 gpm;
- Total dynamic head of 162 feet;
- Speed of 1,440 rpm; and
- Motor size of 125 HP.

The pump station will have a new motor control center ("MCC") which will be integrated into the WTP Supervisory Control and Data Acquisition ("SCADA") system.

12.1.3 Contingency Plan

Several systems will be in place at the pump station to manage issues and problems that may arise during the operation of the system.

There will be two radar level instruments which will continuously measure the level of sludge in the wet well. The level will be recorded by the plant supervisory control and data acquisition ("SCADA") system. Through the SCADA graphical user interface, the operator will be able to select which pump is the lead pump and which is the lag pump, the lead pump start level, lag pump start level, all-off pump level and the speed at which the pumps are to run.

A magnetic flowmeter is included on the discharge forcemain and will continually measure the volume pumped. This will also be recorded in the SCADA system. An analog pressure gauge is included on the discharge forcemain and can be manually read by the operators.

The variable frequency drives that control the speed of the pumps will be specified with over-current and under-current alarms. The under-current alarm may indicate blockage in the pump or forcemain.

If there is a blockage in the forcemain or if the pumps fail to run, the high level in the wet well will provide an alarm via the SCADA system. If the level continues to rise in the wet well, there will be a gravity overflow into the adjacent sludge dewatering lagoon.

The exact nature of the problem can then be assessed and appropriate corrective actions taken. The forcemain and wet well can be flushed with raw water, the pump can be serviced or replaced, etc.

The following instrumentation (or equivalent) is proposed:

Continuous Sludge Level Measurement:

- *Manufacturer: Seimens*
- *Model: SITRANS LR200*
- *Process: Radar, continuous reading*
- *Frequency: 6 GHz*
- *Measuring range: 1 to 65 feet*

Magnetic Flowmeter:

- ***Manufacturer: Toshiba***
- ***Model: LF654 and LF622F***
- ***Measurement range: 0 to 39.4 ft/s***
- ***Accuracy: +/- 0.2% of rate***

Pressure Gauge:

- ***Manufacturer: Ashcroft***
- ***Model: 1279 Duragauge***
- ***Range: 0 to 100 PSI***

12.1.4 Forcemain

The underground forcemain will be connected to the pump system to deliver the lime sludge to the site. The forcemain will be 8-inches in diameter and will be constructed of class 52 DIP with interior cement lining. The forcemain will be constructed at an average depth of 5.5 feet bgs from the pump station to the site.
The forcemain will also have the following design criteria:

- Velocity of 4.64 ft/sec at 800 gpm;
- Approximately 7,600 linear feet from the WTP to the site and on the site to the IW's;
- Asphaltic exterior coating with polyethylene encasement;
- Push-on style pipe joints;
- Fittings to have restrained mechanical Mega-Lug joints; and
- Pipe gaskets to be SBR material.

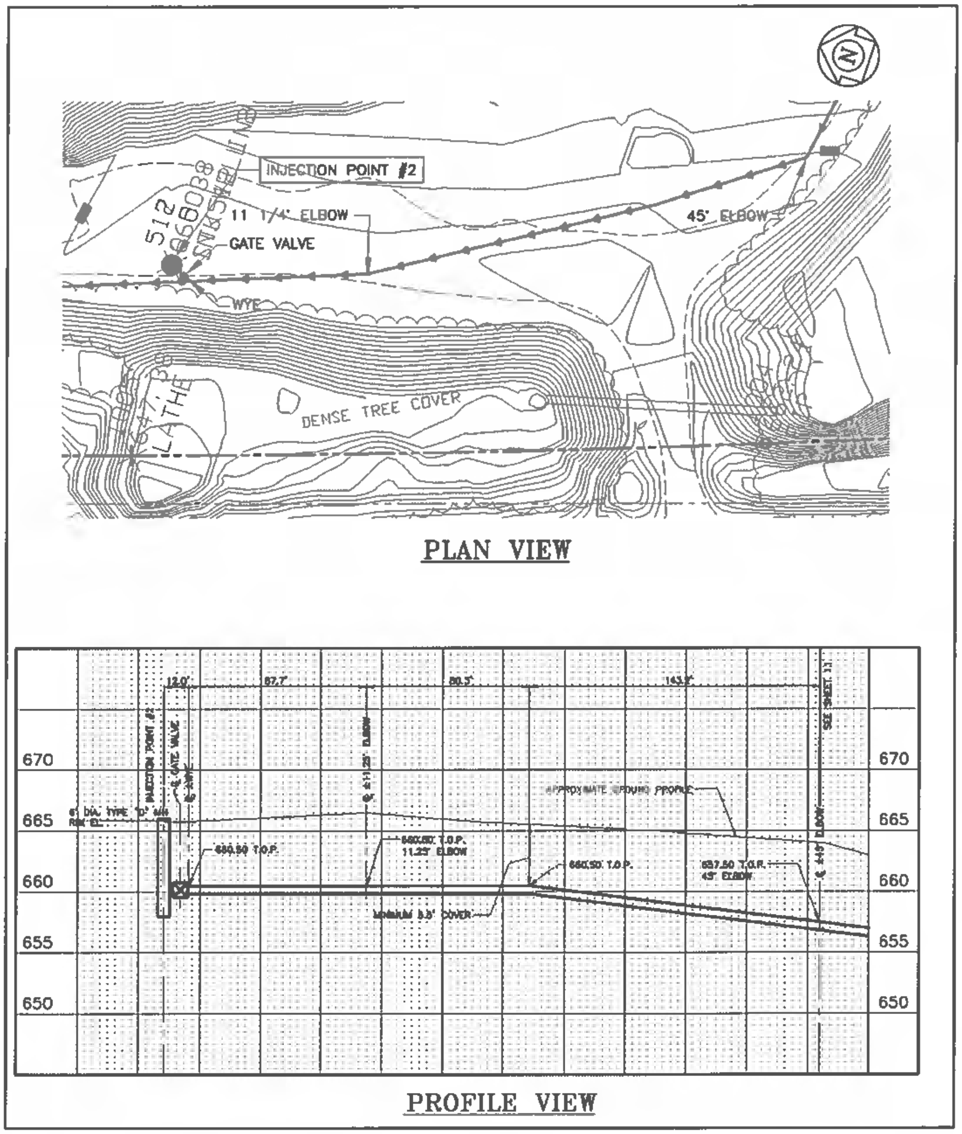


Figure 12.1 – Typical forcemain cross section

The forcemain will have a combination air/vacuum release valve at its topographically highest point as well as at each IW connection. At each IW, the forcemain will be connected to the top section of the IW pipe and will exit the manhole assembly, above the ground surface. In addition to the air/vacuum release valves, the forcemain will have gate valves as well.

The purpose of the air/vacuum release valves is to release air from inside of the forcemain while the lime sludge is pumping, but also to let air back into the vertical IW piping after the pumping has stopped so that the momentum of the falling sludge does not create a vacuum to potentially collapse the vertical piping. The purpose of the gate valves is to control the flow to the four IW's and to open and close the system, if needed, from the WTP. In addition, each IW will have a blind flange to connect to a fire hose for the purpose of flushing the underground distribution pipes, if needed.

12.2 *Injection System*

The injection system is designed to convey the lime sludge from the forcemain for deposition inside of the mine. The injection system includes the following components:

- Injection wells including forcemain connection, manhole access and associated valving;
- Ceiling connections to an energy dissipater;
- Distribution piping network;
- 18 injection points; and
- Three sedimentation basins.

The injection system will convey the lime sludge into the distribution piping on the floor of Level 1 of the mine, to the injection points through the sill between Levels 1 and 2 for deposition directly into Level 2 of the mine.

12.3 *Injection Wells*

The forcemain from the WTP will be connected to 4 different IW's at the site located as depicted on **Figures 4.1, 4.6 and 12.7**. The IW's will be connected at the ceiling of Level 1 of the mine to the distribution piping system.

Since the IW's are Class V and since the lime sludge will be deposited into the empty space of the mine and not forced under pressure into pore spaces of a geologic formation, there will be no back pressure against the annulus and casing of the IW's. The mine will be vented to the atmosphere using the 9-foot diameter air shaft located at the north end of the mine (on both Levels 1 and 2). This airshaft was used to supply air to the mine when it was in operation. The airshaft is constructed from the ground surface through the ceiling of Level 1 of the mine. Air was supplied to Level 2 of the mine through a hole in the rock sill between Levels 1 and 2, approximately 15 feet by 20 feet in size. Based upon this construction, both Levels 1 and 2 of the mine are under atmospheric pressure conditions.

Because of this, as the lime sludge is deposited into the mine by the IW's, air within the mine will be displaced through the large diameter airshaft, as the air escape pathway of least resistance and virtually no pressure will be exerted on the IW annulus or casing.

Therefore, the pressures taken into account in the design of the IW's are those created by the lime sludge as it travels through the IW pipe. As the "slug" of lime sludge drops through the pipe, pressure will be exerted against the pipe pushing outward on the IW casing pipe. Once the slug has passed, pressure will be exerted inward against the casing pipe.

There were several considerations when evaluating the construction material, diameter and wall thickness of the IW pipe, such as:

- Pressure exerted on the pipe from the conveyance of the lime sludge into the mine;
- The depth to which the IW's will be constructed;
- The length of time that the IW's will be in service;
- The pressure that will be exerted on the radius of the IW's at the floor of Level 1, using the diameter of the IW's to decrease the pressure at the radius due to pipe friction; and
- The maximum flow rate of the sludge from the WTP into the mine;

Taking these factors into consideration, the IW's will have the following specifications:

- Each IW will be double cased;
- The ***long string*** casing will be 8-inch diameter schedule 40 carbon steel with threaded connections;
- The ***injection string*** casing will be 6-inch diameter schedule 40 ***carbon*** steel casing with threaded connection;
- All threaded joints ***for the injection string*** will be bead welded; and
- Filled annulus between the 10-inch diameter borehole and the 8-inch diameter ***long string casing***. Annulus will be sealed using (from bottom to top) ***portland*** cement grout, ~~bentonite seal~~ and poured concrete.

The IW's will be able to accommodate the flow rates (800 gpm) from the forcemain and the pressure calculated to be exerted on the pipe as the lime sludge is dropped from the surface into the mine.

There is a significant amount of potential energy from the IW drop into Level 1 of the mine. A vortex energy dissipater will likely be used to reduce the energy and the velocity of the lime sludge to 5 to 6 feet/sec. The energy dissipater will be stiffened using steel plates due to the large dynamic forces that will develop in the drop. The location of the energy dissipater will be determined during the final design phase of the project. It may be located at the end of the 10-foot radius bend in the distribution piping or the bend may be eliminated and the IW may terminate vertically into the energy dissipater. The MOD incorporates the 10-foot radius bend into the preliminary design.

While forces will be generated on the injection string during times of injection, the injection string itself will remain relatively stable throughout the operating life of the injection system. The injection string will be connected to and stabilized at the following points:

- *To the forcemain via megacouplings (see Figure 12.5 on page 12-18 of the PA);*
- *Welded to a steel plate where the injection string pipe protrudes above the ground surface (see Figure 12.2 on page 12-12 of the PA) which will be buried under a concrete pad;*
- *A steel plate which will be bolted to the ceiling of Level 1 of the mine and welded around the injection string pipe as it protrudes into the mine; and*
- *At the base of the injection string pipe to the energy dissipater/long radius bend. The energy dissipater/long radius bend will be anchored to the floor of Level 1 of the mine so as to absorb the force generated as the lime sludge drops within the injection string.*

The force at the top of the injection string where it is connected to the forcemain will be based upon the velocity that the lime sludge is traveling within the forcemain. Based upon the current preliminary design, the velocity of the lime sludge in the forcemain will be 4.64 feet/second at the design flow rate of 800 gpm. This will create a force of 0.14 psi, which will have no impact on the stability of the connection of the injection string to the forcemain or on the injection string itself.

Based upon data supplied by the pipe manufacturer, the long string casing (8-inch) and the injection string casing (6-inch) will have the following strengths:

- *Tensile Strength: 60,000 psi minimum for both strings*
- *Yield: 35,000 psi minimum for both strings*
- *Burst Pressure: 17,080 psi for injection string and 15,070 psi for long string*

The lime sludge will be pumped from the wet well at the WTP when blowdowns occur. As per Section 3.2 of the PA, blanket blowdowns on average occur once every 3 hours (6 to 8 times in a 24-hour period) and grit blowdowns occur twice in a 24-hour period. Therefore, the flow of lime sludge from the wet well to the injection well will be intermittent. Once the lime sludge enters into the injection string from the forcemain, it will drop by gravity into the mine. As the lime sludge reaches the connection, the pressure will increase and "slug" of lime sludge will pass from the forcemain to the injection string. As the end of the slug passes, a vacuum will be created in the pipe. Each injection well will have an air/vacuum release valve installed at the well-head. This will allow air to either be released as the lime sludge approaches the injection well or be allowed to enter the pipe as the last of the lime sludge from a particular *blowdown passes into the mine. Due to this, there will be very little if any force exerted on the injection string pipe as the lime sludge is delivered into the mine.*

Much greater force will be generated once the lime sludge reaches the floor of Level 1 of the mine. Calculations conducted by the energy dissipater manufacturer estimate that at the floor of Level 1 of the mine approximately 9,000 pounds of force will be generated. The energy dissipater will be able to absorb and release most of the energy created by this force. When going to final design of the project, the design may or may not incorporate the large radius pipe at the floor of the mine. If this pipe is used, energy will be further dissipated so that the lime sludge can be conveyed by gravity to the injection points within the mine.

The large radius bend, if incorporated into the final design, will be constructed of schedule 80 carbon steel and the lateral distribution pipes will be constructed of schedule 40 carbon steel. The entire assembly will be secured and anchored so that all of the forces can be dissipated and absorbed at the bottom of the mine. Due to the vectors of force that will be generated, and due to the energy dissipating features of the design, very little, if any force will be translated upward into the injection string to cause any stress or vibration between the long string casing and the injection string casing.

12.3.1 IW Drilling Method

The wellhead for each IW will be contained within a reinforced concrete manhole. The IW's will be constructed after the manhole excavation and prior to placement of the concrete slab. Each manhole will be 6-feet in diameter. The excavation will be conducted such that IW location is in its approximate center. At the bottom of the excavation, an 8-inch layer of gravel or crushed rock will be laid and leveled and a 1-inch steel plate will be placed on top. The steel plate will have a hole in the center through which the borehole will be constructed. The hole in the steel plate will have notches at opposite ends, as depicted on **Figure 12.2**. The purpose of the notches is to allow for the 6-inch diameter IW pipe to be suspended during construction.

The elevation of the steel plate, directly adjacent to the hole will be surveyed using NAVD 88 to establish the surface elevation for the construction of the IW's. All depths recorded while drilling will be based upon this elevation. The surface elevation for the four IW's is anticipated to range between approximately 670 to 700 feet above MSL.

Each IW will be constructed inside of a drilled borehole to an approximate depth of 250 feet bgs, drilling through the ceiling of Level 1 of the mine. The borehole will be 10-inches in diameter to a depth of approximately 240 feet bgs, or 10 feet above the ceiling elevation of Level 1. Each IW location will be surveyed by an Illinois registered land surveyor in the state plane coordinate system and using NAVD 88. This information will be used, along with the surveyed ceiling elevations obtained from the mine survey, to insure that the 10-inch diameter borehole extends to the proper depth. Starting at an approximate depth of 240 feet bgs, the borehole will continue at a diameter of 8-inches until it breaks through the ceiling of Level 1. The 8-inch diameter borehole will be drilled at the center of the 10-inch diameter borehole.

Both the 10-inch diameter and 8-inch diameter boreholes will likely be drilled using an air rotary wire line drill rig as described in **Section 5.0** of this narrative. Drill cuttings will *be logged for determination of the geology and this information will be recorded and submitted as part of the Well Completion Report.* Drill cuttings will accumulate within the manhole excavation and will be removed as needed during the drilling process. Drill cuttings will be stored on-site for later disposal or reuse.

If, for any reason, the boring needs to be stopped and the location abandoned, the drill rig will be pulled off the location and a new satisfactory drilling location will be located in the immediate vicinity. The abandoned borehole will be filled from the bottom to the ground surface with portland cement.

12.3.2 Injection Well Design, Specifications and Construction Methodology

Each IW will be doubled-cased and will be connected at the bottom to the distribution piping system within Level 1 of the mine. The *long string* casing will be 8-inch diameter schedule 40 carbon steel pipe a coal tar epoxy exterior coating. The sections of pipe will be threaded and placed within the 10-inch diameter borehole at its center. The annulus between the borehole and the 8-inch galvanized steel pipe will be *sealed using portland cement* from the bottom of the borehole to a depth that is 2-*feet* below the elevation of the bottom of the manhole excavation. The remaining 2 feet will be filled with concrete (as depicted on **Figure 12.2** below). *The portland cement in the annulus of the long string casing will be place via a tremie hose. The hose will be worked around the casing to insure even distribution and to avoid bridging. The anticipated depth is 290 feet and the anticipated volume of cement to be used is 750 to 800 gallons.*

The specifications for the long string casing and the injection string casing are as follows:

Long string casing:

- *Depth: 300 feet*
- *OD: 8-inches*
- *ID: 7.356-inches*
- *Weight: 28.5 lbs/ft*
- *API Grade and thermal conductivity: TBD information will be included in the*

Well Completion Report

- *NO couplings will be used*

Injection String Casing:

- *Depth: 290 feet*
- *OD: 6-inches*
- *ID: 5.44-inches*
- *Weight: 19 lbs/ft*
- *API Grade and thermal conductivity: TBD information will be included in the Well Completion Report*
- *NO couplings will be used*

After the 8-inch diameter *long string casing* has been installed, *cemented* and sealed, the drilling assembly will be lowered into the pipe to drill the remaining 10 feet of rock between the bottom of the borehole and the ceiling of Level 1 of the mine at a diameter of 8-inches. The timing of the breakthrough into the mine will be communicated in advance with Lafarge to insure that personnel are kept out of the area.

Additionally, as part of the specifications for the project, a cement bond log will be conducted on every well constructed as part of the project (four IW's and one EW). This data will be included as part of the Well Completion Report and will include an interpretation of the results by a qualified log analyst.

Once the drilling has been completed, construction of the 6-inch diameter *injection string casing* will begin. The *injection string casing* will be 6-inch diameter schedule 40 *carbon* steel. The sections of pipe will be threaded together will be placed between the pipe sections to provide a seal. Once treaded together, the pipe sections will be bead welded to provide an additional seal and to enhance the integrity of the pipe during construction and during the operational life of the IW's.

Each section of *injection string casing* will have welded steel tabs toward the top of the flight, a few inches down from the shoulder. *Drillers widely use these welded tabs because they greatly increase the efficiency of the installation of the injection string. The tensile strength, the yield and the burst pressure rating are all several times higher than the maximum load of the entire 300 foot injection string. Based upon this evaluation, there should be no deformation at the end of the injection string.* The section of pipe will be rotated such that the steel tabs will rest on the steel plate to hold the *injection sting casing* in place during construction.

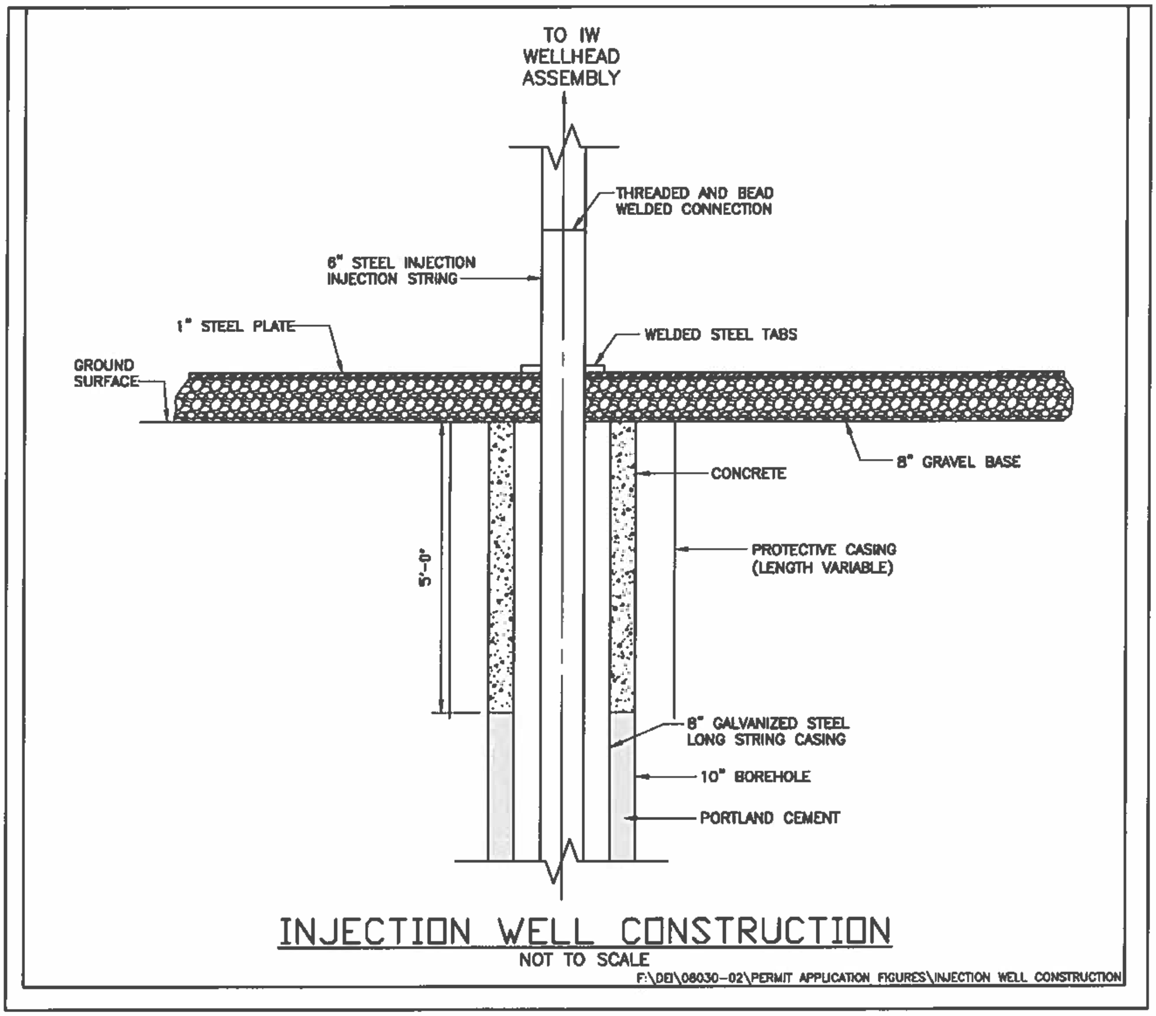


Figure 12.2 – Conceptual Diagram of IW Construction

Once the new section of pipe is threaded and welded to the preceding pipe section, the entire pipe length will be rotated so that the tabs can move through the grooves on opposite sides of the hole through the steel plate (see **Figure 12.3** below). This allows for the new section of pipe to be lowered into the hole. The entire pipe length will be rotated again, so that the steel tabs on the newly attached section of the pipe is rotated 90° from the grooves on the steel plate so that the tabs rest on the steel plate, holding the pipe length in place to attach a new section of pipe. This process will be repeated until the 6-inch pipe protrudes at least 24-inches below the ceiling of Level 1 of the mine.

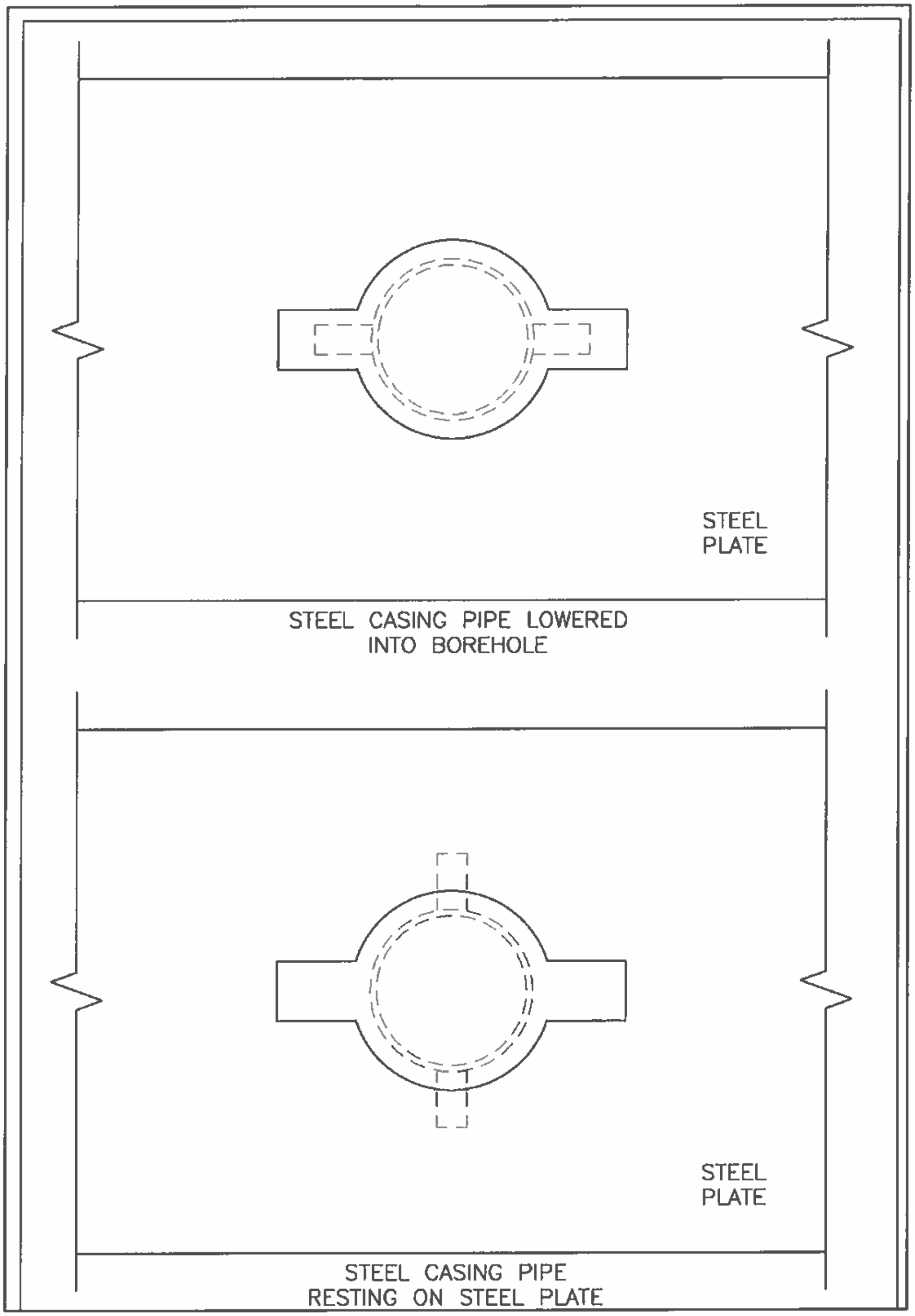


Figure 12.3 – Plan View of Steel Drilling Plate

During the construction of the injection string, the maximum allowable loads will need to be considered. As previously stated, the strengths of the long string casing and injection string casing are:

- *Tensile Strength: 60,000 psi minimum for both strings*
- *Yield: 35,000 psi minimum for both strings*
- *Burst Pressure: 17,080 psi for injection string and 15,070 psi for long string*

Additionally, the weight of the pipe is as follows:

- *6-inch injection string pipe: 19 pounds per foot*
- *8-inch long string pipe: 28.5 pounds per foot*

Based upon a maximum injection string length of 300 feet (the depth to the top of ceiling of Level 1 of the mine is about 240 feet bgs) the axial injection string load in air will be approximately 5,700 pounds. The nominal wall thickness for schedule 40 steel pipe is 0.28-inches. Therefore, the joint force of the entire 300 foot string across the cross-sectional area of the pipe results in the following:

- *Wall thickness = 0.28 inches*
- *ID = 5.44 inches*
- *OD = 6.0 inches*
- *Cross sectional area of steel pipe material = 5.02 square inches*
- *Force exerted on the pipe at joints = 5,700 pounds/5.02 in^2 = 1,133 psi for entire injection string*

Therefore, at the top of the injection string where the highest weight and stress will occur at the uppermost pipe joint, the force exerted on that joint will be 1,133 psi. The threaded and welded joints will have a tensile strength equal to or greater than the tensile strength of the pipe. This is because during the welding process, the steel that comprises pipe is melted and incorporated into the welded material that will be holding the pipe sections together. The maximum allowable stress, which is 33% of the tensile strength of the pipe, is approximately 20,000 psi. Therefore, the maximum allowable joint stress of 20,000 psi is approximately 17.5 times greater than the maximum force of 1,133 psi that will be exerted at the upper-most pipe joint based upon the total suspended weight of the injection string.

Using the 20,000 psi maximum allowable joint stress and the total cross sectional area of the pipe of 5 in^2, the maximum allowable suspended weight of the string is approximately 100,000 pounds.

Although the pipe and the welded connections would be water tight and strong enough to be used in the design without threading, threading was incorporated into the design *as a factor of safety and to provide structural stability to the pipe sections.*

Additionally, the drill rig that is proposed to be used in this project must have a hold back rating that is higher than the maximum axial load of the injection string pipe. For instance, an air rotary Drill Tech T40 drill rig has a rated hold back of 26,500 pounds. Therefore, the drill rig itself can suspend the entire maximum axial load of the injection string with a comfortable factor of safety. Considering this fact, and considering the fact that the pipe sections will be threaded and welded together, the drill rig would be able to hold the entire string in place without the use of the welded steel tabs. Upon conversations with drilling contractors, it is preferable from an efficiency and safety stand point to construct the injection string pipe sections using the welded steel tabs and the notched steel plate as is currently described in the PA.

Once the construction of the injection string has been completed an additional steel plate will be placed around the section of pipe protruding above the bottom of the manhole excavation, on top of the steel drilling plate (see **Figure 12.4** below). The pipe will be welded to the steel plate.

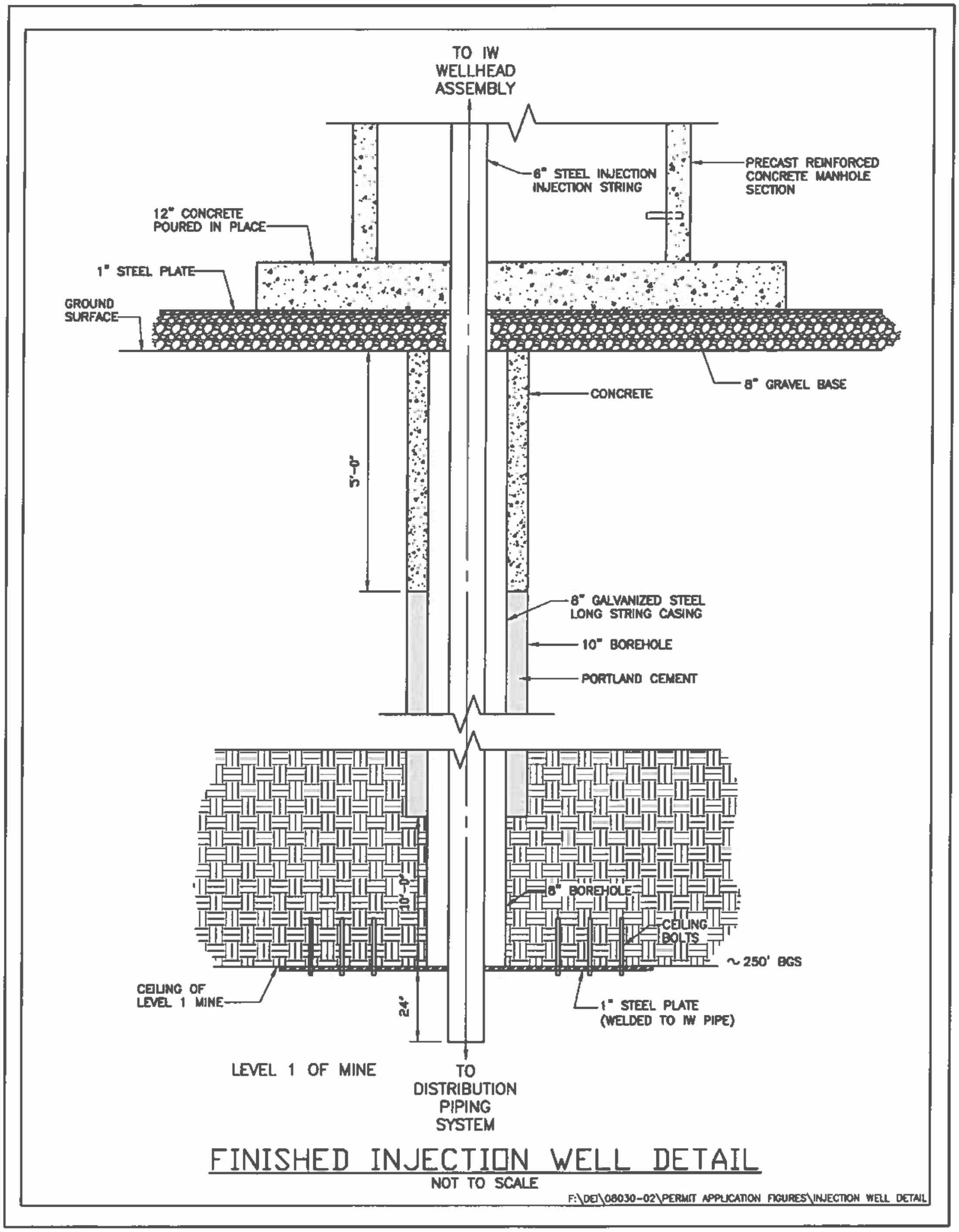


Figure 12.4 – Finished IW Detail

Concrete will then be poured across the entire bottom of the manhole excavation to form a pad 12-inches thick. Another steel plate will be welded to the bottom of the 6-inch ***injection string casing*** that is protruding into Level 1 of the mine. This steel plate will be bolted to the ceiling for the purpose of securing the bottom of the IW to the ceiling of Level 1. The bottom of the ***injection casing*** will later be connected to the distribution piping system.

12.3.3 Connection of IW to Forcemain and IW Wellhead Completion

Once the concrete in the bottom of the excavation has cured, the manhole sections will be lowered and secured to the concrete pad. The 8-inch diameter forcemain from the WTP with a Y mechanical fitting will be connected to the top section of the ***injection casing connected to a pipe reducer***, and will exit the manhole assembly, above ground surface, with a gate valve and air vacuum release valve. The gate valve will allow the COA to connect a fire hydrant hose for the purpose of flushing the ***injection casing*** and distribution pipes, if needed. The air vacuum release valve will provide air balancing during pumping of the lime sludge into the mine (see **Figure 12.5** below).

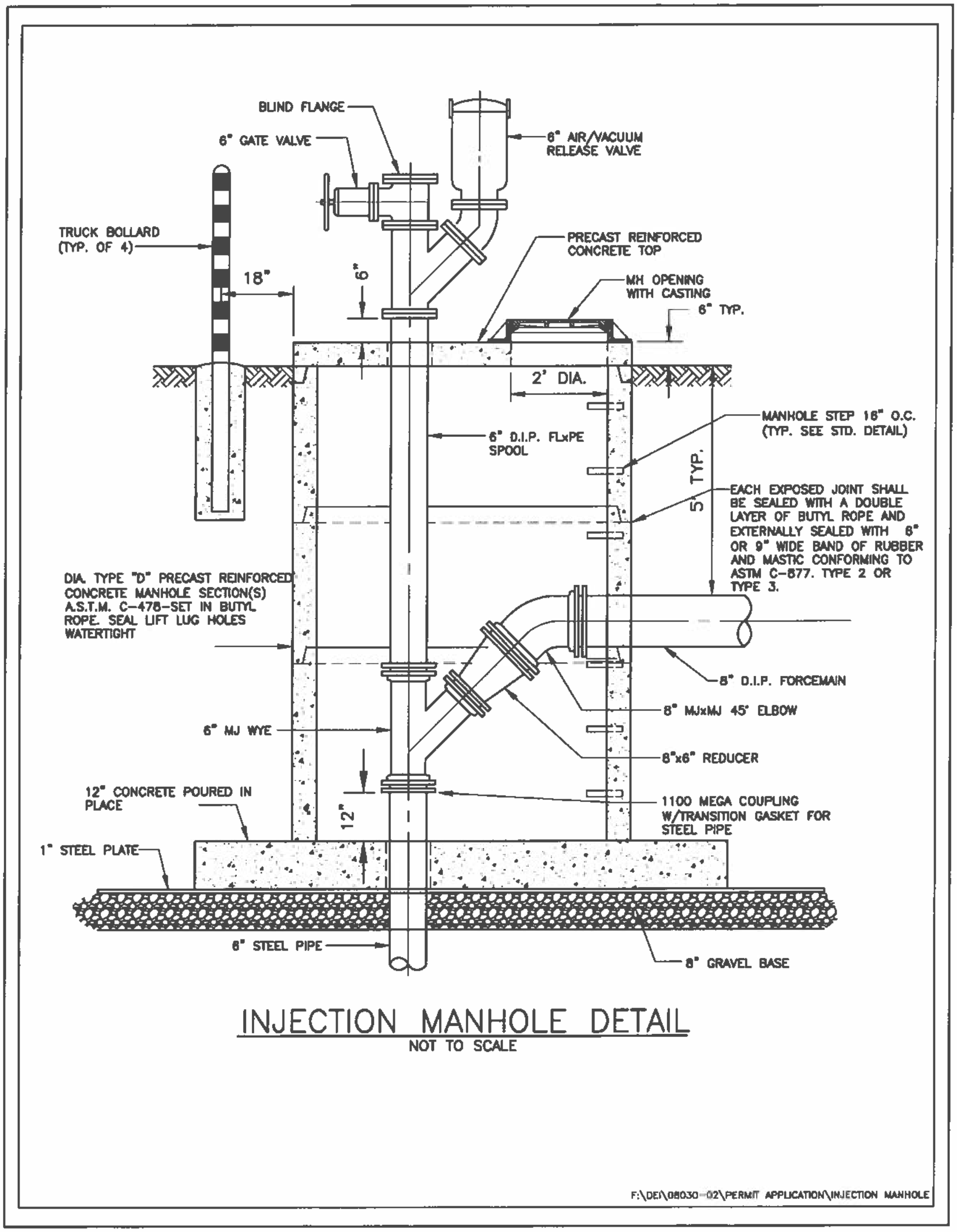


Figure 12.5 – IW Well Head Detail

12.4 Mechanical Integrity Testing

Mechanical Integrity Testing ("MIT") program will include the following elements:

- *Pressure testing on the IW's and the EW;*
- *Cement bond logging on the IW's and the EW; and*
- *Manhole and IW wellhead inspections.*

12.4.1 Pressure Testing

Air pressure testing will be conducted on the casing for the IW's and EW to test for mechanical integrity ("MI"). The testing will have the following general elements:

- *As much of the 300-foot length of casing will be tested;*
- *Inflatable packers will be used to seal the injection string at the top and the bottom;*
- *The packers will be inflated and the test will begin;*
- *The test duration will be 30 minutes;*
- *Pressure measurements will be made every 5 minutes;*
- *The casing will be pressurized to 125 psig;*
- *A pressure loss of greater than 10% will initiate a response; and*
- *A pressure loss of 10% or less, and the casing would be deemed to have MI.*

In the event of a pressure loss of greater than 10%, the following actions will be taken:

- *All equipment will be inspected and tested for defects;*
- *The test will be conducted again;*
- *If the results are the same, then the packers will be pulled and the source of the leak will be identified and potential corrective actions will be evaluated;*
- *If the results are 10% loss or less, then the casing will be deemed to have passed the test.*

All testing will generally conform to the procedures outlined in "Standard Specifications for Water and Sewer Main Construction", Illinois Society of Professional Engineers, May 1996, pages 105 and 106 and USEPA, Region VIII Ground Water Section Guidance Document No. 39, "Pressure Testing Injection Wells".

12.4.2 Cement Bond Logging

As part of the bid specifications for the project, cement bond logging will be required for all wells. A qualified subcontractor will be retained and the presentation in the log will minimally include:

- *A correlation curve (gamma ray) and travel time (μsec);*
- *Amplitude (mV);*
- *Attenuation (dB/ft) curves;*
- *Full wave form display (μsec); and*
- *The Cement Bond Log will be interpreted by a qualified log analyst and this report will be included in the Well Completion Report.*

12.4.3 *Manhole Structure Inspections*

On at least a semi-annual basis (twice per year), all well heads and manholes will be inspected for integrity. Valves and other components will be inspected. Additionally, the surface valving along the forcemain will also be inspected.

All test results will be presented in the Well Completion Report.

12.5 *Distribution Piping and Injection Points*

In order to deliver the lime sludge from the IW's into Level 2 of the mine a network of distribution piping will be constructed along the floor of Level 1 of the mine. The goal of this piping network is to dissipate the energy that will be imparted to the sludge as it drops from the forcemain just below the ground surface into the mine and to distribute the lime sludge as evenly and space-efficiently as possible by gravity.

The IW's, which will be anchored to the ceiling of Level 1, will have a minimum of two feet of pipe protruding into the mine. The IW pipe will be connected to a vertical pipe with a 10-foot radius bend. The bend will have support structures connected to it which will be anchored to the floor of Level 1 of the mine. Horizontal piping will be connected to the end of the radius bend, leading to clusters of 18 uncased, drilled holes (injection points) through the sill between Levels 1 and 2 of the mine.

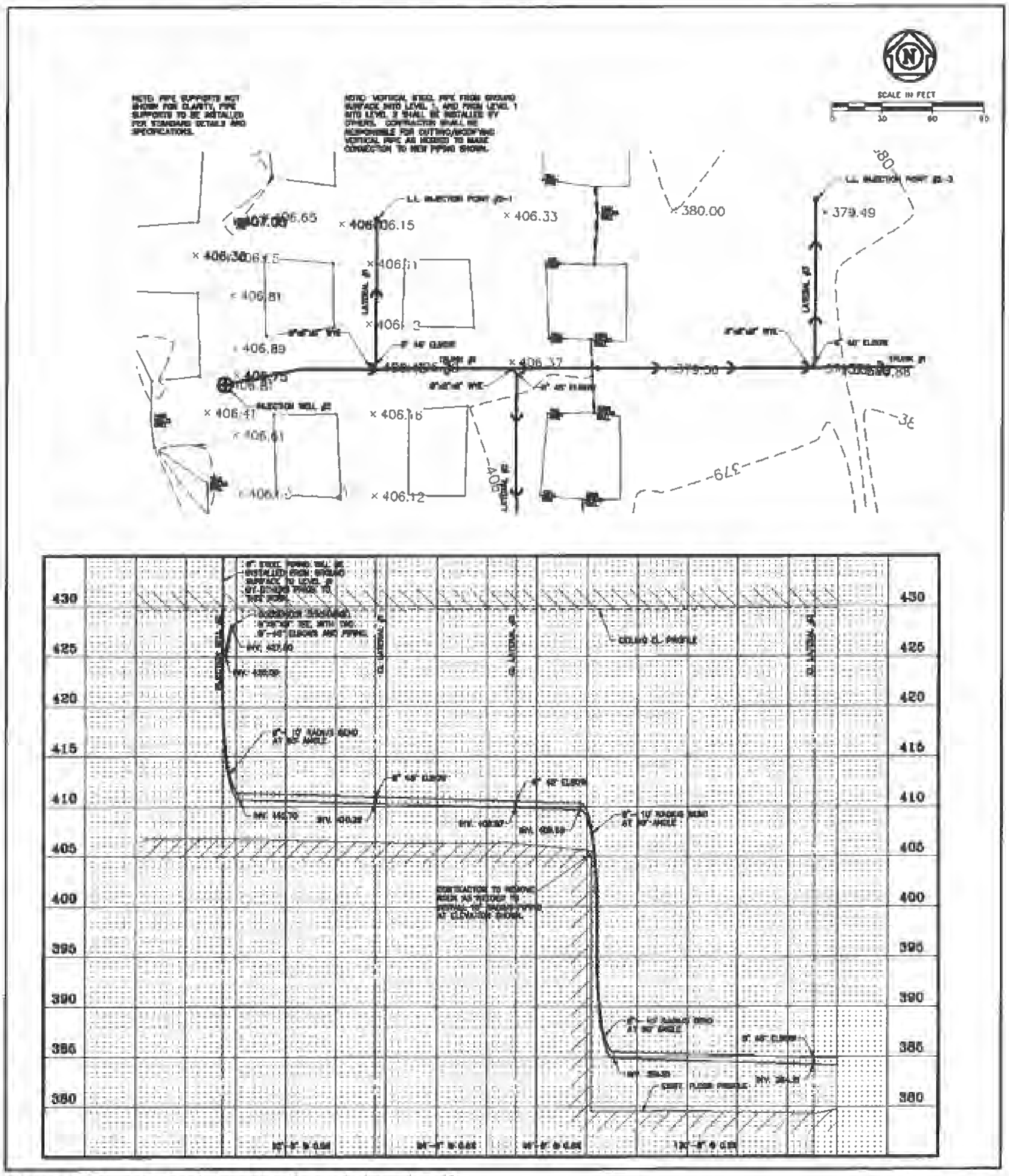


Figure 12.6 – Typical distribution piping detail

The injection points will likely be 10-inch diameter drilled holes and will be uncased. There will be a 90-degree connection from the pipe along the floor of Level 1 of the mine into the injection points. This connection may be anchored to the native rock to enhance its stability. A vertical pipe will be connected to the 90-degree connection that will protrude through the ceiling into Level 2 of the mine. A fitting may be connected to the end of the pipe with 4, 90-degree openings to enhance the distribution of the lime sludge as it enters Level 2 of the mine, if determined to be optimal. The openings of the fitting will be parallel to the floor of Level 2, suspended approximately 2 feet from the ceiling. From this fitting, the lime sludge will deposit into the second level of the mine. The flow of lime sludge into the distribution piping network will be modeled using XP-SWMM or a similar program in order to properly size the pipes in the final design phase in order to equally distribute the flow of lime sludge to the various injection points. Based upon preliminary modeling, the diameter of the distribution piping will range from 8-inches to 4-inches.

The 10-foot radius sections connecting the IW's to the horizontal distribution pipes will be constructed from 8-inch diameter, schedule 80 carbon steel pipe. Additionally, approximately 50-feet of 8-inch, schedule 80 carbon steel pipe will be connected to the end of the radius bend section (as stated above, vortex energy dissipaters will be fitted at the ends of the four radius bend sections and based upon the final design calculations, this may or may not allow for the radius bend section to be eliminated from the design). The horizontal distribution piping will be 4- to 8-inch diameter schedule 40 carbon steel. The pipe and fitting joints for all of the pipes described above will be fully welded and the fittings will either be Y joints or 45-degree elbows. The horizontal piping will have a minimum slope of 0.5% to drain by gravity to the injection points. Each radius section and each injection point will have air vent pipes incorporated into the design.

The top of the distribution pipes, near where they connect to the bottom of the IW's will have an air vent pipe connected to it. This is the point at which lime sludge will eject in order to fill Level 1 of the mine once Level 2 has been filled to its maximum capacity. Please see **Section 12.7** of this narrative for a more detailed description of this process.

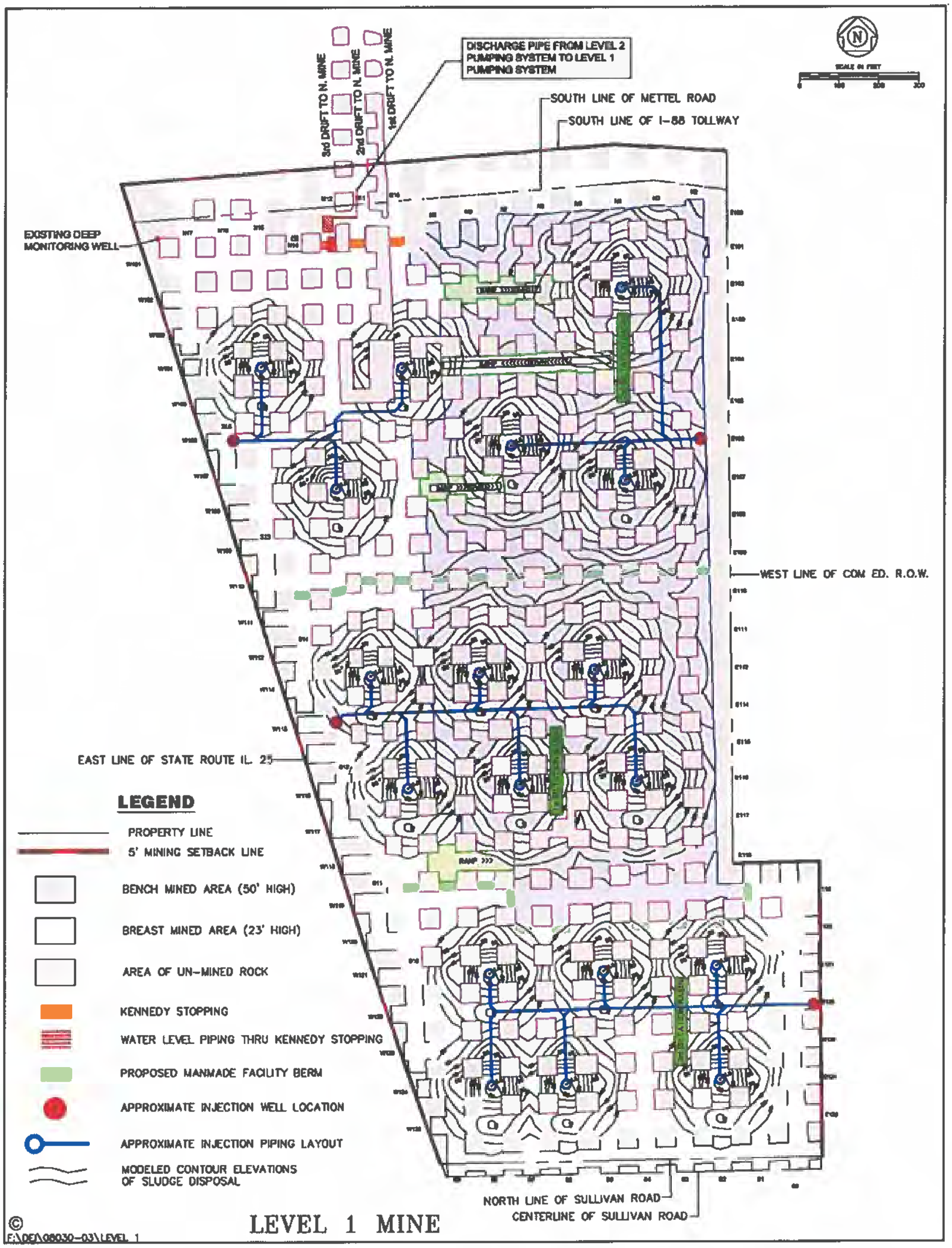


Figure 12.7 – Map showing Level 1 mine configuration and distribution piping system layout

12.6 *Siltation Basins and System Operation*

The system will be constructed so that each of the 4 IW's will have dedicated distribution piping and injection points connected to it. This is done to direct the lime sludge to evenly distribute within each of the three siltation basins that will be created on Level 2 of the mine. The IW's will be connected in the following manner:

- IW-1 will be connected to 6 injection points at the south end of the mine and will deposit sludge into Siltation Basin #1;
- IW-2 will also be connected to 6 injection points and will deposit sludge into Siltation Basin #2; and
- IW-3 and IW-4 will both be connected to 3 injection points each and will deposit sludge into Siltation Basin #3.

By constructing berms between certain pillars on Level 2 of the mine, three siltation basins will be created, such that each injection well will deposit sludge into these siltation basins. The purpose of the basins is to insure that the solids deposit from the south end of the mine, progressing to the north end, while allowing the decant water to travel through the berms to the north end of the mine for extraction to the surface.

Each injection well will be initially operated one at a time, in sequence, starting with IW-1 at the south end of the mine, progressing in order to IW-4 at the north end of the mine. During this initial period, each well will be operated for a limited period of time (currently anticipated to be 3 to 6 months per well) to create a "blanket" of lime sludge on the floor of the mine. The purpose of this initial operational stage is to allow the lime sludge solids to fill any unfilled joints that may exist on the floor of Level 2 of the mine. After this initial operation period, each injection well will be operated in sequence for approximately one year or more each for the purpose of exercising valves and filling the mine in approximate equal volume until that area of the mine on Level 2 has reached its maximum sludge storage capacity.

Routine maintenance and inspection of the delivery, injection and extraction systems will be conducted in accordance with all procedures specified. Also, the bulkheads will be routinely monitored, repaired and maintained by Lafarge for any evidence of leakage and overall integrity.

Additionally, the lime sludge influent into the forcemain from the wet well will be routinely sampled and analyzed for chemical parameters along with the supernatant discharge from the extraction well and the chemistry of the ground water from the on-site monitoring well. Please refer to **Section 16.0** for a more detailed description of the system monitoring that is proposed.

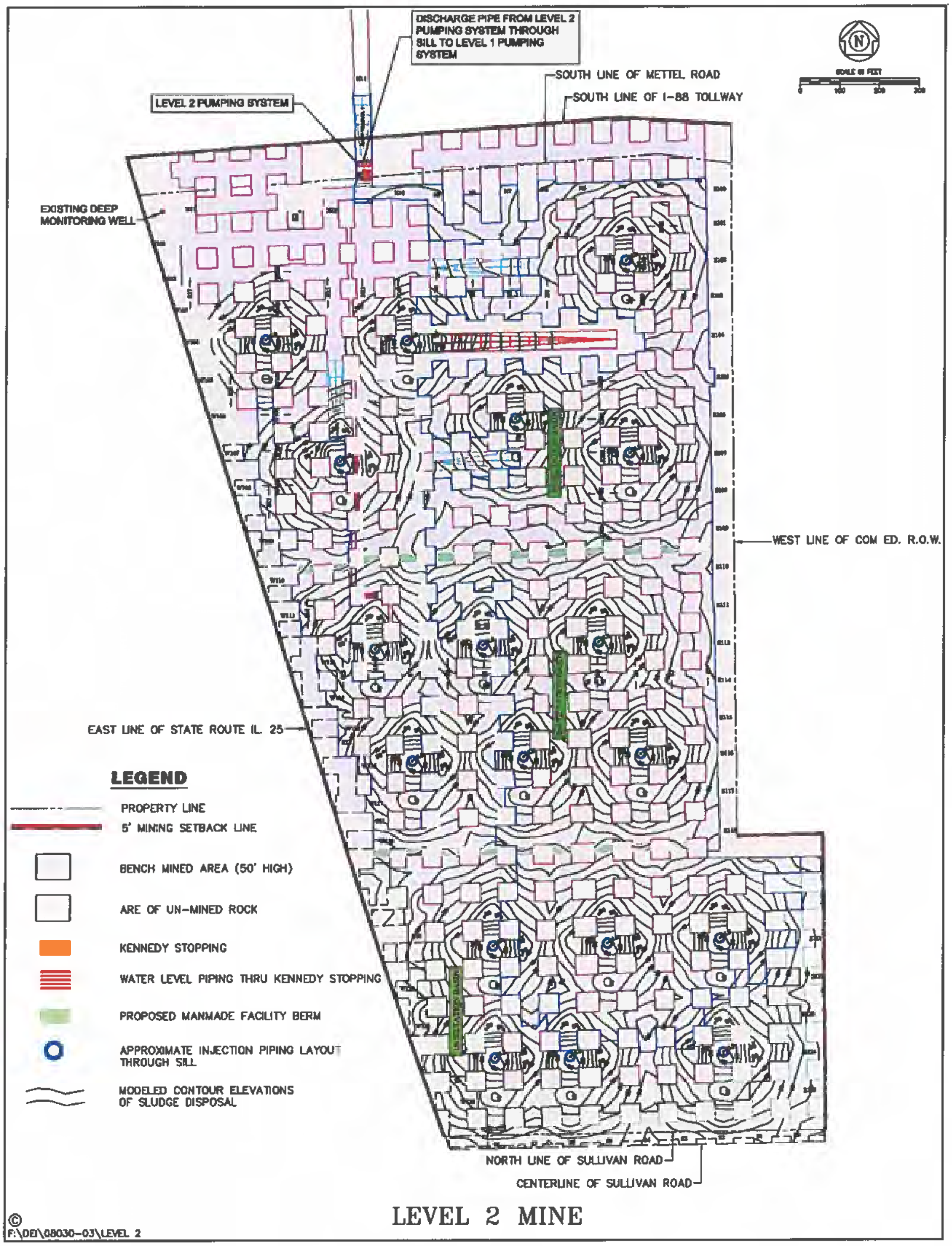


Figure 12.8 – Map showing Level 2 mine configuration, injection points and modeled lime deposition

12.7 Extraction System

As discussed in **Section 11.0**, the bulkhead on Level 2 and one of the bulkheads on Level 1 of the mine will be constructed with piping through it in order the extract the supernatant that will form on top of the lime sludge solids as the sludge dewaters after injection. The supernatant will be then be pumped to the surface via a single extraction well and discharged to a nearby FMWRD sanitary sewer.

12.7.1 Supernatant Inlet Piping

The level of the decant water, or supernatant, will be maintained at a maximum head of 5-feet. This maximum head level will be maintained by creating supernatant inlets constructed through the bulkheads. Each of the flanged inlets on the end of the pipe into the lime sludge storage area will be spaced 5-feet apart, starting with the first inlet approximately 5-feet from the floor of the mine. As the solids level rises, the valve on the lower inlet pipe will be closed and the valve on the next highest inlet pipe will be opened. This will progress until the storage area is completely filled with solids. The supernatant inlets will have sludge monitoring devices to detect the elevation of the solids prior to reaching the inlet pipe in order to determine the proper time to open the next highest inlet valve.

The inlet pipes will be connected together to a discharge line that will connect to the pumping system that will be located north of the bulkhead on the dry side of the mine. The pumping, electrical and control systems will be housed in a prefabricated building. The building will be transported into the mine and will be anchored in place adjacent to the bulkhead on a concrete slab. The discharge line from the inlet pipes will be connected directly to the pumping system inside of the building. In order to prevent potential damage to the pumps, each inlet pipe on the wet side of the bulkhead will have an inverted elbow to prevent any debris from entering the pipes.

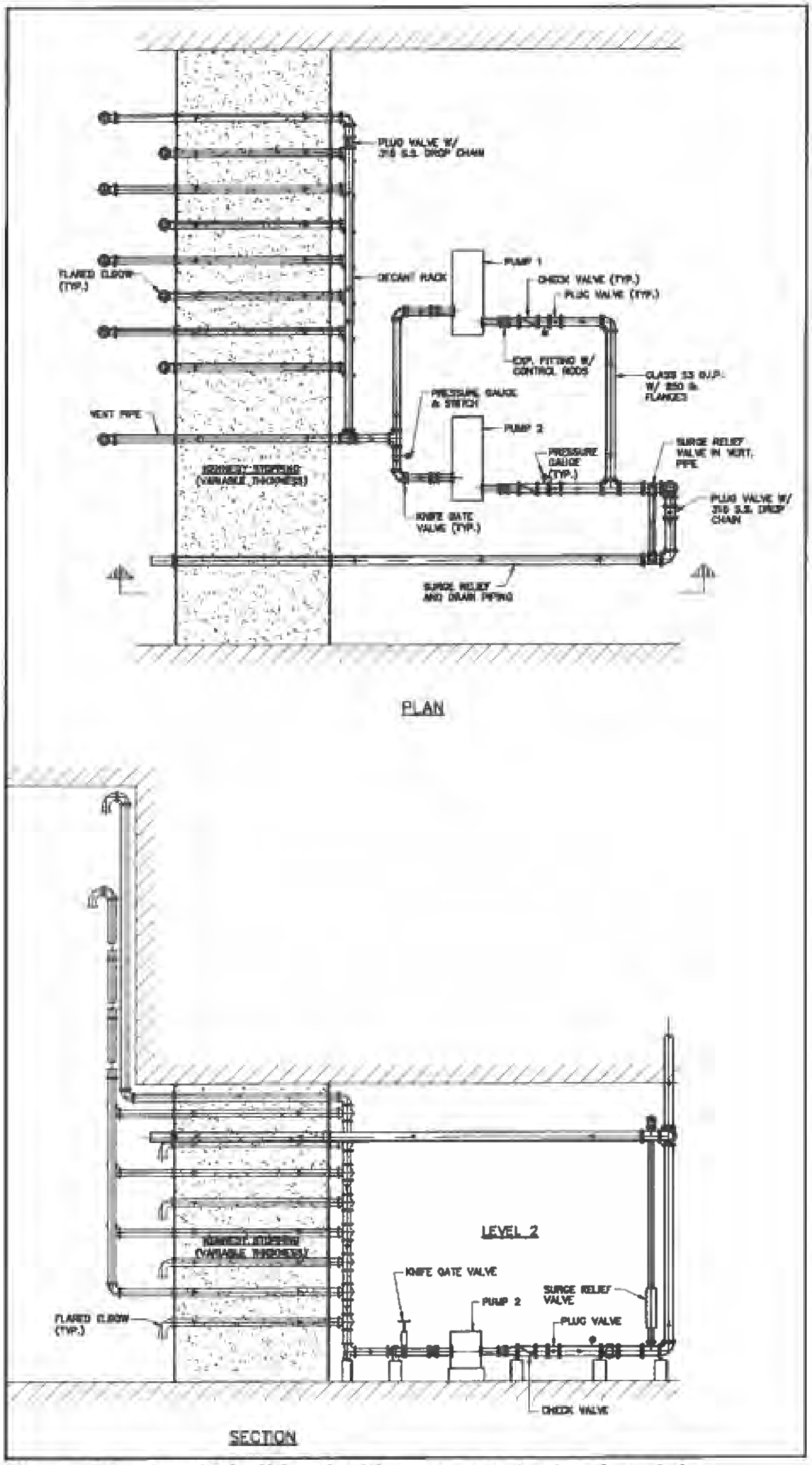


Figure 12.9 – Level 2 bulkhead with supernatant extraction piping

12.7.2 Extraction Pumps, Valves and Controls

The supernatant must be collected from the lime sludge detention area and pumped from the floor of Level 2 of the mine to the ground surface. The elevation of the floor of Level 2 of the mine in the area where the pumping system will be located is approximately 300 feet above MSL (NAVD 88). The surface elevation at the proposed location of the EW is approximately 670 feet. The vertical distance that the supernatant needs to be pumped is therefore approximately 370 feet.

The extraction pumps proposed in the preliminary design will be end-suction, horizontal, close coupled cast iron construction with the following performance specifications:

- Flow rate: 250 gpm
- Total Dynamic Head: 380 feet (minimum)
- Speed: 3,550 rpm
- Motor size: 50 HP

The pumping system will include gate valves, surge relief valves and control check valves to control potential backflow into the system. The system will include an MCC and control panels. The system will have pressure gauges to read the suction and discharge pressures of the system.

A new electrical feed will be supplied to the mine. There is an existing Commonwealth Edison line that currently feeds the air venting system for the Lafarge mining operations. A new 15 kV line will feed down to a point near the extraction pumping station. A fusible primary switch, a 480-volt transformer and a MCC will be installed and housed in the pumping system walk-in type enclosure. The MCC will be a 600-volt class suitable for operation on a three-phase, 60 Hz system. The MCC will provide the electrical power to the pumps, control valves and the air compressor that comprise the extraction pumping system.

12.7.3 Extraction Well

The EW will be designed, drilled, constructed and surface completed in the exact manner as the 4 IW's. Therefore, please refer to **Section 12.3** for the specifications of the IW design and construction.

12.7.4 Discharge to Sanitary Sewer

The EW will be connected to a forcemain as depicted on **Figure 12.5**. The forcemain will be designed and constructed with the same specifications as the blowdown forcemain. The discharge forcemain will be connected to the FMWRD sanitary sewer for supernatant disposal. All necessary permits for this connection and discharge will be obtained prior to the operation of the lime sludge injection system.

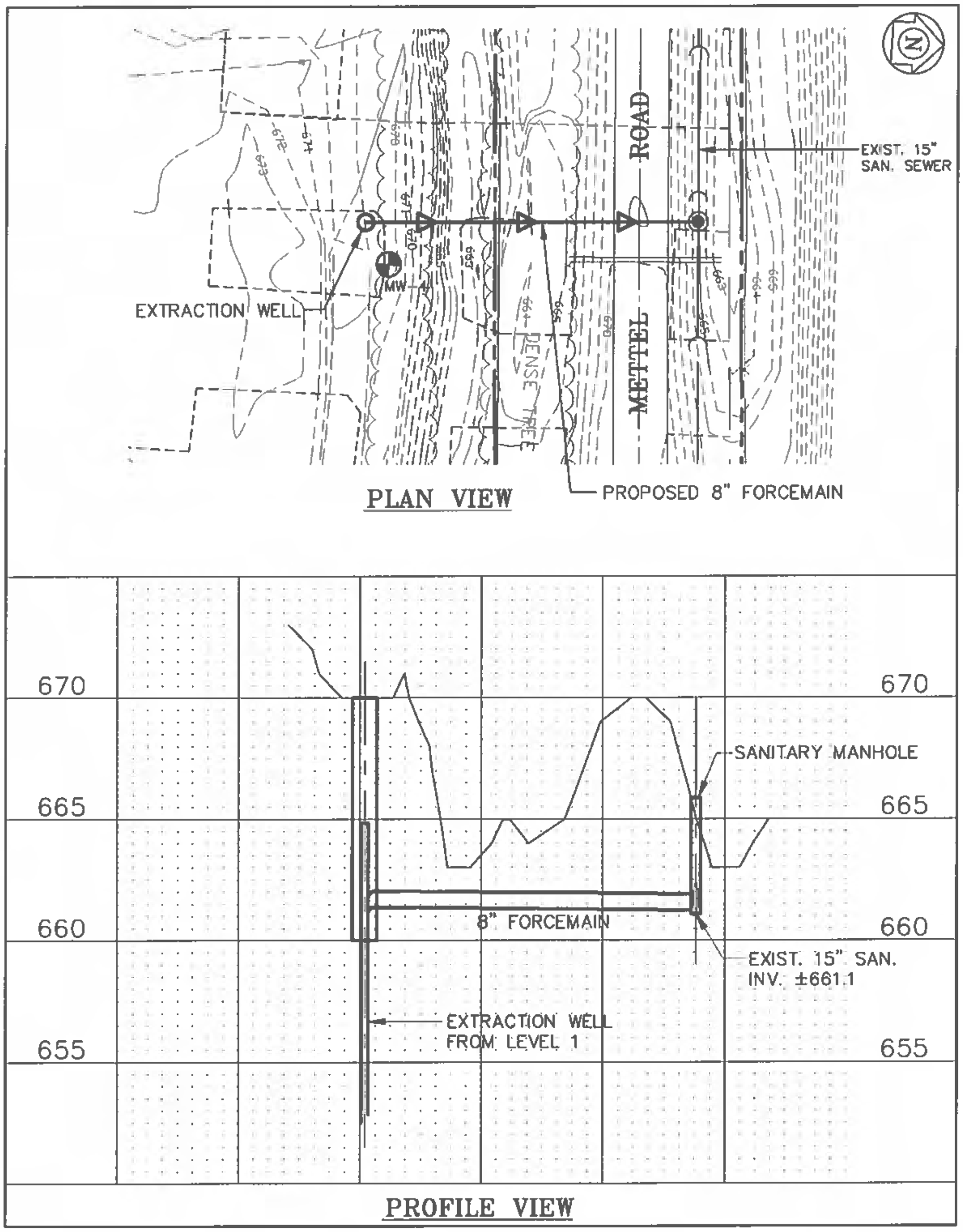


Figure 12.10 – Discharge forcemain and connection to sanitary sewer

12.8 System Pilot Testing, Operation and Maintenance

This subsection discusses the pilot testing, operation and maintenance of the system.

12.8.1 System Pilot Testing

Once the entire system is constructed, a pilot test will be conducted using water. The test will be conducted while the mine is still and accessible and all safety structures are still in place so that the function of the injection system and distribution piping can be directly observed. The mine will be cleaned and debris removed and all of the mapped, unfilled joints will be sealed around the perimeter of and floors of Levels 1 and 2 prior to the initiation of the test.

Water will be introduced into the system through the wet well so that the blowdown forcemain pumping system can be tested including the SCADA, electrical and pumping system and all associated valves. The distribution piping and their connection to both the bottom of the injection wells and the injection points will be tested to be sure that there are no leaks in the pipe joints and connections and to observe the structural stability of the system. The extraction system will also be testing using a water supply connected to the inlet pipes since there will not be enough water at the bottom of the bulkhead to reach the first inlet pipe from the injection system testing.

All observations and data will be recorded and evaluated and all necessary system modifications will be made until its operation is optimal and is performing as it was designed. The pilot testing will be conducted over a period of a few months and once completed, the mine will be cleaned, sealed and the remaining system will be completed in preparation of full-scale operation.

All of the results of the pilot test results will be incorporated into the Well Completion Report.

12.8.2 System Operation and Maintenance

Once all tasks associated with system construction have been completed, the IW's will be initially operated one at a time, in sequence, starting with IW-1 at the south end of the mine, progressing in order to IW-4 at the north end of the mine. During this initial period, each well will be operated for a limited period of time (currently anticipated to be 3 to 6 months per well) to create a blanket of lime sludge solids on the floor of the mine. The purpose of this initial operational stage is to create a blanket of lime sludge on the floor of the mine so that the solids have an opportunity, early in the operational life of the system, to infill any unfilled joints that may exist on the floor of Level 2 of the mine that haven't been sealed by Lafarge.

After this initial operation period, each injection well will be operated in sequence as described above for approximately one year or more for each well for the purpose of exercising the valves and filling the mine in approximate equal volumes for each siltation basin, until that area of the mine on Level 2 has reached its maximum sludge solids storage capacity.

The performance of all system components will be monitored and the entire system will be maintained, and wear parts replaced as needed and in accordance with the manufacturers recommendations.

12.8.3 Filling of Level 1

As previously stated, Level 1 of the mine will fill with lime sludge after Level 2 has reached its maximum storage capacity. As previously stated, cones and beaches will form on Level 2 directly under the injection points. As the level of the lime sludge solids reach the ceiling of Level 2, it will eventually block the end of the distribution pipe in the injection hole. As sludge continues to build, it will eventually be forced through the injection point and into the end of the distribution pipe. Continued injection of sludge at this point will eventually cause the distribution pipe to fill with sludge and it will be ejected out of the air vent pipe at the top of the distribution pipe, near its connection to the bottom of the IW.

At this point the air venting will occur at the air vent at the IW well head and Level 1 of the mine will begin filling with lime sludge. This will be monitored by sensors installed in the lowest inlet pipe on the bulkhead on Level 1. Once it is known that Level 1 of the mine is beginning to fill with sludge, the pumping system will be moved from Level 2 and reinstalled on Level 1. This will be completed by cutting and capping the discharge manifold line from the supernatant inlet pipes on Level 2. Then, the discharge line from the pumping system to the EW will be cut and capped and the entire pumping system (which is self-contained and mobile) will be moved to the dry side of the Level 1 bulkhead. The pumping system will then be connected to the supernatant discharge line and to the EW in the same manner as it was connected to the analogous structures on Level 2, the system will be tested and will be ready to extract supernatant from Level 1 of the mine well in advance of the supernatant starting to flow into the lowest inlet pipe. It should be noted that the EW pipe will be exposed from the ceiling to the floor on both Levels 1 and 2 of the mine allowing for the easy disconnection of the pumping system from the EW.

Filling Level 1 of the mine in this manner will add approximately 10 to 15 years to the effective operational life of the system.

12.9 *Injection Fluid Compatibility*

All of the system components are compatible with the lime sludge injection fluid. This fluid (solids and supernatant) has an average pH of approximately 10, which is the primary factor when considering the compatibility of the lime sludge with the various components of the delivery and injection system.

The WTP has used carbon steel piping inside of the plant and ductile iron pipe in each of the dewatering lagoons for the 30-plus years of operation. In that time, there has been virtually no corrosion of the pipes or unusual operational issues with the pumps, valves or other system components (other than normal wear and tear). This empirical evidence suggests that the carbon steel components (injection string casing, long string casing, extraction string casing and Kennedy Stoppings) and ductile iron components (suction piping, pump discharge piping and fittings, check and plug valves, forcemain piping and fittings and extraction piping) are all compatible with the injection fluid and will not be adversely affected by the pH of the injection fluid solids or supernatant nor will have a decrease in their normal life expectancy.

The evaluation conducted indicates that all system components are compatible with the lime sludge and the characteristics of the lime sludge will not represent a threat to the integrity of the delivery and injection systems.

All of the system components that come into contact with the injection fluid that will be incorporated into the final design of the system will be insured to be compatible with the characteristics of the lime sludge. Please refer to Section 9.0 for the complete characterization of the injection fluid. Please refer to the System Compatibility Table, in Exhibit C.

13.0 BENCH SCALE DEPOSITION TEST

The characteristics of the deposition of the lime sludge solids and generation of supernatant within the dewatering lagoons at the WTP is well known and predictable. It is anticipated that the deposition of the lime sludge will behave similarly inside of the mine. In order to evaluate how the lime sludge will deposit inside of the mine, a bench scale injection test was conducted. This section outlines this test and its results.

13.1 Test Set-up

A 1/100th scale model of the mine was constructed at the DEI facilities. The model was constructed out of wood and in the model 6-inches is equivalent to 50-feet in the mine. A wood frame was scaled and constructed to accommodate a cross section of 8 pillars and 9 cross-cuts. The pillars were constructed to be scaled at 50-feet square by 50-feet high using 6" by 6" wooden beams each cut 6" long. The spacing of the wooden pillars was scaled such that the cross-cuts were equivalent to the 47-foot pillar spacing that exists in the mine.

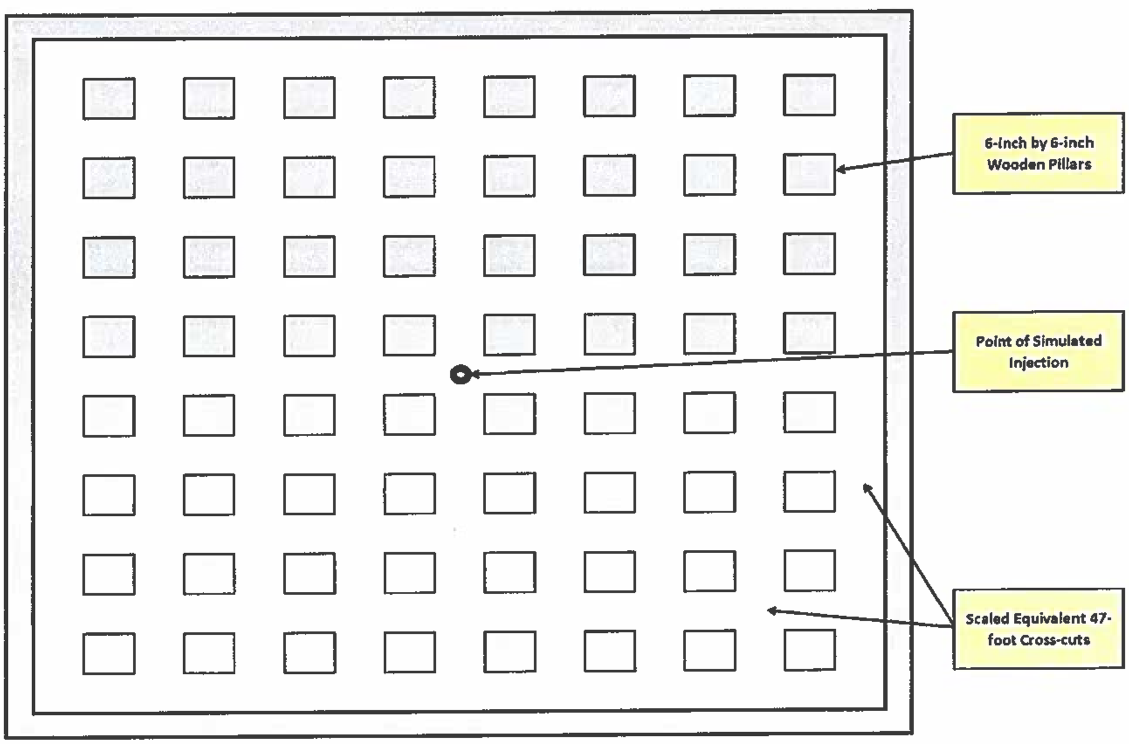


Figure 13.1 – Diagram of scaled model set-up

A hole was drilled in one end of the model and a plug was installed attached to a hose to simulate the supernatant inlet drain that will be constructed through the bulkheads in the mine. All of the wooden pillars were measured and nailed into place. All of the joints between the frame and pillars were caulked and the entire scaled model was then painted with water proof paint to make it water tight.

Photograph 13.1 – Scaled model of mine for simulation of lime sludge deposition

Copper tubing was suspended in the center of the model between the four pillars in the center exactly 6-inches above the floor of the model to simulate the maximum 50-foot drop that will occur in the mine from the injection points on the floor of Level 1 to the floor of Level 2.

A mixing tank was constructed out of a plastic tub and PVC pipe in order to mix and agitate the lime sludge so that all solids were put into, and kept in suspension while the sludge was pumped through the copper tubing to simulate injection. Slotted PVC piping was connected together and laid at the bottom of the tub in a spider web shape and was connected to a vertical PVC pipe in the approximate center of the tub. The vertical PVC pipe was connected to a header pipe that was fitted with an air release valve. A rubber hose was connected to the end of the header pipe, and the hose was connected to a shop vacuum. The shop vacuum was set to exhaust mode to introduce air into the tub to agitate the lime sludge mixture.

Photographs 13.2 and 13.3 – Mixing tub set-up

A metal tube with a stop valve was fitted vertically from the PVC piping assembly at the bottom of the tub and connected to a 1/3 HP slurry pump. The copper tubing was then connected to the vertical metal tube and the lime slurry was pumped from the tub, into the tube and dropped into the scaled model.

13.2 Testing Procedures and Simulation Runs

Lime sludge was collected from the WTP dewatering lagoons for use in the simulation. The lime sludge was allowed to completely dry and was physically mixed to the point that the solids reverted to their powdered form. The powder was carefully weighed and the volume was calculated. The lime powder was then mixed with a measured volume of water (whose weight was known) in the mixing tub at a precise mixture so that the resulting slurry would be 10 - 15% by weight.

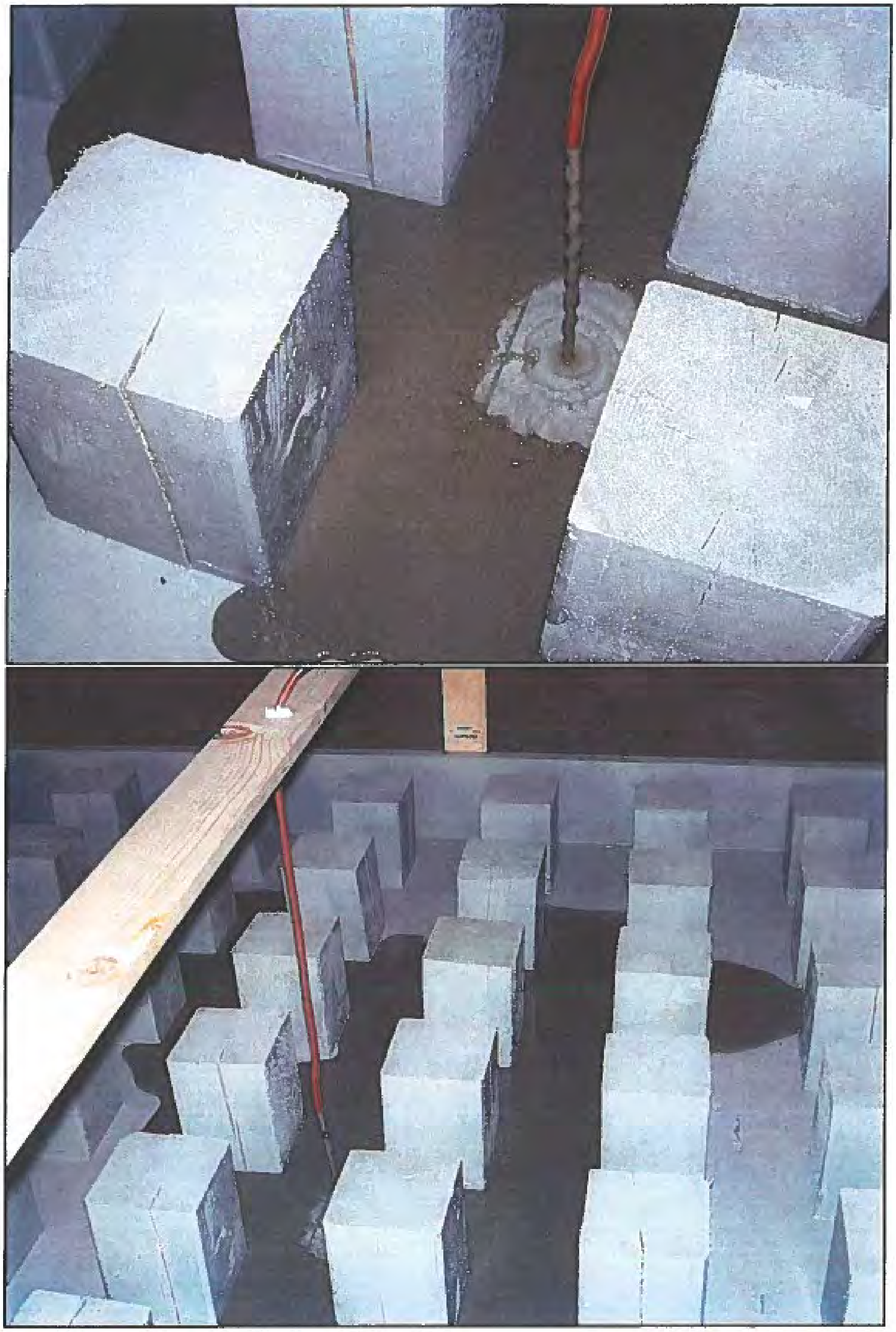
Photographs 13.4 and 13.5 – Dried and weighed lime powder and scaled model discharge line

The maximum capacity of the mixing tub was 500 gallons. The tub was filled with 400 gallons of water and this translated to 3338 pounds of water (at 8.345 lbs/gallon of water). In order to meet the solids percent goal, a total of between 334 and 400 pounds of dried lime powder was added to the tub. The shop vacuum was turned on to agitate the mixture and put the solids into suspension and the mixture was also hand mixed with a shovel to insure that the mixing was uniform.

Photographs 13.6 and 13.7 – Mixing tub set-up

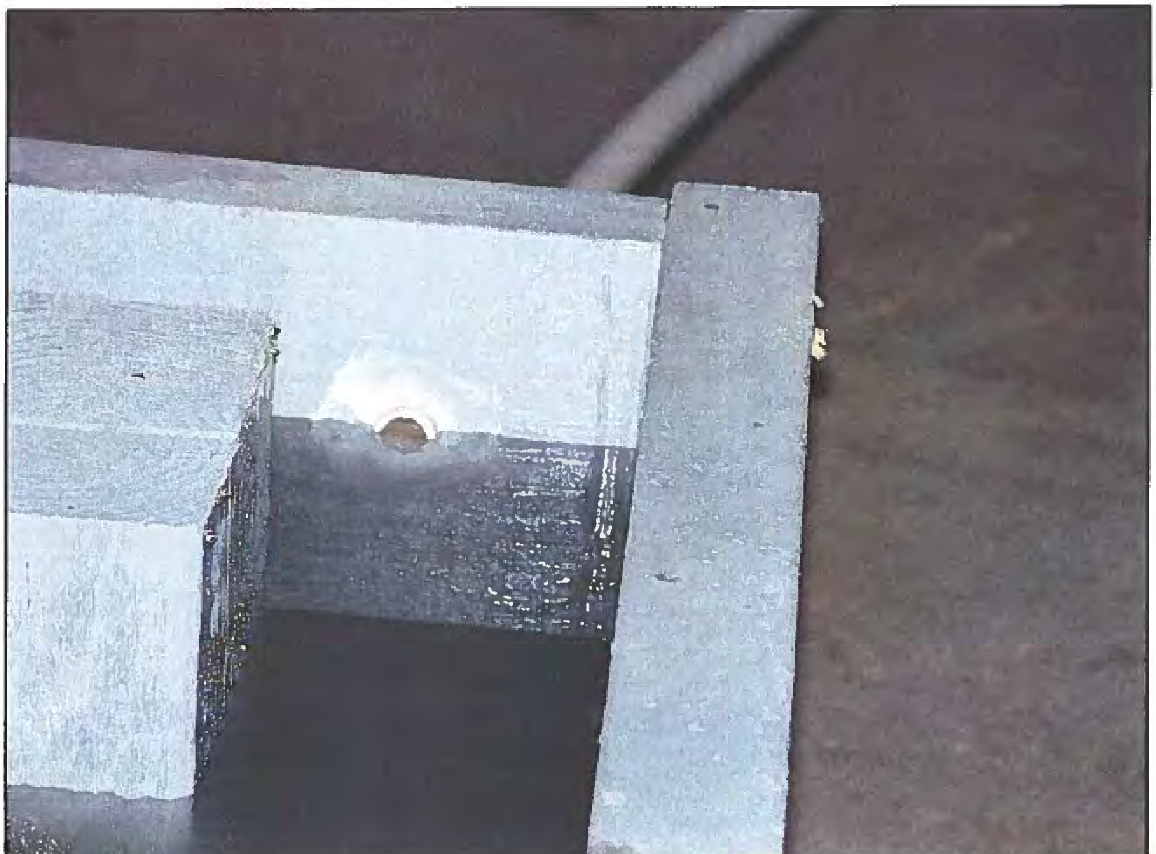
Once the slurry was fully mixed and the solids were in suspension, the slurry pump was turned on and the simulation began. The slurry was agitated in the mixing tub for the entire duration of the simulation and the slurry was pumped into the scaled model until it reached its capacity.

Photograph 13.8 – Start of simulation



Photographs 13.9 and 13.10 – Start of simulation

The pumping rate used in the simulation was calibrated by measuring the length of time it took to pump one gallon of slurry into the scaled model. The pumping rate achieved during the simulation was approximately equivalent to the pumping rate designed for the system.



Photograph 13.11 – Discharge line draining the supernatant forming on top of the deposited solids

Photographs 13.12 and 13.13 – Simulated lime sludge injection

Photographs 13.14 and 13.15 – Simulation nearing completion

Photograph 13.16 – Simulation completed and supernatant draining

Once the scaled model was entirely filled with lime sludge, the supernatant drained to the level of the discharge line. Then, over a few days, the remaining supernatant was allowed to completely evaporate leaving the deposited solids in the scaled model.

13.3 Simulation Results

The simulation was run a total of three times on July 11, 2008, July 25, 2008 and August 25, 2008. The thickness of the lime sludge solids deposited in the model was carefully measured with a tape measure at the corners of each wooden pillar by measuring the length to the top of the solids down from the top of the wooden pillar.

After each simulation, solids covered the bottom of the entire model at various thicknesses. Each time, the thickest deposit of solids occurred around the center of the simulated injection point, with a depressed cone of solids directly under the point of injection. This is caused by the force of the slurry as it was dropped into the model, which pushed more of the solids away from the area directly under the point of injection, creating the cone. The thickness of the solids decreased proportionally to the distance away from the point of injection in a radial fashion. This created a "beach" of solids sloping away from the point of injection. The slope of this beach was approximately 1%, correlating well to the beach angle observed in the dewatering lagoons at the WTP.

The thickness data were then averaged between the simulation runs to determine the average solids thickness across the model to develop the output that was used to develop the full-scale preliminary design of the injection system. **Figure 13.2** below shows the averaged lime sludge solids thicknesses between simulation runs. The numbers at the corners of each pillar are the measured length to the top of the solids in tenths of an inch. This was converted to full scale and the contours and cross sections in **Figure 13.2** below are shown in feet.

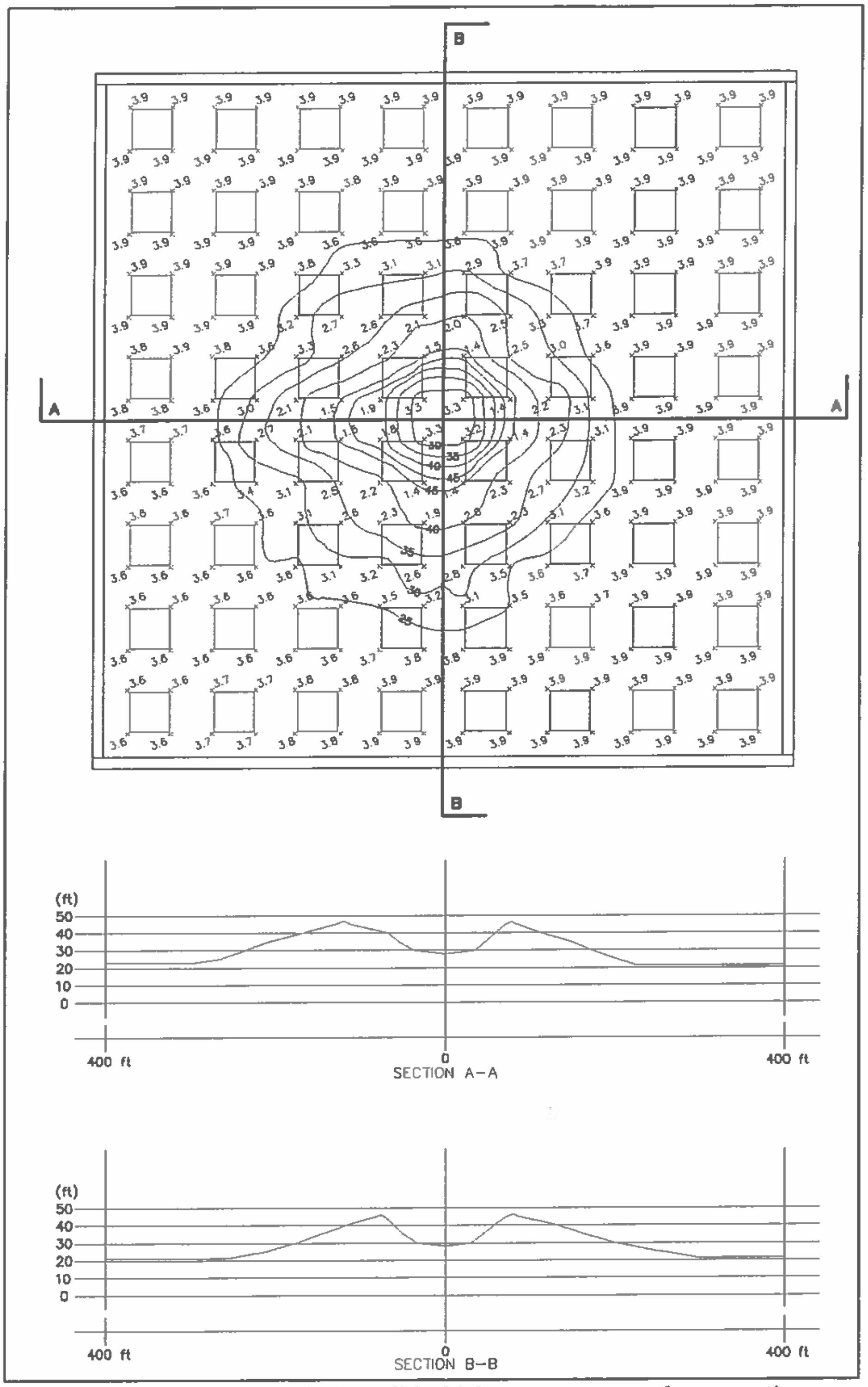


Figure 13.2 – Averaged lime sludge solids thickness contours and cross sections

13.4 Correlating Simulation Results to Full-Scale Injection Design

Due to the characteristics of the cone and beach that will develop under the point of injection, the full height of the mine (50 feet) cannot be filled from a single point of injection. As the rim of the cone rises higher and higher as injection continues, it will reach the ceiling of the mine, and there will be an area of unfilled space radially around the injection point corresponding to the slope of the beach.

It is theorized that continued injection once the rim of the cone reaches the ceiling may cause the slurry to eventually start to back up into the injection point into Level 1 of the mine. It is possible at this point that the injected slurry could force itself into the already deposited solids and push the cone radially outward, away from the point of injection, but this would cease at some point and the back-up into Level 1 would occur, effectively shutting off the injection point before the mine is filled with solids.

After this phenomena was observed and evaluated, it was determined that the injection system would need to incorporate multiple IW's tied to multiple injection points in order to maximize the storage capacity of lime sludge solids inside of the mine. Various configurations of injection points were evaluated to overlap the beaches from multiple injection points taking into account the configuration of Level 2 of the mine and the perimeter shape of the property boundary.

Another complicating factor is that the IW's couldn't be located in the center of the site because of the proposed operation of the CCDD facility at the surface by Heartland. Eventually the surface quarry will be filled and brought to grade and therefore IW's couldn't be feasibly placed in the central portion of the site.

After this evaluation was completed, it was determined to place 4 IW's on the rim of the surface quarry as depicted on the previously presented figures and diagrams. With the IW's located around the perimeter of the site, the concept of the distribution piping network on the floor of Level 1 of the mine leading to injection points was developed. Based upon the geometry of the cone and beach formation from the model simulation runs, it was determined that a total of 18 injection points would be needed at an average spacing of 300 feet in order to overlap the beaches so as to maximize the space utilization in the mine. From this evaluation, the layout of the distribution piping and the location of the IW's were determined.

Further refinement of the design led to the development of the concept of siltation basins so that the solids will deposit in a more uniform fashion across the floor of Level 2 of the mine and so that the supernatant could be efficiently extracted from the mine from a single point of extraction.

14.0 SYSTEM LIFE ESTIMATES

The last element to evaluate in order to determine the feasibility of the project was to estimate the effective operating life of the proposed system. If the operating life is too short, the annual cost savings of the proposed system versus the current landfilling method wouldn't be enough to offset the assessment, evaluation, permitting and construction costs and would therefore make the project financially infeasible. This evaluation was conducted initially using conservative assumptions (i.e., assumptions that would tend to overestimate lime sludge production, percent solids, etc.) giving a conservative bias in the calculation of system life estimates.

Estimating the life of the system will be based upon the following:

- The average percent solids by weight of the lime sludge;
- The rate of lime sludge production from the WTP;
- The volume of air space on Level 2 of the mine available for filling;
- The volume of lime sludge solids retained in the mine; and
- The efficiency of filling the air space with solids based upon the bench scale lime solids deposition simulation.

Since the supernatant will be extracted from the lime sludge detention area, the system life estimates will be based upon the physical characteristics of the lime sludge solids, the geometry of the beaching effect and the rate of lime sludge production.

14.1 *Lime Sludge Production and Average Percent Solids Estimates*

As stated in **Section 3.0** of this narrative, the average annual production of lime sludge for the past three years is approximately 45,000,000 gallons per year. The COA Water Production Department conducted a water use rate study that projected water use (and therefore, lime sludge production since it is proportional to water production) into the future. This study was conducted in 2011 by Black & Veatch and concluded that the population of the City will remain essentially flat through at least 2015 and that water (and therefore lime sludge) production will correspondingly remain fairly consistent from the current levels.

Since the proposed system would be in operation well past 2015, the lime sludge production rate will be assumed to increase in the future to provide a conservative assessment of lime sludge production as it relates to system life calculations.

Table 14.1 – Blowdown Quantities from COA Water Treatment Plant

Month	Gallons			
Jan-10	4,429,621			
Feb-10	2,918,937			
Mar-10	3,195,195			
Apr-10	3,285,705			
May-10	4,012,162			
Jun-10	3,910,539			
Jul-10	4,604,418			
Aug-10	4,875,924			
Sep-10	3,807,024			
[1]Oct-10	3,892,752		**2010 monthly max =**	**4,875,924**
Nov-10	3,413,508		**2010 monthly min =**	**2,918,937**
Dec-10	3,154,767		**2010 monthly avg =**	**3,791,713**
Jan-11	3,150,893		**2010 total =**	**45,500,552**
Feb-11	2,863,426			
Mar-11	3,579,962			
Apr-11	2,663,556		**2011 monthly max =**	**4,461,098**
May-11	3,739,062		**2011 monthly min =**	**2,663,556**
Jun-11	4,085,306		**2011 monthly avg =**	**3,612,659**
Jul-11	4,461,098		**2011 total =**	**43,351,904**
Aug-11	4,127,766			
Sep-11	4,106,132		**2012 monthly max =**	**5,709,958**
Oct-11	4,148,021		**2012 monthly min =**	**2,810,276**
Nov-11	3,375,352		**2012 monthly avg =**	**3,870,270**
Dec-11	3,051,329		**2012 total =**	**45,436,605**
Jan-12	3,223,648			
Feb-12	2,810,276			
Mar-12	2,993,350			
Apr-12	3,006,040			
May-12	4,134,204			
Jun-12	4,582,841			
Jul-12	5,709,958			
[2]Aug-12	4,501,845			
[2]Sep-12	3,956,578			
[2]Oct-12	4,020,387			
[2]Nov-12	3,394,430			
[2]Dec-12	3,103,048			

[1] Only 30 days of data provided
[2] Actual volumes presented through July 2012; August to December 2012 projected based upon corresponding monthly averages from 2010 and 2011

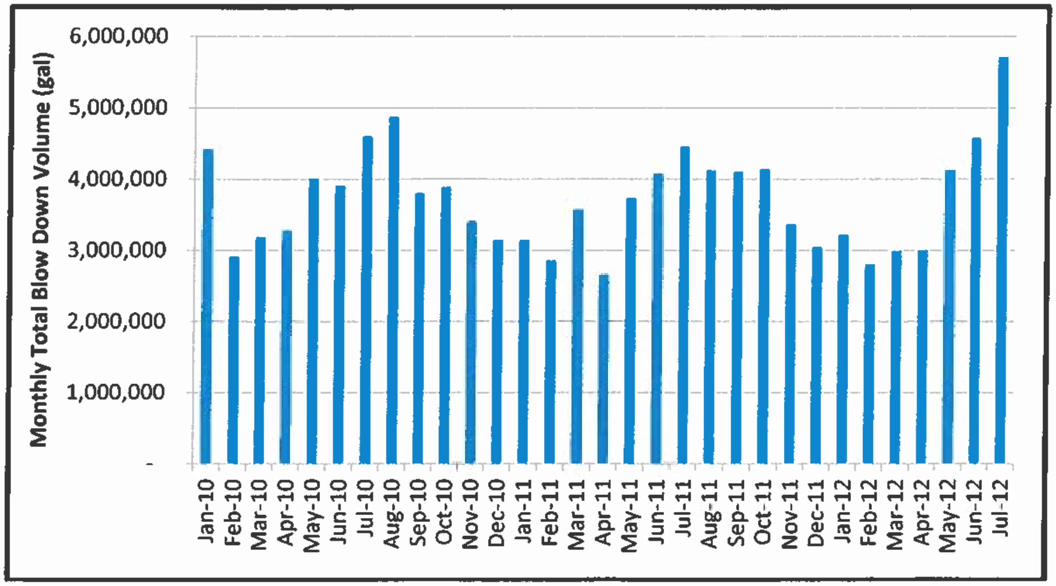


Figure 14.1 – Lime sludge blowdown volume graph

In order to provide a conservative estimate of lime sludge production for this portion of the feasibility evaluation for the project, it is assumed that lime sludge production will increase 10% in 10-year increments as follows (in gallons):

- Years 1 through 10: 50,000,000 annually;
- Years 10 through 20: 55,000,000 annually;
- Years 20 through 30: 60,500,000 annually; and
- Years 30 through 40: 66,500,000 annually.

This will provide a conservative assumption of the volume of lime sludge produced by the WTP over the potential operating life of the proposed system.

The COA Water Production Department routinely measures the percent solids (by weight) of the lime sludge produced at the WTP and has provided this data for evaluation in this permit application. Based upon the data provided, the average percent solids of the lime sludge between 2010 and 2012 was 6%. This correlates well with the City of Elgin which uses the same water treatment process at an average percent solids of 7%.

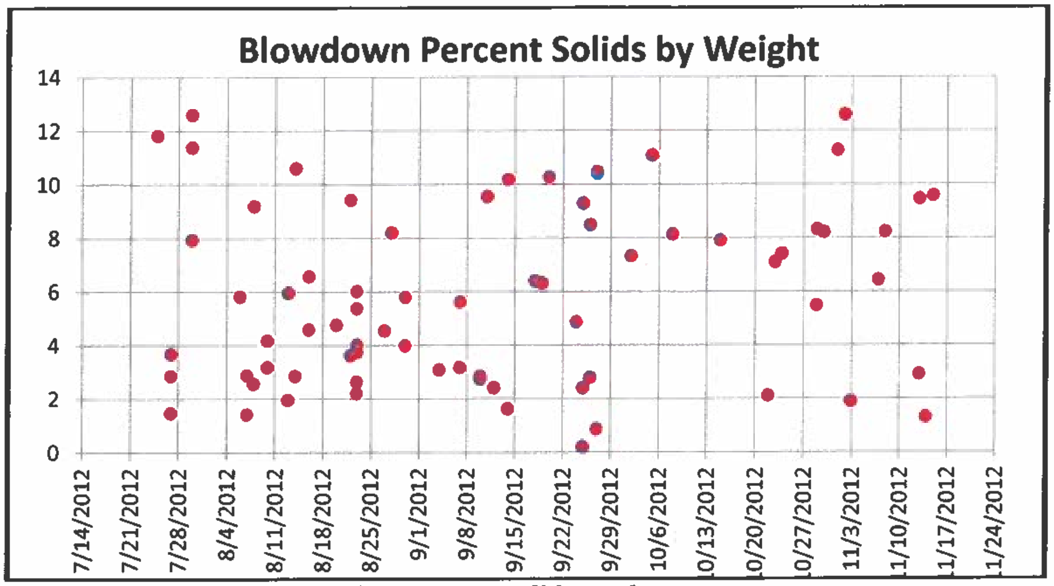


Figure 14.2 – Lime sludge blowdown percent solids graph

14.2 Estimate of Air Space Volume in Mine

The volume of air space in Level 2 of the mine was calculated based upon the survey information obtained and the mine configuration provided by Lafarge. The air space is equivalent to the total surface area minus the area occupied by the pillars and other unmined areas (perimeter areas, ramps, etc.). This will be equivalent to the surface area of the rooms created by mining. This value was then multiplied by the height of the rooms in both breast and bench cut areas. Based upon this, the total volume of the air space on Level 2 of the mine was calculated to be approximately 93,600,000 cubic feet. This is the volume available for retention of lime sludge solids within Level 2 of the mine.

14.3 Percent Volume of Lime Sludge Solids Retained in the Mine

The lime sludge has both a solids and a liquid component. In order to maximize the effective operating life of the system, as much of the liquid portion of the lime sludge will be removed by the supernatant extraction system. The supernatant forms at the top of the deposited sludge very quickly after injection and will be readily available for extraction. The lime sludge solids however will retain a great deal of liquid within the pore spaces between the individual lime particles.

Therefore, the mass balance that must be calculated in order to determine the volume of lime sludge solids that will be retained in the mine is based upon the following:

- The total volume of lime sludge (solids plus water) entering the mine;
- The total volume of supernatant that will be extracted; and
- The total volume of solids retained (solids plus some of the total amount of water that enters the mine).

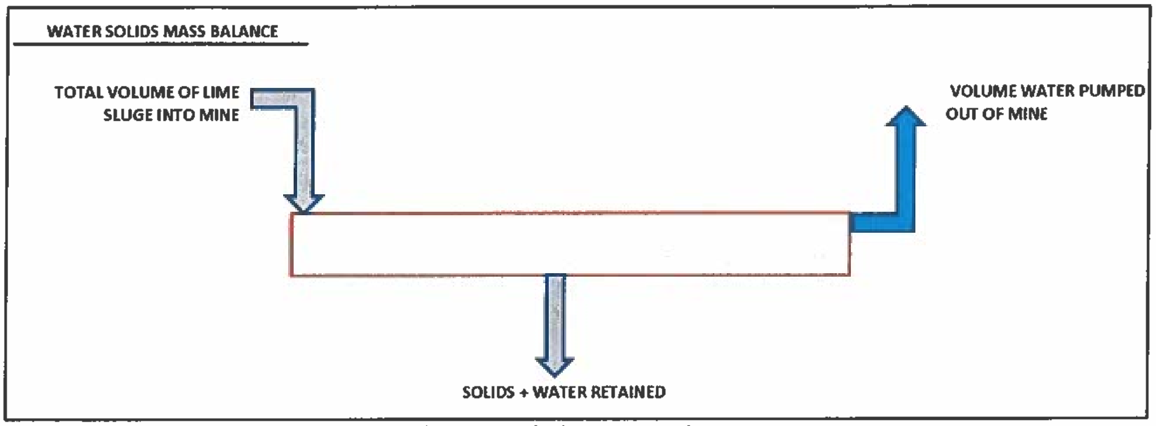


Figure 14.3 – Diagram of water and solids mass balance equation

This mass balance is reflected in the following equation:

$$\text{Volume of Solids Retained} = \frac{\text{Weight}_{\text{sludge}}}{\rho_w * \text{S.G.}_{\text{solids}} * \text{Average \% Solids}_w}$$

Where: $\text{Weight}_{\text{sludge}}$ = Total unit weight of lime sludge entering the mine
ρ_w = Density of water
$\text{S.G.}_{\text{solids}}$ = Specific gravity of the lime sludge solids
$\text{\% Solids}_w$ = Average percent solids (by weight) of the lime sludge retained in the mine

Based upon this equation, the total volume of lime sludge retained in the mine will be directly proportional to the total volume of lime sludge entering the mine. The following measured values, conversion factors and assumptions were used:

- 100% of the solids that enter the mine are retained in the mine (i.e., no solids will be pumped out by the supernatant extraction system;
- The specific gravity of the lime sludge entering the mine is 1.044;
- The specific gravity of the dewatered lime sludge that will be retained in the mine is 1.233;
- The average percent solids of the lime sludge entering the mine is 6%; and

- The average percent solids of the sludge retained in the mine is 27%.

Specific gravity data was obtained by laboratory testing from three different locations in 2009 with the following results: 1.24, 1.12 and 1.16. These values represent the specific gravity of the lime sludge after it has dewatered (i.e., as it will be retained in the mine). The specific gravity of the lime sludge entering and that is retained in the mine can also be calculated by taking the specific gravity of water (1.0) and the specific gravity of the lime powder used at the WTP (3.3) and applying the applicable percent solids (6% entering the mine and 27% retained in the mine). Using this formula, the specific gravity of the lime sludge entering the mine will be 1.044 and the specific gravity of the lime sludge retained in the mine will be 1.233. The theoretical value of the lime sludge retained in the mine matches well with the measured laboratory values.

The percent solids from the dewatered lime sludge just before excavation and transport for disposal has been tested by laboratory analysis periodically from 1997 through 2008. Over this period of time, the highest percent solids were 60% and the lowest was 49% and the average was 55% over this period of time. Since there will be several tens of feet of lime sludge deposited in the mine, this would represent the percent solids for the lime sludge that will be at the bottom of the mine, due to compression caused by the weight of the lime sludge above. The lime sludge at the top of the depositional pile will have a percent solids of about 20%, as is found to be the case in the dewatering lagoons at the WTP. Therefore, an average percent solids for the lime sludge retained in the mine of 27% was used in this evaluation.

Application of these factors yields the following results:

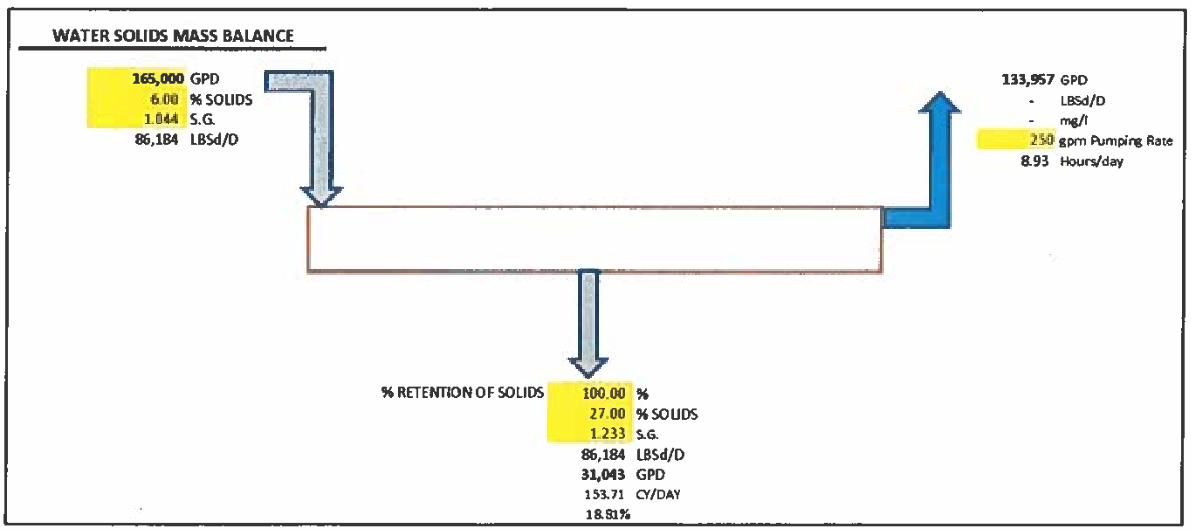


Figure 14.4 – Diagram of water and solids mass balance equation solution

Therefore, assuming a flow rate into the mine of 165,000 GPD, the total lime sludge retained in the mine will be about 31,000 GPD, or approximately 18.8% of the total volume pumped into the mine. This is a direct proportionality, so that if the flow rate of lime sludge entering the mine is greater or less than 165,000 GPD, the percent of that total that will be retained as a combination of solids and water will remain 18.8%.

14.4 *System Life Calculations as a Function of Filling Efficiency*

Taking the evaluation of the above parameters, the final element to be considered in the calculation of the effective life of the lime sludge injection system is the percentage of the total air volume in the mine that will be occupied by the retained sludge. From the bench scale lime sludge deposition tests that were conducted, it is known that the sludge will deposit in cones and beaches underneath each injection point. Based upon this characteristic, it is known that it isn't possible to fill the entire mine space with retained sludge. Therefore, system life is going to be a function of the percentage of the total air space that can reasonably be expected to be filled with retained sludge, or in other words, the efficiency of the lime sludge injection system.

Taking a ratio of 18.8% of lime sludge retained in the mine versus the total amount of lime sludge entering the mine, at the projected total lime sludge production ranging from 50,000,000 gallons/year to 66,500,000 gallons per year, the following maximum volumes of lime sludge that could potentially be retained in the mine (converted to cubic feet below) at 100% filling efficiency:

- Total volume retained after 10 years: 12,500,000 CF
- After 20 years: 26,400,000 CF
- After 30 years: 41,600,000 CF
- After 40 years: 58,300,000 CF
- After 50 years: 75,100,000 CF
- After 60 years: 91,800,000 CF

The total volume of airspace in Level 2 of the mine was calculated to be 93,600,000 cubic feet. Therefore at the following filling efficiencies, the effective life of the disposal system would be:

- 27 years at 40% filling efficiency (meaning 40% of available air space is filled with sludge)
- 33 years at 50% efficiency
- 39 years at 60% efficiency
- 44 years at 70% efficiency
- 49 years at 80% efficiency

Based upon the results of the bench scale deposition tests, it can be conservatively assumed that the injection system will operate at between 50% and 70% space efficiency, giving an effective operational life for the injection system of between **33 and 44 years**.

The results of this evaluation indicate that the project as described is financially feasible and would result in savings of approximately $1,300,000 per year over the current method of sludge management. Over the life of the system, it is projected that the COA will save between approximately **$43,000,000** to **$57,000,000** total for Level 2 filling only.

Using the same reasoning, if the COA wishes to continue injection into Level 1 of the mine which has 30% less air space than Level 2 and will likely operate at a lower filling efficiency (30 to 40%), filling of Level 1 will add approximately 15 years to the effective life of the system. Therefore, the entire effective life of the mine (Levels 1 and 2) will range between **48 to 59** years and the savings could approach **$62,000,000 to $77,000,000**.

The influent (lime sludge into the mine) and effluent (supernatant extracted from the mine) flows will be monitored and recorded. Using the mass balance described above, a general idea of the approximate volume of lime sludge that is being retained in the mine can be gained. These data will be assessed on a routine basis to determine the volume of lime sludge retained and, as a function of time, the filling efficiency of the system can be evaluated.

15.0 SCHEDULE AND ORDER OF SYSTEM CONSTRUCTION

Upon approval of the Class V UIC permit application, the final design, specifications, bidding and construction of the system will be initiated. Due to the characteristics of the system, there is a specific order in which the various elements of the system must be constructed.

15.1 Completion of Lafarge Mining Activities

In accordance with the lease agreement between the COA and Lafarge, Lafarge is allowed to mine Levels 1 through 3 to within 5-feet of the surface property boundary. Lafarge has completed most of the mining of Level 1 (except for the remaining 55 feet of the setback zone) and is projected to complete mining of Level 2 by the end of 2013. Most of Level 2 will have a bench cut completed and mining will also include the removal of rock walls and partial walls that were left in place during mining operations to direct air flow.

It is anticipated that Lafarge will begin mining for Level 3 no later than 2019 and estimates that it will take approximately 10 years to complete the breast and bench cuts across the entire footprint of the property. Lafarge is required to provide the COA access to Level 3 of the mine during and upon completion of mining activities. Lafarge's mining of all three levels must maintain a minimum distance of 75-feet away from the deep monitoring well that will be used for ground water monitoring under the UIC permit.

Lafarge must also maintain a minimum separation of 100 feet between the elevation of the floor of Level 3 and the elevation of the top of the Ancell Group. Additionally, the elevation of the floor of Level 3 must be above the elevation of the potentiometric surface of the St. Peter Formation aquifer, as measured from the on-site monitoring well.

Lafarge will provide ventilation and access to Levels 1 and 2 of the South Mine until all system construction has been completed and the injection system is operational.

15.2 Schedule of System Construction

The proposed order and schedule of system construction is outlined below. It is anticipated that the system will be constructed, pilot tested and ready for operation within 20 months of final permit approval by the Illinois EPA.

The schedule is provided as the number of months after the date of UIC permit approval by the Illinois EPA for the completion of the listed activities. The schedule may need to be modified based upon the correlation of the approval date of the permit application to the optimum utilization of the construction season. As a governmental subdivision, the project is subject to the State of Illinois public bidding requirements. The tasks associated with the various system components may be bid in separate bid documents as determined to be compatible. Many of the tasks will be conducted and completed concurrent to one another. Assuming a permit approval date of **October 31, 2013**, the proposed schedule is as follows:

- **January 2014:** Completion of final system design and bid specifications. It is anticipated that this work will overlap with the Illinois EPA review and approval process, once the Agency's notice of intent to approve the application is issued.
- **April 30, 2014:** Removal of mining equipment including, but not limited to the rock crusher and conveyor system.
- **June 1, 2014:**
  - WTP improvements including construction of Pump station and wet well, emergency bypass to dewatering lagoon #3, blowdown forcemain to the southern property boundary of the site, blowdown forcemain pumping system and all electrical and control systems.
  - IW construction not including wellhead manhole structures, connection to the blowdown forcemain and valves and control features.
- **August 1, 2014:**
  - Construction of two bulkheads with supernatant inlet piping (one on Level 1 and the single bulkhead on Level 2. Once the Level 2 bulkhead has been completed, access and egress for Level 2 will be via ramps from Level 1.
- **September 1, 2014:**
  - Final construction of blowdown forcemain to the IW locations.
  - Completion of IW wellhead features, manhole structures, valves and control features and connection to the blowdown forcemain.
- **October 1, 2014:**
  - Injection point drilling.
  - Distribution piping system including connection to the bottom of the IW's, starting at the south end of the mine and progressing to the north.
  - Berms for creation of siltation basins completed from south to north as the distribution piping system is completed.
  - Construction of supernatant extraction pumping system and connection to bulkhead piping (Level 2 only) and associated electrical and control systems.
- **November 1, 2104:**
  - Lafarge initial cleanup of mine in preparation of sealing unfilled joints (not including COA construction items)

- **December 1, 2014:**
  - Lafarge completion of sealing of all unfilled joints on the floors and perimeter of Levels 1 and 2 of the mine.
  - Construction of supernatant extraction forcemain and connection to FMWRD sanitary sewer.
  - Construction of EW, wellhead features, manhole structures, valves and control systems, electrical feed and control systems.
- **March 1, 2015:**
  - All system pilot testing completed.
  - COA to conduct mine cleanup of all items and debris associated with construction activities.
  - Lafarge to remove last of equipment including, but not necessarily limited to MCC, lights, cables, doors, tools, etc.
- **April 1, 2015:**
  - Lafarge to remove temporary air flow structures, temporary safety structures, portable toilets, and final mine cleanup.
- **May 1, 2105**
  - Lafarge completion of construction of final bulkheads and sealing of mine.
  - Lafarge removal of surface structures associated with supplying air to mine including blowers, intake ducts and MCC. Concrete pad, steel collar and security fencing to remain.
  - COA to secure vent shaft opening with grate and collar.
- **May 30, 2015**: System start-up.

16.0 MONITORING PROGRAM

The following are proposed to be included in the monitoring program associated with the Class V UIC permit for this site:

- Sampling and analysis of the influent lime sludge from the pump station wet well at the WTP;
- Sampling and analysis of the supernatant effluent from a sampling port at the extraction wellhead ***for compliance with the permit that will be received from FMWRD*** ; and
- ~~Monitoring of the chemistry of the nearest USDW (the St. Peter Formation) from the existing deep monitoring well at the site~~ ***Other system monitoring activities***.

The fluid to be injected into the mine is generated at the COA WTP as a byproduct of the lime softening water treatment process. The waste stream that generates the injection fluid is as follows:

- Water extracted from a network of municipal water supply wells;
- Surface water from the Fox River; and
- Lime powder within the WTP claricones.

As outlined in **Section 9.0** of this permit application narrative, the lime sludge solids, supernatant and raw source water have been extensively tested prior to the preparation of this application. During this testing, VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's have rarely been identified above the laboratory reporting limits. ~~Due to this fact and based upon the fact that~~ None of these parameters are neither used nor generated in the process that creates the injection fluid. ~~the COA requests that they be excluded from the parameter list in the monitoring program, except as noted in the subsections below.~~

16.1 *Influent Monitoring*

Please refer to the Ground Water Monitoring Waiver Request in Exhibit A for a detailed description of the influent monitoring proposal.

~~It is proposed that the lime sludge be sampled at the WTP wet well because it is representative of the influent going into the injection system. Since the sludge has two components (solids and water), the sample obtained from the wet well will be dried by the lab and the solids will be tested as outlined below. The representative samples of the lime sludge will be obtained directly from the wet well using sterile sampling equipment and containers supplied by an accredited laboratory.~~

~~As previously stated, no VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's have been detected above the laboratory reporting limit in any of the lime sludge solids samples obtained from the dewatering lagoons at the site, except for the following:~~

- ~~Benzene in the April 24, 2012 sample;~~
- ~~cis-1,2 Dichloroethene in the April 24, 2012 sample;~~
- ~~MTBE in the April 24, 2012 sample; and~~
- ~~Phenol in the October 20, 2008, April 24, 2012, July 3, 2012 and July 19, 2012 samples.~~

~~As previously discussed, there are no sources in the waste stream generation process that have been identified (raw river/well water or the lime powder) that can introduce these chemicals into the lime sludge. The lime sludge is stored outside of the WTP in the dewatering lagoons for several weeks at a time and these chemicals were likely imparted to the sludge from a surface source outside of the WTP or could be representative of cross contamination either in the field sampling or at the laboratory.~~

~~In the injection process proposed in this permit application, the entire system is closed, with no points at which these types of chemicals can be introduced into the waste stream. Therefore, it isn't anticipated that these chemicals will show up in the monitoring program once the system is operational.~~

~~The COA realizes that the Agency may wish to have empirical evidence of this, so it is proposed that the following parameters be analyzed on a quarterly basis for a one year period:~~

- ~~Benzene;~~
- ~~cis-1,2 Dichloroethene;~~
- ~~MTBE; and~~
- ~~Phenol~~

~~It is also proposed, that if these parameters are below the laboratory reporting limit after the end of the quarterly sampling, then they should be tested on an annual basis for a period of four years. If after this four year annual testing period these parameters are still below the laboratory reporting limit, then they should be excluded from the routine parameter list for the permit.~~

~~The laboratory analysis methodology will be consistent with the methods outlined in the permit issued by the Illinois EPA.~~

16.2 *Effluent Monitoring*

It is proposed that the injection fluid effluent be sampled directly from the sampling port attached to the extraction well. This sampling port will be readily accessible and will provide representative samples of the supernatant being extracted from the lime sludge storage area in the mine.

The City will obtain a permit from FMWRD for the discharge of the supernatant effluent from the system direct to the on-site sanitary sewer. This permit will establish the sampling and monitoring requirements for the system effluent.

~~As previously stated, no VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's have been detected above the laboratory reporting limit in any of the supernatant samples obtained from the dewatering lagoons at the site, except for the following:~~

- ~~Chloroform in the April 24, 2012 sample; and~~
- ~~2,4-D in the July 3, 2012 sample;~~

~~As with the lime sludge solids, there are no sources in the waste stream generation process that have been identified (raw source water or the lime powder) that can introduce these chemicals into the supernatant and is likely from a surface source while the sludge was in the dewatering lagoon.~~

~~It is proposed that these two chemicals not be included in the effluent sampling for the site because:~~

- ~~The proposed injection process is a closed system with no potential sources for these chemicals to be introduced into the waste stream; and~~
- ~~Although detected, these chemicals were both well below both the 620 Class I ground water standards and the 611 MCL's and MCLG's.~~

~~The supernatant effluent will also be subject to the testing that will be required by FMWRD as part of the discharge permit that will be obtained upon approval of the Class V UIC permit by the Illinois EPA.~~

16.3 *Ground Water Monitoring*

Ground water monitoring is not proposed in association with this permit application. Please refer to the Ground Water Monitoring Waiver Request located in Exhibit A of this PA.

~~It is proposed that no additional parameters be added to the routine quarterly~~

~~parameter list for the ground water at the site. This is due to the fact that the supernatant is representative of the fluid that is available for potential transport to the nearest USDW. The supernatant did not exhibit any levels for any parameters that exceeded the 620 Class I Ground Water Standards nor the 611 Drinking Water MCLG's or MCL's in any of the sampling events conducted.~~

~~Therefore, it is felt that considering the water stream that the routine parameter sampling list will be sufficient to monitor for potential impacts from the storage of the lime sludge solids within the mine.~~

~~*16.4 Routine Monitoring*~~

~~It is proposed that the following parameters be analyzed on a quarterly basis for the lime sludge influent at the WTP wet well, the supernatant effluent at the extraction well and the nearest USDW from the on site deep monitoring well:~~

- ~~pH~~
- ~~Cyanide, total~~
- ~~Nitrate, as N~~
- ~~Nitrite, as N~~
- ~~Sulfate~~
- ~~Ammonia, as N~~
- ~~Fluoride~~
- ~~Antimony~~
- ~~Arsenic~~
- ~~Barium~~
- ~~Beryllium~~
- ~~Boron~~
- ~~Cadmium~~
- ~~Chromium~~
- ~~Cobalt~~
- ~~Copper~~
- ~~Iron~~
- ~~Lead~~
- ~~Manganese~~
- ~~Nickel~~
- ~~Selenium~~
- ~~Silver~~
- ~~Thallium~~
- ~~Vanadium~~
- ~~Zinc~~
- ~~Radium 226~~
- ~~Radium 228~~

~~The laboratory analysis methods employed will be consistent with those methods identified in the Class V UIC permit issued by the Illinois EPA.~~

16.5 Other System Monitoring

Other monitoring of the system will be conducted as follows:

- Monitoring of bulkheads: Lafarge is required to monitor the bulkheads on a regular basis for leakage. This will include data from pressure transducers that will be installed in the bulkheads to warn against excessive pressures being exerted against the wall. Lafarge is also required to maintain the integrity of the bulkheads and to make repairs and respond to any emergencies that may arise associated with the performance of the bulkheads.

- Supernatant inlet monitoring: The supernatant inlets will have sludge monitoring devices to detect the elevation of the solids prior to reaching the inlet pipe. At such time, the valve for that inlet will be closed, and the next vertically higher inlet will be opened.
- System influent flow monitoring: The system will include flow monitoring devices located at the WTP pump station that will record flow rate data that will be available for reporting to the Illinois EPA.
- System effluent flow monitoring: The extraction system will include flow monitoring devices that will be constructed on the line for the extraction pumping system. These meters will record the supernatant flow out of the lime sludge storage area and into the sanitary sewer. This data will be recorded and will be available for reporting to the Illinois EPA.

16.6 Assessment and Corrective Action

In the unlikely event that the proposed injection was to impact the environment, the COA will conduct assessment and corrective actions as agreed upon with the Illinois EPA.

17.0 SYSTEM CLOSURE POST CLOSURE CARE

When the system has reached the end of its operational life, or if the COA wishes to discontinue the use of the system, it will be closed. It is anticipated that due to compression of the lime sludge, supernatant may continue to be drawn out of the lime sludge detention area for a period of time after injection has ceased.

It isn't possible at this point in time to determine the exact length of this "lag" period, but it isn't anticipated to be longer than 12 months after cessation of injection. Pumping of the supernatant will continue until such time that the pumping becomes ineffective. Once the extraction system withdrawal has reached its practical extent, all elements of the system will be closed. The system closure will include the following:

- Plugging the blowdown forcemain at the WTP wet well;
- Disconnection and removal of the blowdown forcemain pumping system;
- Abandonment of the injection wells;
- Disconnection and removal of the extraction pumping system;
- Abandonment of the extraction well;
- Disconnection of the extraction forcemain from the extraction well and the sanitary sewer; and
- Securing the vent shaft.

Each of these elements are discussed below.

17.1 *Closure of the Pumping System*

Closure of the pumping system will include:

- Plugging the blowdown forcemain at the WTP wet well pump. The end of the forcemain will be capped where it is exposed at the pump house.
- Removal of the pumping system including all electrical and control systems.
- Disconnection of the blowdown forcemain at each injection well. The forcemain will be cut and capped inside of the manhole access and will be left in place.

The pump station building will be left in place for potential reuse by the COA.

17.2 *Injection Well Abandonment*

Each of the 4 IW's at the site will be abandoned in place as follows:

- The IW wellhead assembly will be removed (for reuse or disposal) from the well and the forcemain will be cut and capped at a point just inside of the wall of the manhole structure;

- ***A bridge plug will be inserted into the IW to a depth just above the ceiling elevation of Level 1 of the mine (approximately 295 feet). The plug will be permanently inflated. Once inflated the portland cement will be emplaced in the well with a pressure hose, being careful to evenly place the cement at a reasonable rate of flow;***
- The well pipe will be filled with ***portland cement to the floor elevation of the manhole***;
- ***The annular space between the injection string and the long string casing will also be filled with portland cement. It will be filled with a pressure hose making sure to evenly distribute the cement around the injection string.***
- ***Once the cement has cured,*** the manhole structure will be abandoned ***by filling it with crushed stone.***

17.3 Closure of Extraction System

The extraction system closure will include the following:

- Disconnection of the pumping system from the supernatant inlet piping manifold;
- Capping of the inlet piping manifold;
- Disconnection of pumping system from the EW pipe. It will likely be cut off at the EW pipe joint and the joint end of the EW will be capped;
- Removal of pumping system, excess piping, electrical feed and MCC for reuse, recycling or disposal;
- Abandonment of the EW in place as described for the IW's except that a ***bridge plug*** will not be required as the end (bottom) of the EW will be capped and all materials used for well abandonment will be supported; and
- Disconnection of the extraction forcemain from the EW to the FMWRD sanitary sewer will be capped.

17.4 Securing the Vent Shaft

The vent shaft and the immediate area around the vent shaft are currently protected with a 10-foot high security fence that will remain in place and will be monitored during the time that the proposed system is operating. Once the system has reached its effective operating life, it is proposed that the vent shaft be permanently closed in the following manner:

- The vented hatch on top of the steel collar at the surface of the vent shaft will be removed and recycled or disposed;

- A reinforced concrete pad 16-inches thick will be constructed over the shaft opening and anchored to the existing concrete slab;
- The security fence will be removed;
- The area surrounding the sealed vent shaft will be landscaped; and
- The COA will retain title of the vent shaft area in perpetuity.

17.5 Cost Estimate and Financial Assurance

The following elements of system closure will be included in the cost estimate for the purpose of determining financial assurance parameters:

- *4 monitoring wells*
- *4 manhole structures*
- *1 extraction well*
- *1 monitoring well (will be abandoned in similar fashion as IW's and compliant with state and county requirements)*

All of the wells that are abandoned will have the proper well abandonment forms filled out and returned to Kane County. All costs listed below include estimated labor and material costs:

INJECTION WELLS AND EXTRACTION WELL

Bridge Plugs for injection wells = $30,000 each x 4 wells = $120,000
Volume of annulus and injection string = 5 CY
Total volume of all wells = 5 CY x 5 wells = 25 CY
Estimated cost of portland cement = $275/CY
SUBTOTAL = 25 CY x $275/CY = $6,875
Estimated delivery, labor, material and other costs = $3,000
TOTAL = $129,875 or approximately 130,000

MANHOLE STRUCTURES

Estimated labor to disconnect wellhead from forcemain and well = $10,000
Extended cost = $10,000 x 4 structures = $40,000
Volume of structure = 11 CY
Estimated cost of CA6 = $50/CY
SUBTOTAL = 11 CY x $50/CY = $550 x 4 structures = $2,200
TOTAL = $42,500 or approximately $45,000

MONITORING WELL

Volume of well = 5 CY

Estimated cost of portland cement = $275/CY
SUBTOTAL = 5 CY x $275/CY = $1,375
Removal of stickup, bollards and concrete pad = $10,000
Estimated delivery, labor, material and other costs = $3,000
TOTAL = $14,375 or approximately $15,000

Subtotal = $190,000
Contingency 15% = $28,500
TOTAL = $218,000 or round up to $220,000
Inflation factor of 5% for two years = $22,550
TOTAL = $242,550 or round up to $243,000

The City of Aurora will provide financial assurance in amount of $243,000 using one of the methods acceptable to the Illinois EPA, but will most likely be using the financial statement method. The City will inform the Illinois EPA confirming this.

17.6 Reporting and Record Retention

The COA will comply with all monitoring, system closure and post-closure care requirements and all reporting requirements as well as all retention of record requirements as outlined in the permit issued by the Illinois EPA for this site.

18.0 SUMMARY AND CONCLUSIONS

In order to reduce the cost of handling and disposal of the lime sludge, the COA is seeking a Class V Permit from the Illinois EPA under its UIC program for the disposal of its lime sludge into a subterranean limestone and dolomite mine, located approximately 3,500 feet north of the WTP at the southeast corner of Mettel Road and Illinois Route 25.

The lime sludge that is generated by the water treatment process is proposed to be transmitted from its point of origin at the WTP to its point of proposed injection to the north via an underground forcemain. From the forcemain, the lime sludge will be injected into the rooms within the mine via 4 IW's at the site. Finally, the water within the sludge will be removed from the lime sludge detention area, pumped to the surface via a single EW and disposed into a FMWRD sanitary sewer.

The COA WTP produces water at an annual average of approximately 17 MGD depending upon demand. The source water is blended between ground water pumped from a network of 18 wells and surface intake on the Fox River. The source water is treated by a lime softening process prior to distribution. Over the past three years an average of approximately 45,000,000 gallons of lime sludge is generated annually as a byproduct of the treatment process. The lime sludge is comprised of the lime powder used in the treatment process and water from the municipal wells and the Fox River.

Currently, the lime sludge is diverted from claricone blowdowns into dewatering lagoons at the WTP. In the lagoons, the lime sludge solids fall out of suspension quickly after deposition and water is forced to the top of the solids as supernatant. Most of the water contained within the sludge will separate out as supernatant.

The lime sludge solids and supernatant have been extensively tested as part of this permit application. The results of this testing indicate the following:

- The lime sludge is not a listed hazardous waste, and the lime sludge solids do not exhibit the characteristics of a hazardous waste for ignitability, corrosivity, reactivity or toxicity;
- The supernatant (water from municipal wells and the Fox River) meets all applicable standards as outlined in 35 IAC 620 and 611; and
- The lime sludge is chemically compatible with the rocks that comprise the mine into which it will be injected (the lime powder itself has the same chemical make up as those rocks and was likely extracted from a mine similar to the one in which the injection will occur).

The mine has been extensively assessed and evaluated. It has a room and pillar design with approximately square pillars 50 feet by 50 feet and rooms with the approximate dimensions of 47 feet by 47 feet. There are currently two levels of the mine with a third level planned to be excavated concurrent with the proposed lime sludge injection. The levels of the mine have (or in the case of Level 3, will have) a 25-foot thick sill of rock separating them. The rooms on Level 1 are either 23-feet high or 50-feet high and most of the rooms on Level 2 are 50-feet high. The mine is part of a facility that is operated by Lafarge. Lafarge operates two underground mines. One mine is located in the Village of North Aurora, across the Interstate 88 Tollway (North Mine) and the other is the site of injection south of the tollway (South Mine). Both mines are accessed via a ramp located on the North Aurora property from the floor of the former surface quarry down to the depth of the Galena-Platteville Group approximately 250 feet bgs.

There are four tunnels connecting the two mines; three from Level 1 of the North Mine to Level 1 of the South Mine and one connecting Level 1 of the North Mine to Level 2 of the South Mine.

The proposed injection is to occur via 4 IW's that will convey the sludge from the surface to Level 1 of the mine and into a network of piping along the floor to 18 different injection points (holes drilled between Levels 1 and 2). From these injection points, the lime sludge will be deposited into Level 2 of the mine.

The four mine openings will need to be sealed using bulkheads. These bulkheads have been used for years in mines for a variety of purposes and will provide a water tight seal to keep the sludge in place and prevent its migration into Lafarge's active mining operations to the north.

As the lime sludge is injected into the mine, it will form cones and beaches under each injection point as was demonstrated by the bench scale deposition test. The injection points are spaced so that the available air space that was calculated is most efficiently used. The bulkhead on Level 2 will have piping constructed through it to capture the supernatant, have it drain by gravity out of the detention area, pumped to the surface and disposed in the nearby FMWRD sanitary sewer.

The primary issues addressed in the feasibility study for this permit application are: 1) the stability of the mine as it relates to lime sludge detention and the excavation of Level 3 concurrent with said detention, and 2) potential fluid movement out of the lime sludge detention area, and 3) what impact, if any, this fluid will have on the nearest USDW (the St. Peter Formation, which is the first geologic unit beneath the Galena-Platteville Group).

The term "fluid" as it is used in the UIC regulations and forms, is a misnomer when used to describe the lime sludge. The "fluid" in the lime sludge is simply water from the COA municipal wells and the Fox River that has been in contact with lime powder used in the water treatment process for a period of time. Most of this water exists as supernatant which will be captured from the detention area and disposed of and will not be available for potential flow. Since the chemistry of the supernatant will be the same as the other water held within the lime sludge, and since this chemistry is well documented, the chemical composition of the water that is available for potential movement is also known.

The results of the hydromechanical modeling and calculations conducted by AAI indicate that the mine will be stable and that Level 3 can be safely excavated concurrent with lime sludge detention on Levels 1 and 2.

To address the issue of potential water movement from the detention area, extensive testing of the ground water, the rocks in the subsurface and the waste stream along with two dimensional hydromechanical modeling were conducted.

Packer tests conducted in the core that was advanced at the site as part of the feasibility study indicate that very little horizontal flow is possible through bedding planes that are hydraulically connected to any fractures (called joints) that may exist in the rocks. The hydromechanical modeling corroborated this and found that the primary pathway for potential water movement is vertical, downward from the detention area.

The rocks that comprise the mine are the limestones and dolomites of the Galena-Platteville Group. A thorough field assessment of the mine was conducted. A series of through-going joints exist in the rocks with predictable and regular lengths and spacings. A majority of these joints are filled with low permeability infillings (clay or calcite) and are resistant to fluid movement. Some of the joints are unfilled, but with a very small aperture size. Therefore, the primary pathway for potential fluid movement is through these unfilled, but tight joints.

The hydromechanical model predicted that very little water could potentially move downward toward the St. Peter Formation (0.021 to 0.035 gpm/acre) under a worst case scenario. When you compare this to the amount of water present in the aquifer, it becomes an insignificant amount of potential flow.

Any potential flow of water out of the detention area will be mitigated by the following:

- The unfilled joints have been identified and mapped within the mine and they will be sealed along the perimeter and floors of Levels 1 and 2 of the mine which will drastically reduce the ability for water to flow vertically or horizontally out of the detention area.
- The particle size of the lime sludge solids is smaller than the measured aperture

size of the unfilled joints. The injection system will be operated in such a manner so as to blanket the entire floor of Level 2 quickly after system operation is initiated. The lime sludge solids will therefore infill the top of any unmapped, unfilled joints near the floor of Level 2 of the mine. Additionally, as lime sludge solids accumulate on the floor, the bottom layers become more and more compacted, thus enhancing this effect over time. Furthermore, the lime sludge itself has a now intrinsic permeability (average hydraulic conductivity of 1.10 x 10^{-5} cm/s) and will act as a low permeable barrier to the water in the layers above.

- Once Level 3 is excavated, any water that is available for potential downward movement will be captured in the mine before it has the opportunity to migrate to the St. Peter Formation.

Based upon this, there will be very little water movement out of the detention area that could potentially reach the St. Peter Formation. Furthermore, the results of the supernatant testing, which is analogous to the chemistry of water that could flow out of the detention area, indicate that it meets all water quality standards that are outlined in 35 IAC 620 and 611. In fact, the levels of many of the parameters tested (e.g., radium and iron) are lower in the supernatant than in the ground water that was sampled from the St. Peter Formation from the on-site monitoring well. Therefore, the small amount of water that could potentially reach the St. Peter Formation from the lime sludge detention area has no ability to impact the water quality of the nearest USDW. Thus, the injection system as proposed will meet the requirements of 35 IAC 704.122.

In closing, the City of Aurora respectfully requests that the Illinois EPA approve the request for a Class V UIC Permit for the proposed injection system because:

- The lime sludge solids are not contaminated and will be safely contained in the detention area within the Lafarge Conco South Mine in perpetuity;
- Very little water could potentially move out of the detention area;
- The lime sludge water is not contaminated and, therefore, even if some of it moves into the nearest USDW, it will not contaminate it nor will it adversely affect HH&E;
- The proposed system is a more environmentally friendly method of managing the lime sludge generated by the WTP because it will not use valuable landfill space and it will reduce the carbon footprint associated with its management; and;
- The proposed system will save the City of Aurora over $50 million dollars over its effective operational life.

Exhibit A

1.0 GROUND WATER MONITORING WAIVER REQUEST

Due to the conditions present in the mine (injection zone), the nature of the geology in the AOR and due to the characteristics of the lime sludge generated by the WTP, the City respectfully requests a waiver from ground water monitoring requirements as per instructions outlined on form 4e.

The basis of this request is as follows:

- The geology of the injection zone as visually inspected within the mine;
- Mine characteristics and sealing;
- Full modeling conducted using empirical data collected from within the mine and from the adjacent Deep Monitoring Well;
- Data collected on the lime sludge solids and the supernatant over a 12 year period consistently establishing that it is a non-contaminated waste material.

1.1 Potential for Fluid Flow

Potential fluid movement within the types of rocks comprising the injection zone can only occur along bedding planes and along post-lithification secondary porosity features (fractures/joints and dissolution features). The rock mass itself is essentially impermeable. The subsections below will discuss the geology and these potential pathways of fluid movement.

1.1.1 Geology

In most circumstances the geology of an injection zone can only be determined by vertical boreholes, with interpretation conducted between them. This case is unique in that the geology of the entire injection zone has been inspected from floor to ceiling as exposed inside of the mine. This allowed the City to map and identify fractures and joints, bedding planes and joint apertures, infillings and all other physical feature present within the injection zone.

Agapito Associates, Inc. ("AAI") was retained by Deuchler Environmental, Inc. ("DEI") to assist in the mapping of the geologic features of the mine and to collect specific data that would be required to run the hydromechanical model, with the goal being to use as much actual data from the site as possible. All of this work is outlined in Appendix A of the PA, and is also summarized in **Section 10.0** of the PA. The mine is comprised of standard room and pillar design, with each averaging about 50 feet square.

The injection zone is comprised of limestone of the Dunleith Formation of the Galena Group in Level 2 of the mine. Level 2 has a ceiling elevation of approximately 300 feet above mean sea level. DEI and AAI conducted field mapping of the mine with the following summary of results:

- Rock was comprised of limestone, with bedding planes of variable thickness;
- No faulting or vertical or horizontal off-sets, or folding was observed within the mine
- The rock mass exhibited 4 sets of through-going joints: J1 (northeast-southwest), J2 (northwest-southeast), J3 (east-west) and J4 (north-south).

The primary joint sets are J1 and J2 and the complimentary joint sets are J3 and J4. The complimentary joint sets are minor, localized and limited in size and length.

1.1.2 Joint Sets

The primary joint sets (J1 and J2) had an average length of 80 feet on Level 2. The maximum observed joint length was approximately 200 feet. The spacing of the joints (as measured perpendicular to the joint faces) averages approximately 110 feet on Level 2, with the maximum observed joint spacing ranging from 350 to over 500. AAI noted that this information is consistent with for other locations in northeast Illinois for both the Silurian System dolomite and the Galena and Platteville Groups.

Each joint set observed was speciated based upon the type of infilling presented, the speciation was as follows:

- Closed Joints with small aperture and no infilling: 69 total (23%);
- Simple clay infilling: 227 total (75.4%);
- Clay pods: 2 total (0.60%); and
- Calcite/Breccia: 3 total (1.0%).

For these types of joints, the following results were obtained through field measurement of laboratory measurement of infilled material:

- Samples that were predominately clay had a mean hydraulic conductivity of 2.7 x 10^{-8} cm/s;
- Samples with clay with dolomite and calcite fragments had a mean hydraulic conductivity of 2.5 x 10^{-7} cm/s; and
- The aperture size was measured on 15% of the joints with no infilling using a feeler gauge. All of the joints tested were smaller than the smallest gauge. Making the aperture size 0.0015-inches with an assumed hydraulic conductivity

of 6.16 x 10^{-2} cm/s. Note that for an average joint spacing of 116 ft (Table 3-1), a joint hydraulic conductivity of 6.16E-02 cm/s is equivalent to a hydraulic conductivity in a porous medium of 1.74E-05 cm/s, which is comparable to the highest hydraulic conductivities estimated from the packer tests.

1.1.3 Bedding Planes

A monitoring well was constructed on the property but outside of the mine area. The purpose of this well was to characterize the geology of the injection area from the ground surface into the USDW of concern, the St. Peter formation. As part of this process, a series of packer test were conducted within the bore hole as depicted on Figure 11.2 on page 11-6. A total of 20 tests were conducted at 20 foot intervals from the top of the Galena Group to the bottom of the Platteville Group. The average hydraulic conductivity was 9.26 x 10^{-6} cm/s. This is approximately the same as the values from within the injection zone.

1.1.4 Hydromechanical Modeling

AAI conducted hydromechanical modeling using the UDEC 4.0 model. UDEC 4.0 is a two-dimensional numeric program based upon the distinct element method for discontinuum modeling. The UDEC model was chosen because the potential flow of fluids out of the storage area in the mine will be along bedding planes and secondary porosity features and not through the rock matrix itself. This is consistent with field studies of the Galena-Platteville Groups.

Because, as discussed in **Section 9.0** of the PA narrative, the lime sludge contains no contaminants, fate and transport modeling was determined to not be necessary in order to evaluate the feasibility of the project. Therefore, the primary purposes of the modeling were to characterize and predict:

- Potential fluid flow through a solid rock matrix with secondary porosity features;
- The overall stability of the rock system in the presence of the stored lime sludge.

UDEC models fluid flow through the joints and bedding planes within the system of impermeable blocks. All of the assumptions listed in Section 1.1.2 were used in the model. Additionally, as the sludge deposits and thickens in the mine, additional sludge will be deposited and some of the water may seep downward. Therefore the hydraulic conductivity of the sludge solid was also taken into account in the model. The hydraulic conductivity of the solids was averaged to be 1.0 x 10-5 cm/sec.

The primary assumptions and boundary conditions used were:

- An assumed maximum supernatant head elevation of 6 feet above the settled lime sludge solids within the mine;
- A blanket of lime sludge solids will be allowed to deposit across the floor of the mine by alternating the injection from the four IW's;
- Lime sludge solids are assumed to eventually reach a 50-foot thickness;
- The lime sludge is assumed to have a bulk density of 144 pcf;
- Assumes no fluid flow within the rock matrix, which is assumed to be impermeable;
- Bedding planes are repeated at 20-foot vertical intervals corresponding with the spacing of the packer tests at the average measured hydraulic conductivity of the packer tests;
- Joints are assumed to be vertical;
- Based upon field mapping, lateral joint spacings are assumed to be 120-feet and joint lengths are assumed to be 200-feet (both based upon field observation and mapping;
- Joints are assumed to repeat in the same vertical plane separated by 100-feet between joint ends;
- Fluid flow is assumed to be along joints, taking into account the populational breakdown and hydraulic conductivity of the 3 different joint types mapped in the mine as listed above;
- An assumed potentiometric surface elevation of 180.40 feet above MSL;

Model results and discussion:

- The model predicts a worse case flow of 0.9 to 1.5 GPM across the entire mine. To put this in perspective, if the amount of flow predicted by the model is taken as a function of the total surface area of the floor of the mine (assuming a floor surface area of 43 acres), the worst case flow would be approximately 0.021 to 0.035 GPM/acre.
- The model predicted very low flow horizontally, and contributed almost nothing to the total flow.
- The model predicts flow will decrease over time;
- The model assumes a full 50 foot thickness of sludge on the first level of the mine; this will not occur;
- The mining company is going to seal all unfilled joints along all perimeter walls and on the floor with shotcrete or a similarly performing material;
- The aperture size of the joints is larger than the particle size of the lime solids with an average D_{50} grain size was 0.0129 mm versus the aperture of 0.038 mm;

- The mining company is planning on constructing a new Level 3 below Level 2 concurrent with the operation of sludge deposition operations. They have stated that they plan on commencing on 2019 and it will take approximately 10 years to complete the mining. Agapito states: "Only negligible flow, on the order of a few gallons *per day*, is expected to reach the water table (once Level 3 has been completed)" (AAI Report, page ix).

1.2 Characteristics of the Lime Sludge

The lime sludge once inside the mine will almost immediately separate into a solid fraction and a liquid fraction (supernatant). As the solids settle, the supernatant forms at the top. At the dewatering lagoon, samples of supernatant were obtained prior to its evaporation. After the solids had sufficient dried, samples were obtained for laboratory analysis.

The lime sludge solids have been tested a total of 15 times between June 1999 and July 2012. During this time, the following organic parameters were detected above the laboratory reporting limit:

- Benzene in the April 24, 2012 sample;
- cis-1,2 Dichloroethene in the April 24, 2012 sample;
- MTBE in the April 24, 2012 sample; and
- Phenol in the October 20, 2008, April 24, 2012, July 3, 2012 and July 19, 2012 samples.

There are no sources in the waste stream generation process that have been identified (raw river/well water or the lime powder) that can introduce these chemicals into the lime sludge. The lime sludge is stored outside of the WTP in the dewatering lagoons for several weeks at a time and these chemicals were likely imparted to the sludge from a surface source outside of the WTP or could be representative of cross contamination either in the field sampling or at the laboratory.

The supernatant has been tested a total of 7 times between August 2002 and July 2012. In that time, the following organic parameters were detected above the laboratory reporting limit:

- Chloroform in the April 24, 2012 sample; and
- 2,4-D in the July 3, 2012 sample.

All other parameters for VOC's, SVOC's, PAH's, pesticides, herbicides or PCB's were below the laboratory reporting limit in every sampling event for the sludge solids and the supernatant.

As with the lime sludge solids, there are no sources in the waste stream generation process that have been identified (raw source water or the lime powder) that can introduce these chemicals into the supernatant and is likely from a surface source while the sludge was in the dewatering lagoon.

In all sampling events on the solids and supernatant, none of the parameters that were detected exceeded any of the standards set forth in 620.410 as well as 35 IAC 611.

1.3 Characteristics of the System

The City of Aurora uses a lime treatment process. They have a blended water system that is usually 60% Fox River water and 40% well water. Once the water enters the plant, it enters the claricones which contain the lime power used in the treatment process. Lime sludge is created and is blown out of the cone at regular intervals. Currently, the lime sludge is diverted to dewatering lagoons.

Under this system proposed in the PA, the sludge will be discharged to a covered wet well, and will be pumped into a forcemain which will be fed to one of four different injection wells at the site (see **Figure 4.1**). The sludge will fall by gravity into a series of distribution pipes on the floor of Level 1 of the mine, and then will be dropped into Level 2 of the mine. From the Water Treatment Plant to the deposition into the mine, the injection system is completely closed and at no point along the length of the system is it possible for contaminants to be introduced (as opposed to the dewatering lagoons). For a more complete description of the proposed system, please refer to **Section 4.0**. Therefore, any sample taken at the pump discharge port within the proposed pump house, will represent the exact composition of the material entering the mine.

2.0 PROPOSAL FOR VARIANCE REQUEST

As was defined above, the proposed system is inherently safe and would be protective of ground water and comply with both 35 IAC 620 and 611. This is due to the following:

- The geology of the area;
- Mine preparation activities, including sealing of all unfilled joints;
- The very small amount of flow as predicted by modeling;
- The method of injection into the mine through a closed system; and
- The fact that the lime sludge isn't contaminated.

It is understood that the Illinois EPA considers monitoring as an important part of the Permit in this case. As such, the City is prepared to monitor the system, but believes that it is more prudent to do so by sampling and analyzing samples of the lime sludge as it enters the mine, gaining a very quick feedback on these data, rather than indirectly monitoring what chemicals MAY be reaching the aquifer, perhaps decades later. There is approximately 175 feet of dolomite of the Platteville Group between the floor of the injection zone and the top of the aquifer. A network of monitoring wells would have years of delay in determining if the system is adversely impacting the aquifer.

Also, given the configuration of the site to the property boundaries, it would be very difficult to create a monitoring well network considered approvable to the Illinois EPA.

We propose installing a sampling port to the discharge line of the pump in order to facilitate the collection of representative samples of the sludge for laboratory analysis. From the sampling port location the lime sludge will be fed into the forcemain. Since the system is completely closed, the sample obtained at this point will be directly representative of the material entering the mine.

2.1 Sampling Methods and Media

Three separate media will be sampled as part of the operation of the system as follows:

- ***Sludge samples;***
- ***Solids samples: and***
- ***Liquid (supernatant) samples.***

The sampling location will be from the sampling port in the wet well pump discharge line.

The proposed sampling method is very simple. The sample will be analyzed as a sludge under United States Environmental Protection Agency ("USEPA") SW-846. The laboratory will supply three sterile 8 ounce glass jars. The sampling port will be controlled by a manual valve. During the day of sampling, after a sludge blowdown occurs it will fill the wet well at the pump house. Once the sludge reaches a certain height within the wet well level, the pumps will be activated and will begin pumping the sludge into the forcemain. At the time of sampling, one end of a plastic hose will be attached to the sampling port and the other end will be inserted into one of the jars, which will be held at an approximate 45° angle. The valve will then be slowly opened so that a manageable stream of sludge is produced and the jar will be filled. The cap will be replaced tightly, and the jar will be labeled, wrapped and placed in an ice-filled cooler for transport to a NELAC laboratory for analysis.

One jar will be used for the analysis of the sludge and the other two jars will be used for the analysis of the solids and the liquid. Upon receipt of the samples, the

laboratory will analyze the jar for sludge analysis immediately. Laboratory personnel will allow the solids and liquid to separate in the other two jars, and will obtain the liquid and solid samples for analysis.

If the laboratory that is awarded the contract for this project is unable to allow the solids and liquid to separate for sample acquisition, then this procedure will be conducted at the plant, and the liquid and solid samples will be placed in the appropriate laboratory supplied sterile containers for the analysis methods to be conducted.

Jars will be labeled with the following information:

- Date
- Time sample obtained
- Sampler(s)
- Project Number
- Sampled Media
- Sample ID
- Project ID

The process will be repeated identically for each jar.

Custody tape will be wrapped around the cooler and chain of custody sheet will be completed prior to leaving the plant. The samples will be transported immediately to the laboratory, where they will be relinquished to the laboratory for analysis.

2.2 *Parameter List and Analysis Methods*

After consultation with the Illinois EPA Permit Section, it was agreed that the parameter list would be the compounds listed in 620.410 for Class I aquifers ***and for characteristic hazardous waste testing as outlined in 35 IAC 721, Subpart C, Sections 721.122 and 721.124. Based upon the characteristics of the solid fraction of the waste that were established by previous sampling, only corrosivity (Section 721.122) and toxicity (Section 721.124) would apply to this waste.***

It is agreed that the lime sludge is not a listed hazardous waste. The Illinois EPA has stated that injection into the mine cannot occur if the lime sludge exhibits characteristics for hazardous waste as outlined in 35 IAC 721. Therefore, the lime sludge will be tested for corrosivity and toxicity in accordance with the standards set forth in 35 IAC 721 for determination of whether it can be injected into the mine, or if it would need to be diverted to the dewatering lagoon as described in the contingency plan in Section 2.4 of this Exhibit.

It is proposed that the following parameter lists will be tested for the three sampling media:

- ***Liquid – Parameter list outlined in 620.410;***
- ***Sludge – Parameter list outlined in 620.410, including pH; and***
- ***Solid – Toxicity characteristic parameter list as outlined in 721.124.b.***

The most recent corresponding SW-846 test methods will be used by the laboratory and all of the parameter suites and individual parameters will be indicated on the chain of custody.

The sludge and liquid media will be tested for the compounds listed in 620.410 using the following analysis methods:

- Volatile Organic Compounds ("VOC's"): 5030B/8260B/8011;
- Semi-volatile Organic Compounds ("SVOC's"): 3510C/8270C;
- Pesticides and Polychlorinated Biphenyls ("PCB's"): 3510C/8081A/8082;
- Herbicides: 8321A;
- Metals: 3010A/6010B;
- Mercury: 7470A;
- Radium 226 and 228: 903.1/Ra-05;
- Cyanide: 335.4R1;
- Nitrate, as N: 353.2R2.0;
- Sulfate: 375.2R2.0;
- Total Dissolved Solids: 2540C;
- pH: 4500H+, B;
- Chloride: 4500Cl, E; and
- Fluoride: 4500F, C
- Perchlorate
- Total Solids Analysis
- ***Temperature***

Total solids analysis is necessary ***for the sludge media*** ~~because the sample will be analyzed as a sludge~~. Additionally, a note will be added to the notes section on the COC form saying "As received basis".

The percent total solids analysis is critical to know because the presence of the solids will skew the analysis results higher. The results can then be adjusted accurately using the percent solids as the conversion factor. ~~All~~ ***Results for the analysis of the sludge*** will be reported in mg/kg.

2.2.1 *Corrosivity*

The pH of the lime sludge as it exits the WTP through the blowdown line typically ranges between 8.5 and 11.5 units. Previous samples collected from the solid media and the liquid media from the dewatering lagoons is consistent with these levels (please refer to Appendix O and Appendix P). The pH levels will continue to be monitored as part of the monitoring program under the permit issued by the Illinois EPA.

2.2.2 *Toxicity*

It is proposed that the laboratory will hold two of the sample jars to allow the liquid and solid fractions of the sludge to separate. Once the solids have been separated and the samples have been prepared, they will be analyzed for toxicity characteristics using USEPA Method 1311, Toxicity Characteristic Leaching Procedure ("TCLP").

It is proposed that only the parameters in the 721.124 list that are detected in the sludge media analysis would be analyzed using the TCLP test.

2.3 *Tiered Sampling Frequency*

~~In lieu of ground water monitoring, the City proposes to analyze for all parameters listed in 620.410~~ *The sludge, solid and liquid media will be sampled* on the following ~~sampling~~ schedule:

- ~~Bi-monthly~~ *Once every two months* for the first year *(6 sampling events)*;
- Quarterly for years 2 through 6 *(20 sampling events)*;
- Semi-annual for years 7 and 8 *(4 sampling events)*; and
- Annually thereafter.

Therefore, for the anticipated initial permit cycle of 10 years, there will be 1 year of ~~Bi-monthly~~ *sampling every two months*, 5 years of quarterly sampling, 2 years of semi-annual sampling and 2 years of annual sampling.

2.4 *Applicable Regulatory Standards and Contingency Plan*

The contingency plan outlined below has been prepared for the purpose of defining the conditions under which normal sludge injection can occur. Since the sludge is not a listed hazardous waste, this determination will be based upon the sludge meeting the State of Illinois standards for the characteristics of hazardous waste. The following standards will be applied in order to make this determination:

- *Solid media: standards for the parameters listed in 721.124.b and the radium standard established by the Illinois Emergency Management Agency ("IEMA").*

In the unlikely event that the pH of the sludge exceeds the State standard of 12.5, the sludge from the WTP will be diverted into the dewatering lagoon at the WTP. The Illinois EPA will be notified of the exceedence and additional pH measurements will be taken. The diversion of the sludge will continue until sampling indicates that the pH standard is being met. Once the standard has been met, normal system operation will commence and the pumping of the sludge will resume.

Additionally, the standards that will be applied to evaluate the solid fraction of the sludge for toxicity characteristics are the levels as outlined in Section 721.124.b. If at any point one of the standards listed is exceeded in the routine TCLP testing, the sludge will be diverted as described above until it is demonstrated that the sludge meets the standards. Compliance will be demonstrated by either re-testing the sample at the laboratory for the parameter(s) of exceedence or by obtaining an additional sample for testing. Once it is demonstrated that the solid fraction meets the toxicity standards, then normal system operation will re-commence.

The solid media will also be subject to the radium standard established by IEMA in their memo dated April 7, 2014 (please refer to Exhibit D). The radium (total) standard established in the referenced memo is 25 pCi/g. If the average annual concentration of radium exceeds this standard, then injection will cease, the sludge will be diverted to the dewatering lagoon as described above and IEMA and the Illinois EPA will be notified.

~~In the event that one or more parameters exceed the State standards, the following shall apply:~~

- ~~If occurrence is during Bi-monthly sampling, continue sampling until 4 consecutive sampling events meet the standards; then proceed one year of quarterly sampling, 1 year of semi-annual sampling, and annual thereafter;~~
- ~~If occurrence is during quarterly sampling, then continue quarterly sampling until 4 consecutive quarters meet the standards, then proceed to semi-annual sampling for one year, then annual thereafter; and~~
- ~~If occurrence is either during the semi-annual or annual sampling, then sample quarterly until 4 consecutive quarters meet the standards, then semi-annual for 1 year and annual thereafter.~~

- ~~If occurrence is during quarterly sampling, then continue quarterly sampling until 4 consecutive quarters meet the standards, then proceed to semi-annual sampling for one year, then annual thereafter; and~~
- ~~If occurrence is either during the semi-annual or annual sampling, then sample quarterly until 4 consecutive quarters meet the standards, then semi-annual for 1 year and annual thereafter.~~

2.5 *Reporting*

For each sampling event, a report will be generated and submitted to the Illinois EPA for review. Each report will include the following:

- A cover letter summarizing the event, with notations of any significant results
- All laboratory analysis reports
- Data in tabular form (updated)

Additionally, in the event of sludge diversion to the dewatering lagoon resulting from characteristic hazardous waste standard exceedence, the IEPA will be notified within 72-hours.

The monitoring reports will be submitted within 30 of receipt of the analysis results from the laboratory. Since radium will be analyzed, the laboratory report could take as long as 6 weeks to be issued after receipt of the samples.

3.0 CONSLUSIONS

The ultimate goal of any monitoring program is to protect a resource; in this case the Ancell Group, specifically, the St. Peter Formation. The City feels strongly, that as presented in the Permit Application the project would have no chance to adversely impact this aquifer. The City is submitting this waiver request based upon what are felt to be the intrinsic elements of the project that make it protective of human health and the environment while maintaining compliance with state regulations.

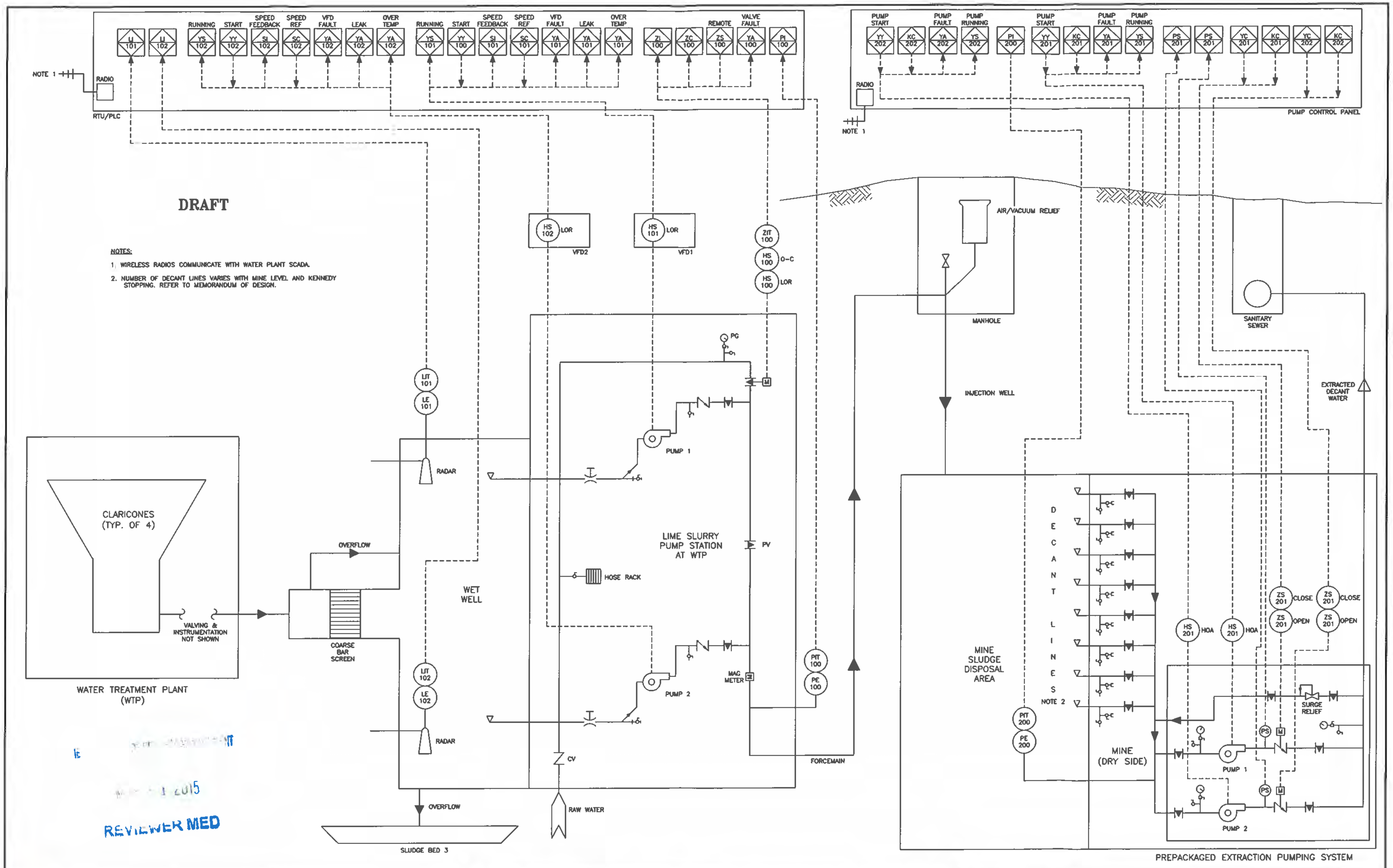
The benefits of this project to the City and the State of Illinois are clear; drastic cost reduction, reduces carbon emissions through the elimination of transportation and use of heavy equipment and saves landfill space to name but a few.

The supports of this proposal are:

- In all of the sampling events conducted on the solids and supernatant, over 90% were not detected and those that were detected were below both the 620.410 and 611 standards;

- The hydromechanical model predicted very little flow out of the mine under worst case assumptions; under realistic assumptions, actual flow will most likely be much less than predicted;
- The characteristics of the mine and the mine preparation activities that will be conducted prior to the initiation of injection activities (e.g. sealing the unfilled joints); and
- The City's proposal for an aggressive sampling program for monitoring the sludge prior to its entry into the mine so that any issues that are identified can be proactively addressed.

Exhibit B



DEUCHLER ENVIRONMENTAL, INC.
Consulting Engineers — Aurora, Illinois

REVISIONS: REVISION 1.0 – SEPTEMBER 30, 2014

DATE 0/0/13 | DESIGNED M.H/YA | DRAWN JES | APPROVED MJH | BOOK | SCALE SHOWN | CAD DWG F:\DEI\08030\MOD\PIDS\PID 1 | JOB NO. 08030-00

UIC PROGRAM
LIME SLURRY PUMP STATION AND EXTRACTION PUMP STATION
PRELIMINARY PIPING & INSTRUMENTATION DIAGRAM

SHEET 1 OF 1

Exhibit C

REVISION 1.0
September 30, 2014

SYSTEM COMPONENT TABLE

UIC Lime Sludge Handling Components	Materials					
Wet Well	Concrete					
Pump Suction Piping	Ductile Iron	Std. Cement Lining	SBR Gasket	Std. Asphaltic Coating		
Suction Pinch Valve	Cast Iron Body	BUNA-N Rubber Sleeve				
Suction Pressure Ring	Stainless Steel	BUNA-N elastomer				
Suction Piping Water Flush piping and valves	304 Stainless Steel					
Lime Sludge Pump	White Iron					
Pump Discharge Piping and Fittings	Ductile Iron	Std. Cement Lining	SBR Gasket	Std. Asphaltic Coating		
Suction and Discharge Expansion Joint	BUNA-N elastomer					
Discharge Pressure Gauge Piping	304 Stainless Steel					
Pump Discharge Check Valve	Ductile Iron Body and Disc	BUNA-N Disc Seat	Stainless Steel Pivot Shaft			
Pump Discharge Plug Valve	Ductile Iron Body	BUNA-N Plug				
Force main piping	Ductile Iron	Std. Cement Lining	SBR Gasket	Std. Asphaltic Coating		
Megalug Restraining Joints	Powder-coated ductile iron		SBR Gasket			
Force main Gate Valves	Epoxy Coated Ductile Iron	Ductile Iron Wedge Encapsulated in EPDM Rubber				
Force main Fittings	Ductile Iron	Std. Cement Lining	SBR Gasket	Std. Asphaltic Coating		
Air Release Valves	304/316 Stainless Steel	UHMW-PE	HDPE			
Gate Valves for Flushing	Epoxy Coated Ductile Iron	Ductile Iron Wedge Encapsulated in EPDM Rubber				
Injection Well Piping and Fittings	ASTM A53 B, Schedule 40 Carbon Steel	ASTM A53 B, Schedule 80 Carbon Steel	No Interior Lining	Coal Tar Epoxy Coating	Std. Welding at Joints	
Energy Dissipater	304 Stainless Steel					
Pipe Supports	ASTM A992, Grade 50 Carbon Steel 'W' and 'WT' shapes, Epoxy Coated	ASTM A36 Carbon Steel Channel and Angles, Epoxy Coated	ASTM A36 Carbon Steel Plates and Bars, Epoxy Coated	ASTM F1554, Grade 36 Carbon Steel Threaded Rods	Non-Shrink, Non-Metallic grout	Chemical Epoxy for Anchor Bolts
Kennedy Stoppings	Coated Steel Panels					
Extraction Piping Through Kennedy Stopping	Ductile Iron	Std. Cement Lining	SBR Gasket	Std. Asphaltic Coating		

Exhibit D

IEMA
Illinois Emergency Management Agency

Jonathon E. Monken, Director
Joseph Klinger, Assistant Director

TO: Jonathon E. Monken
Director

THRU: Jenifer L. Johnson
Chief Legal Counsel

FROM: Adnan Khayyat, Chief
Bureau of Radiation Safety

DATE: April 7, 2014

SUBJECT: Exemption allowing for Alternative Disposal of radium residuals for the City of Aurora.

Approximately 481 municipalities throughout the State of Illinois, in the course of treating groundwater to meet applicable drinking water standards, may concentrate radium in their treatment residuals. The resulting concentrations are dependent upon the treatment technology employed, as well as the local hydrogeology. Among other regulatory requirements, when both of these factors contribute to elevated concentrations of radium, 32 Ill. Adm. Code 330.40(d)(4)(A) allows for two disposal options: landfill disposal and land application.

Section 330.40(d)(4)(A) specifies that radium residuals and sludge less than or equal to 100 pCi/g (dry weight basis) may be sent to an Illinois Environmental Protection Agency (IEPA) approved landfill or may be used for soil conditioning purposes on agricultural crop land provided certain conditions are met. This provision does not allow for an alternative disposal analysis by IEMA as does Section 330.40(d)(4)(B).

Disposal of this type of waste by means of an underground injection control (UIC) permit is regulated by IEPA under, 35 Ill. Adm. Subtitle G, Part 702, 704, and 730. Under these regulations non-hazardous special waste, which includes low-level radioactive waste, may be discarded by injection with a Class V UIC permit. As part of the IEPA approved permit, groundwater monitoring, including limitations for radioactive components, would generally be included.

As a result of treating groundwater, the City of Aurora, Illinois (City) produces an average radium sludge concentration less than 10 pCi/g and currently disposes the material through the landfill and land application processes. The City has submitted a Class V UIC permit application to the IEPA which would allow the City to inject the water treatment sludge into a subterranean limestone and dolomite mine through a Class V UIC well as defined in the IEPA regulations. However, this means of disposal is not provided for in 32 Ill. Adm. Code 330.40(d)(4)(A).

EMAP Accredited

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If prior to injection, a dose assessment model specific to the geological parameters of the proposed injection site conducted by IEMA indicates the City's proposed disposal method is protective of public health and the environment and Pursuant to 32 Ill. Adm. Code 310.30(a), the IEMA would like to grant an exemption from the disposal options currently allowed in Section 330.40(d)(4)(A) to the City thus allowing the City to utilize the UIC process provided the following conditions are met: the alternative disposal method is a Class V UIC; the IEPA grants the City a UIC permit for a Class V well(s); radium sludge injected into the Class V well(s) under the IEPA approved UIC will not exceed an annual average concentration of 25 pCi/g of total radium (the sum of Ra-226 and Ra-228); if the average annual concentration of total radium exceeds 25 pCi/g the City will cease well injection activities and notify the IEMA; all other applicable provisions currently in 32 Ill. Adm. Code 330.40(d) are met.

Request for exemption approved:

________________________ Date: 4/11/14

Jonathon E. Monken
Director

Request for exemption denied:

________________________ Date: ____________

Jonathon E. Monken
Director

Appendix A

APPENDIX A:

Agapito Associates Report

635-04

Water-Treatment Sludge Disposal in Portions of the Lafarge Conco Mine Aurora, Illinois

Prepared for

Deuchler Environmental, Inc.
CONSULTING ENGINEERS

February 2013

AGAPITO ASSOCIATES, INC.

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303/271-3750 • FAX 303/271-3891

WATER-TREATMENT SLUDGE DISPOSAL IN PORTIONS OF THE LAFARGE CONCO MINE AURORA, ILLINOIS

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EXECUTIVE SUMMARY

The City of Aurora (Aurora) extracts approximately 16 million gallons per day (winter) and 28 million gallons per day (summer) domestic-use water blended from the northern Illinois Deep Cambro-Ordovician Aquifer and the Fox River. Before distribution, the water is treated to improve its quality. One of the by-products from this treatment is a sludge consisting, on average, approximately 85% water by weight with 15% calcium carbonate ($CaCO_3$) solids or "slimes," as a very fine material suspended in water. Aurora proposes to dispose of the water treatment plant lime sludge within the Lafarge Conco South Mine. The City currently manages the sludge by diverting it to several drying beds at their Water Treatment Plant (WTP). Once the sludge has been sufficiently dewatered to pass a standard Paint-Filter Test, it is excavated from the drying beds and transported to a municipal landfill as a non-hazardous special waste for disposal.

Aurora is proposing to dispose of the lime sludge through four injection wells at different locations at the surface of the property located at the southeast corner of the intersection of Illinois Route 25 and Mettel Road in Aurora, Illinois as shown on Figure ES-1. The Lafarge Conco South Mine is located beneath this property, starting at a depth of approximately 250 feet (ft) below the ground surface (bgs).

Sludge will be transmitted to the site through a force main. The force main will connect to four different injection wells located as depicted on Figure ES-2. The injection wells will be drilled vertically into Level 1 of the mine and connected at the roof to a vertical pipe in the mine. This pipe will be connected to steel distribution manifolds along the floor of Level 1 of the mine.

These distribution manifolds will connect the four injection wells to various clusters of eighteen injection holes drilled through the sill between Levels 1 and 2 of the mine. Steel piping in the injection holes will extend to just below the roof of Level 2 of the mine where they will be connected to fittings with 4 outlets at right angles to each other. From the outlets of these fittings, the lime sludge will discharge into the second level of the mine.

Each of the four injection wells will have dedicated distribution piping and injection holes connected to it. Injection Well 1 (IW-1) will be connected to six injection holes at the south end of the mine, IW-2 will also be connected to six injection holes, and IW-3 and IW-4 will be connected to three injection holes each. By constructing berms between certain pillars on Level 2 of the mine, three siltation basins will be created, such that each injection well will deposit sludge into one of these siltation basins. The purpose of the basins is to insure that the solids deposit from the south end of the mine, progressing to the north end, while allowing the decant water to travel to the north end of the mine for extraction to the surface. As shown on Figure ES-2, IW-1 will deposit into siltation basin 1, IW-2 into siltation basin 2, and IW-3 and IW-4 into siltation basin 3. The injection wells will be operated singly in sequence, starting with IW-1 at the south end of the mine and progressing to IW-4 at the north end of the mine.

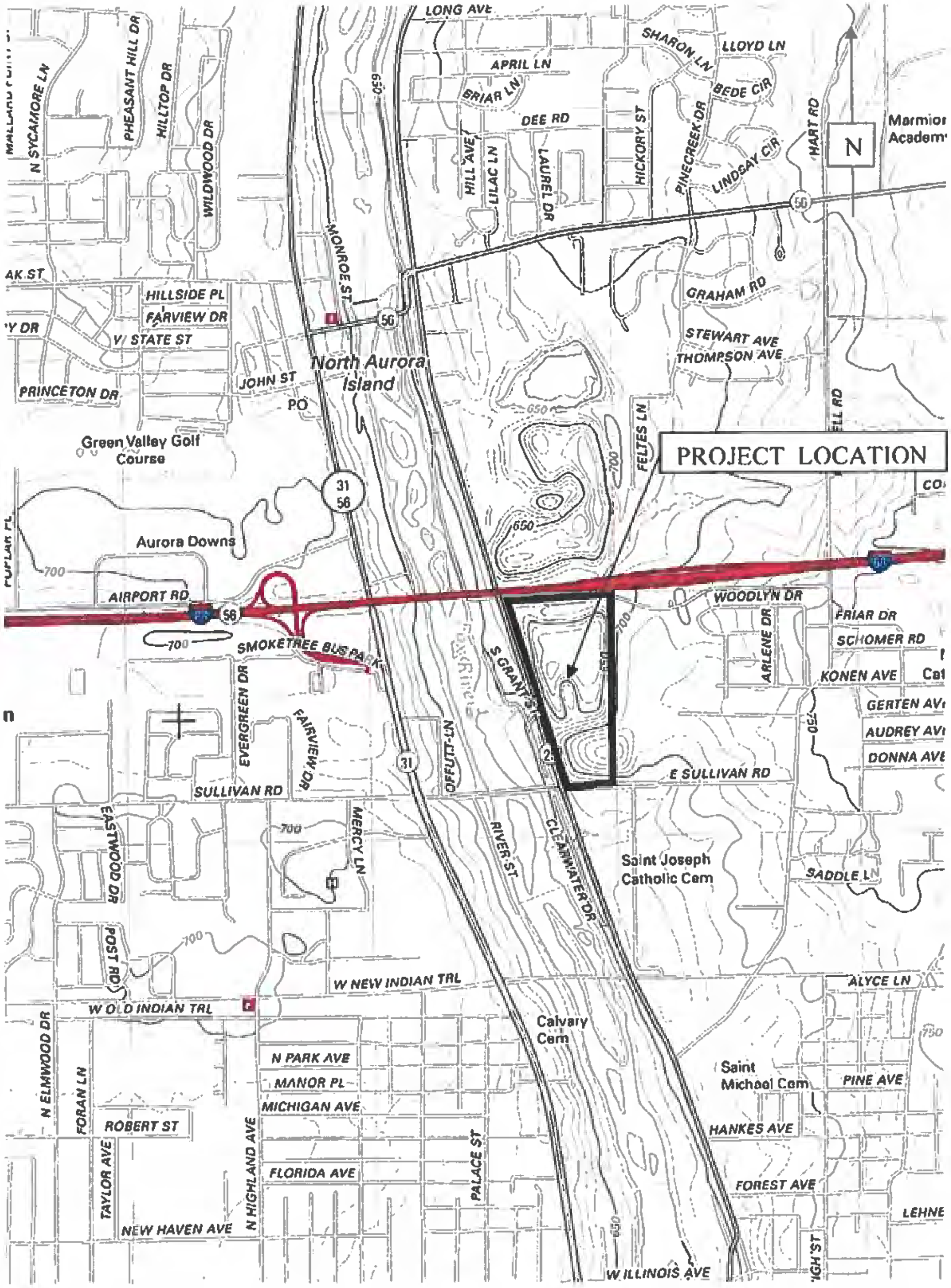

Figure ES-1. Conco South Mine Location Map (source: USGS Aurora North 7.5 minute topographic quadrangle map, 2012)

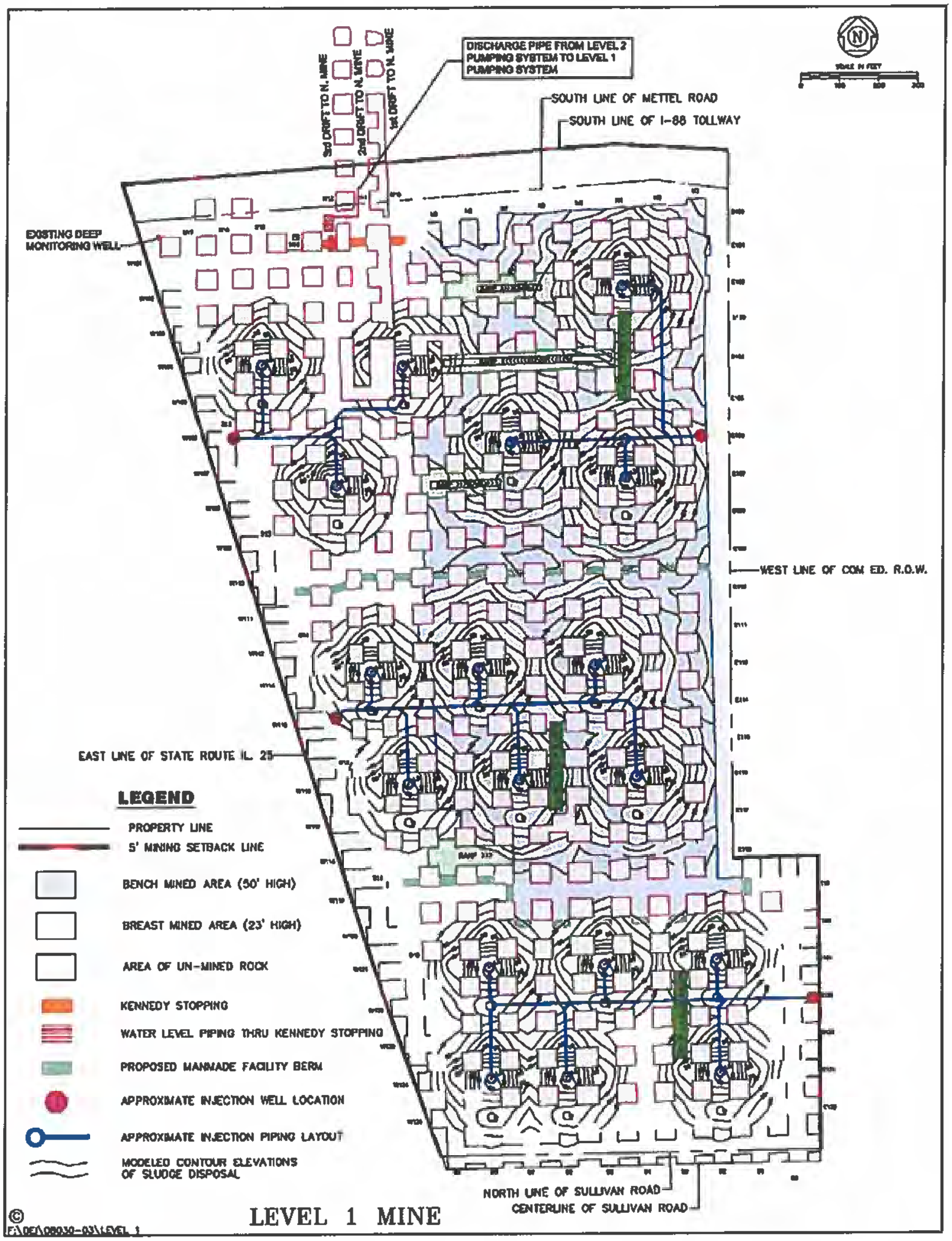

Figure ES-2. Conco South Mine Level 1 Plan showing Injection Wells and Pipe Manifolds

At the north end of the mine, the four tunnels connecting the Conco South Mine to the Conco North Mine will be sealed using Kennedy Stoppings to completely isolate the South Mine from the Lafarge mining operations in the North Mine. These stoppings will be keyed into the rock to completely seal the 50-ft by 47-ft openings. Lafarge will design and construct the Kennedy Stoppings and will also seal any fractures in the rock surrounding the stoppings to create a leak-proof seal.

As the lime sludge is deposited in the mine through the injection wells, the water in the sludge will decant and the solids will settle out of suspension toward the floor of the mine. The level of the decant water, or supernatant, will be maintained at a maximum head of 5-ft above the level of the fill. This maximum head level will be maintained by constructing outlet pipes for the supernatant liquid through the Kennedy Stoppings that are spaced 5 ft apart vertically, starting at the floor of the mine. (The pipe at the floor will be perforated and wrapped in filter cloth to prevent passage of solids.) This operation will continue until the storage area is completely filled with solids.

On the "dry" side of the Kennedy Stoppings, the decant water will be pumped from the outlet pipes, in progression from the bottom to the top, to a single discharge pipe that will be connected to a pump column that will extend from Level 2 of the mine to the ground surface (approximately 250 ft vertical distance). The pump column will be connected to a force main approximately 5 ft below ground surface (bgs) that will discharge the water to a nearby sanitary sewer.

Aurora retained Deuchler Environmental, Inc. (DEI) to complete the geological, hydrogeological, and engineering services necessary to obtain the Illinois Environmental Protection Agency (IEPA) permits to dispose of water treatment sludge in the Lafarge Conco South Mine. DEI contracted with Agapito Associates, Inc. (AAI) to provide mining, geological, and underground construction engineering consulting services for the proposed water treatment sludge disposal facility in the Lafarge Conco Mine.

The Lafarge Conco Mine was developed by Conco Western Stone Co. (Conco Western) in the early 1990s by driving a "decline" or inclined tunnel from the existing quarry floor down to the upper portion of the Galena dolomite approximately 200 ft vertically below the quarry floor. Mining at this depth to the south of the Reagan Tollway was initiated after completion of an agreement between Conco Western and Aurora, which owns land that had once been surface-mined by Conco Western.

Conco Western was acquired in 2007 by Lafarge North America Aggregates, which continues to operate the mine as the Lafarge Conco Mine. South of the tollway easement, the mining pattern includes 50-ft square pillars and 45-ft-wide rooms and crosscuts, with the same 50-ft heights as the northern portion. A second lower level with identical dimensions and superimposed pillar placements is being mined underneath the upper level with the roof of the lower level 25 ft below the floor of the upper level.

Agapito Associates, Inc. (AAI) staff visited the Lafarge Conco Mine on several occasions in July and October 2008 and March and June 2009 to inspect and map joints in the mine and collect samples of joint infilling material for examination and testing. Three types of joint infillings were noted—breccia or shear zones, joints with simple clay infillings, and joints with expanded oval pods filled with clay. The composition of the infilling material in each sample was evaluated qualitatively by AAI using a stereo microscope. The nature of the clay infillings was determined using X-Ray Diffraction (XRD) analysis. The XRD analysis confirmed that the joint infillings could be divided into two groups: one consisting mainly of greenish-gray clay of the illite type and the other consisting of calcite, rock fragments and occasionally sulfides.

The hydraulic conductivity of the infilling materials was determined in the laboratory using the falling-head method. The samples of illite clay had a mean hydraulic conductivity of 2.7×10^{-8} centimeters per second (cm/s); samples of calcite and dolomite fragments mixed with clay had a mean hydraulic conductivity of 2.5×10^{-7} cm/s.

AAI used proprietary AAI-authored spreadsheets for the empirical pillar-strength formulas to evaluate the stability of existing 50-ft square pillars at the mining depths of the existing first and second levels and the projected third level. AAI evaluated the stability of a 25-ft-thick sill pillar between the second level and a proposed third level using calculation methods for the stability of pillar-supported floor slabs.

A numerical hydro-mechanical model was constructed to simulate fluid flow from the mine resulting from sludge impoundment. Modeling was performed using UDEC 4.0 which simulates the response of discontinuous media, such as a jointed rock mass, subjected to either static or dynamic loading, using an assemblage of blocks. UDEC is capable of analyzing fluid flow through the fractures of a system of impermeable blocks using a fully coupled mechanical-hydraulic analysis in which fracture conductivity is dependent on mechanical deformation and, conversely, joint water pressures affect the mechanical computations. The site-specific model geometry represented a two-dimensional profile through the mine extending vertically from the ground surface to 424 ft below the floor of the Lower Level, and laterally from a point near the center of the mine in an east-west cross section to 1,070 ft into the solid beyond the edge of mining.

Water is well known for its ability to erode rocks as a result of alternating wetting and drying cycles. To gather data on the effects of wetting and drying on limestones and dolomites, AAI consulted with representatives and web pages of the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), the Milwaukee Metropolitan Sewerage District (MMSD), and persons knowledgeable concerning other tunnels in limestone or dolomite. AAI also performed a search of the tunneling literature regarding water problems in tunnels in limestone or dolomite.

Aurora water is obtained from the Fox River and from supply wells that pump from the Cambro-Ordovician aquifer below the Galena-Platteville Group. Results of water-supply well sample analyses showed that its pH and hardness concentrations are indicative of water that has been in contact with carbonate rocks such as the Galena-Platteville Group.

As a result of these investigations, AAI concludes the following:

- Modeling of the mine hydro-geomechanical system with UDEC indicates that mining has not and will not in the future have a significant influence on the hydraulic conductivity of the natural system. Mining results in a localized perturbation of the in situ stress state in close proximity to the mine openings. Results indicate that mining is likely to cause some fracturing of healed joints and dilation of unfilled joints several feet into the roof, rib, or floor. However the change in natural hydraulic conductivity extends a negligible distance into the rock mass when compared to the distance to the water table.

- Fluid flows out of the sludge impoundment area are predicted to be very low relative to the pumping capacity of the mine (historically on the order of 600 gallons per minute [gpm]), due to the low permeability of the geologic system. Total fluid flow from Level 2 into Level 3 is predicted to increase from about 0.9 gpm initially to 1.5 gpm over the life of the operation based on simulated "best estimate" (i.e., most accurate possible) conditions. Only negligible flow, on the order of a few gallons per day, is expected to reach the water table of the Cambro-Ordovician aquifer.

- The total flow from the impoundment area could be greater than predicted because of unknown or unobservable joints, vugs, or other conduits, as is typical of most geologic systems. Experience and observations in the mine, and in other, similar mines operating in the same stratigraphy, suggest that the risk of problematic flow is limited. Moreover, the risk is partially offset by the probability that the solids in the sludge will plug drainage paths and that the majority of flow will be intercepted by Level 3 before entering the water table. Worst case flow could increase two orders of magnitude above "best estimate" predictions (0.9 to 1.5 gpm) and still be considered readily manageable using the mine's existing pumping system. Although considered as very low probability, flows into Level 3 in excess of 1,000 gpm could be managed by adding pumping capacity and/or using localized grouting, drilling of interceptor drains, or other flow control techniques. Flow and any flow control system would be temporary until the sludge reservoir was fully drained or flow pathways were self-sealed.

- Hydro-mechanical modeling indicates that the potential for joint pressurization from fluid flowing from the sludge impoundment area poses minimal risk to global geomechanical stability in the mine.

- The pillar-stability formulas result in safety factors that exceed 1.79 for all cases. (A safety factor of unity implies that the pillar strength just equals the stress applied to the pillar.) Given that the mine pillars have a width/height (W/H) ratio of approximately 1 and that the minimum acceptable safety factor as taken by AAI in that situation is 1.3, all three formulas predict that the existing mine pillars should be stable. The sill stability calculations resulted in safety factors greater than 1.85 in all cases.

- Based on experience in unlined sewer and wastewater tunnels sited in similar rocks elsewhere in the Chicago area, wetting and drying cycles are unlikely to cause significant erosion of the roof and walls of the mine openings. Internet and telephone contacts indicated that little erosion has occurred in unlined portions of the deep (250 to 300 ft below surface) tunnels of the MWRDGC and MMSD that are sited in Silurian dolomites similar to the Ordovician Galena and Platteville Groups. Inspection of the MMSD tunnels some years after construction found that joints that had been mapped as weeping at the time of construction had healed as a result of calcification.

- Rockfalls may occur if the mine is dewatered for inspection. The primary cause of such falls is the loosening of small blocks bounded by joint planes that have become water-saturated. Such rockfalls are unlikely to result in water inflows or significant tunnel instability unless other conditions such as joints filled with soft gouge are also present.

- Aurora water is obtained from the Fox River and from supply wells that pump from the Cambro-Ordovician aquifer below the Galena-Platteville Group. Results of water-supply well sample analyses showed that its pH and hardness concentrations are indicative of water that has been in contact with carbonate rocks such as the Galena-Platteville Group. Consequently, few, if any, adverse chemical interactions can be expected due to the chemistry of the water.

1.0 BACKGROUND

1.1 Disposal of Aurora Water-Treatment Sludge

The City of Aurora (Aurora) extracts approximately 16 million gallons per day (winter) and 28 million gallons per day (summer) domestic-use water blended from the northern Illinois Deep Cambro-Ordovician Aquifer and the Fox River. Before distribution, the water is treated to improve its quality. One of the by-products from this treatment is a sludge consisting, on average, approximately 85% water with 15% calcium carbonate ($CaCO_3$) solids or "slimes," as a very fine material suspended in water. The sludge has a pH range from 9 to 12 and a density of 1.6 gram per cubic centimeter (g/cm^3) when settled. Aurora anticipates the need for continued disposal of 15,000 to 20,000 cubic yards or 30,000 to 35,000 tons per year of sludge or slimes.

Aurora currently manages the sludge by diverting it to several drying beds at their Water Treatment Plant (WTP). As the sludge settles in the drying beds, the water decants to the top and the sludge settles to the bottom. Once the sludge passes a standard Paint-Filter Test, it is excavated from the drying beds and transported to a municipal landfill as a non-hazardous special waste for disposal. Some water flows as leachate from the bottom of the drying bed, but most water is either held within the matrix of the sludge or is present as decant or supernatant water.

Aurora proposes to dispose of the lime sludge in the Lafarge Conco South Mine through four injection wells at different locations on the surface of the property located at the southeast corner of the intersection of Illinois Route 25 and Mettel Road in Aurora, Illinois (see Figure ES-1.) The Lafarge Conco South Mine is located beneath this property, starting at a depth of approximately 250 ft below the ground surface.

Aurora retained Deuchler Environmental, Inc. (DEI) to complete the geological, hydrogeological, and engineering services necessary to obtain the Illinois Environmental Protection Agency (IEPA) permits necessary to dispose of water treatment sludge in the Lafarge Conco Mine. DEI contracted with Agapito Associates, Inc. (AAI) to provide mining, geological, and underground construction engineering consulting services for the proposed water treatment sludge disposal facility in the Lafarge Conco Mine.

Sludge will be transmitted to the site through a force main. The force main will connect to four different injection wells located as depicted on Figure ES-2. The injection wells will be drilled vertically into Level 1 of the mine and connected at the roof to a vertical pipe in the mine. This pipe will have a 90° elbow at the floor of the level from whence it will be connected to steel distribution manifolds along the floor of Level 1 of the mine.

These distribution manifolds will connect the four injection wells to various clusters of eighteen injection holes drilled through the sill between Levels 1 and 2 of the mine. There will be 90° elbows connecting the pipes along the floor of Level 1 of the mine into the injection holes. Steel piping in the injection holes will extend from the elbows to just below the roof of Level 2 of the mine. The ends of the injection pipes at the roof of Level 2 of the mine will be connected to fittings with four outlets at right angles to each other. These fittings will be suspended approximately 2 ft below the roof of Level 2. From the outlets of these fittings, the lime sludge will flow into the second level of the mine.

The system will be constructed so that each of the four injection wells will have dedicated distribution piping and injection holes connected to it. Injection Well ("IW") 1 will be connected to six injection holes at the south end of the mine, IW-2 will also be connected to six injection holes, and IW-3 and IW-4 will be connected to three injection holes each. By constructing berms between certain pillars on Level 2 of the mine, three siltation basins will be created, such that each injection well will deposit sludge into one of these siltation basins. The purpose of the basins is to cause the solids to deposit over the entire area of the mine, while allowing the decant water to travel to collection pipes at the north end of the mine for pumping to the surface. As shown on Figure ES-2, IW-1 will deposit into siltation basin 1, IW-2 into siltation basin 2, and IW-3 and IW-4 into siltation basin 3.

The injection wells will be operated singly in sequence, starting with IW-1 at the south end of the mine and progressing to IW-4 at the north end of the mine. Injection of the sludge will be sequenced so that the sludge will be maintained at an approximately equal height over the entire area.

At the north end of the mine, the four tunnels connecting the Conco South Mine to the Conco North Mine will be sealed using Kennedy Stoppings to completely isolate the South Mine from the Lafarge mining operations in the North Mine. These stoppings will be keyed into the rock to completely seal the 50-ft by 47-ft openings. Lafarge will design and construct the Kennedy Stoppings and will also seal any fractures in the rock surrounding the stoppings to create a leak-proof seal.

As the lime sludge is deposited in the mine through the injection wells, the water in the sludge will decant and the solids will settle out of suspension toward the floor of the mine. The level of the decant water, or supernatant, will be maintained at a maximum head of 5 ft above the level of the fill. This maximum head level will be maintained by constructing outlet pipes for the supernatant liquid through the Kennedy Stoppings that are spaced 5-ft apart vertically, starting at the floor of the mine. (The pipe at the floor will be perforated and wrapped in filter cloth to prevent passage of solids.) This operation will continue until the storage area is completely filled with solids.

On the "dry" side of the Kennedy Stoppings, the supernatant will be pumped through the outlet pipes, in progression from the bottom to the top, to a single discharge pipe that will be connected to pump column extending from Level 2 of the mine to the ground surface (approximately 250 ft vertical distance). The pump column will be connected to a force main approximately 5 ft below ground surface (bgs) that will discharge the supernatant to a nearby sanitary sewer.

1.2 Mining at Lafarge Conco Mine

The Lafarge Conco Mine was developed by Conco Western Stone Co. (Conco Western) in the early 1990s by driving a "decline" or inclined tunnel from the existing quarry floor down to the upper portion of the Galena dolomite, approximately 200 ft vertically below the quarry floor. The decline was driven near, and parallel to, the northern boundary of the mining area.

The mine is a room-and-pillar mine with mining operations conducted to the north and south of the Ronald Reagan Memorial Tollway of the Illinois State Toll Highway Authority (ISTHA), which is Interstate Highway 88 (I-88). To the north of the tollway easement, the mining layout consists of square pillars 40 ft on a side and rooms and crosscuts also 40 ft wide, initially 23 ft high and eventually extended to 50 ft high.

Mining to the south of the Reagan Tollway was initiated after completion of an agreement between Conco Western and Aurora, because Aurora owns the land immediately south of the tollway right-of-way. (This land had formerly been owned and surface-mined by Conco Western, but was sold to Aurora before 1980.) Conco Western was acquired in 2007 by Lafarge North America Aggregates, which continues to operate the mine as the Lafarge Conco Mine. The mining pattern south of the tollway easement was altered to 50-ft square pillars and 45-ft-wide rooms and crosscuts, with the same planned 50-ft heights as the northern portion. A second lower level with identical dimensions and pillar placements is currently being mined underneath the upper level with the roof of the lower level 25 ft below the ultimate floor of the upper level. A third, 50-ft-high level is planned for below the second level. A geologic section showing the active and proposed mining levels is presented in Figure 1-1.

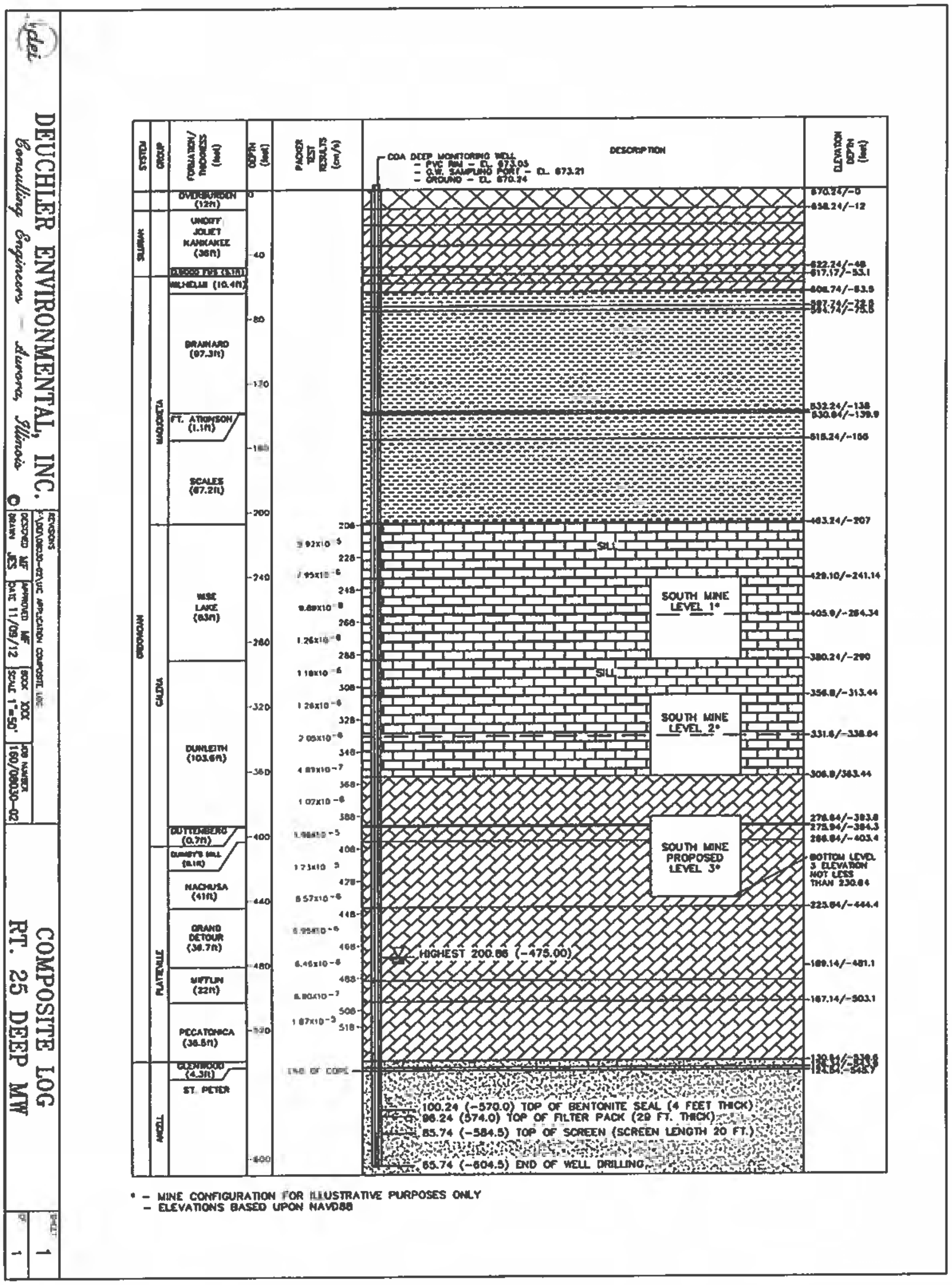

Figure 1-1. Geologic Section through Conco South Mine showing Existing and Planned Mine Levels

2.0 Regional Geologic and Hydrogeologic Setting

2.1 Local and Regional Geology

The Conco Western Quarry is a former surface quarry developed in Silurian-age dolomite for construction aggregate use. The surface quarry is underlain by non-saleable rock of the Maquoketa Group, which, in turn, is underlain by mineable and saleable dolomite of the Galena and Platteville Groups. The underground Galena and Platteville Groups are the target of present underground multiple-level room-and-pillar mining of dolomite for use as construction aggregate.

The Galena and Platteville Groups consist of dolomites and limestones of Ordovician Age that were formed from marine sediments of biologic origin. The sediments were deposited as limestone or calcium carbonate, but the action of circulating seawater replaced some of the calcium with more chemically-active magnesium to form dolomite. Silica and clays are also present, sometimes as much as a few percent, and are derived from washed-in or blown-in materials. There are also distinct thin beds of minerals derived from volcanic ash-falls that have been altered to clays by the action of seawater in the quiet seas in which the limestones were deposited. These ash-fall beds are limited in thickness but laterally extensive and restricted to distinct positions within the stratigraphic succession making them useful as "marker beds."

The Galena and Platteville Groups derive their names from Galena, Illinois, and Platteville, Wisconsin, where they are prominent cliff-forming strata that were formerly mined for lead and zinc. The Galena and Platteville Groups, as they are known in the Midwest, are equivalent to the Trenton and Black River Groups, respectively, in other states and underlie an area that extends from Minnesota and Iowa on the west to the Appalachian Mountains on the east.

2.2 Rock Jointing

The rock formations in the Lafarge Conco Mine are dissected by through-going fractures, termed joints, that are a very common, almost universal feature of rocks at the earth's surface. Such fractures usually occur in related like-oriented families called "sets." Joints are of tectonic origin and are either the result of compressive and shearing forces in the crust or a manifestation of relief of compressive forces and consequent tensile-fracturing. The fractures or joints separate the rock strata into "blocks" and the resulting rock masses containing both the blocks and fractures exhibit strength properties considerably less than the intact non-fractured rock as tested in the laboratory. The fractures or joints themselves, being planes of weakness, can act as conduits for fluid flow through the rock mass under certain conditions.

The presence of the near-vertical through-going joints, when combined with bedding planes, creates a condition of three-dimensional "fracture-flow" for groundwater in the rock masses present in the Lafarge Conco Stone Mine. However, as mentioned above, vertical continuity, and therefore fluid flow, is often blocked by clay-rich strata.

Buschbach (1964) and Willman (1971) have noted an unconformity at the contact between the Galena and Platteville Groups. In the Lafarge Conco Mine, this unconformable contact, which is encountered at approximately the bottom of the top heading of the second level, is characterized by small solution caverns and strata collapse features. These small caverns, which are small, strata-bound and flat-topped, are typically less than 10 ft in horizontal extent and somewhat less in vertical extent. They often contain large calcite crystals and small deposits of other minerals, particularly sulfides.

2.3 Hydrogeologic Setting

The five underground stone mines in northeastern Illinois (out of a total of eight) that have been inspected or visited by AAI (including one mine that is no longer active) are "dry" and require minimal to no pumping to maintain efficient operations. Underground in these mines, water seeps from some joints and bedding planes; however, the water amounts to only a nuisance. The regional and local ground-water flow is blocked by clay-rich strata and clay-filled joints.

In northeastern Illinois, there are four major aquifer systems or aquigroups. In order of increasing depth, these groups are (Visocky, Sherrill, and Cartwright 1985):

- the Prairie Aquigroup consisting of unconsolidated materials;
- the Upper Bedrock Aquigroup consisting of Silurian limestones immediately underlying and hydraulically connected to the Prairie Aquigroup sediments and overlying the Maquoketa Group that serves as an aquitard;
- the Midwest Bedrock Aquigroup otherwise known as the "Cambro-Ordovician Aquifer"; and
- the Basal Bedrock Aquigroup, otherwise known as the Mt. Simon Aquifer.

The Galena-Platteville Group is the uppermost water-conducting geologic unit in the Cambro-Ordovician Aquifer and is separated from the Upper Bedrock Aquigroup, or Silurian Aquifer, by the Maquoketa Group, which serves as an aquitard. It should be noted that the primary, or matrix, permeability of the Galena-Platteville is very small and that water movement in the unit is along bedding planes and through joints.

In the Greater Chicago area, the Cambro-Ordovician Aquifer was formerly extensively pumped for domestic, industrial, and municipal water supplies. Between 1980 and 1990, Lake Michigan water was made available to most municipalities east of the Fox River that formerly obtained their water from the Cambro-Ordovician Aquifer, which has resulted in a considerable reduction in pumping from that aquifer. The result of the reduction in pumping has been a relatively rapid rise of the aquifer potentiometric surface (water table pressure level) throughout most of the northeastern Illinois area, as the surface returns to its pre-pumping level. The rise in the potentiometric surface at some locations has been hundreds of feet since 1985 (Burch 2002).

However, in the Aurora area, the potentiometric surface has remained approximately static since 1995 due to continued reliance on the Cambro-Ordovician Aquifer for water supply. Water level measurements taken in on-site drill hole DH-01 between October 2008 and March 2012 have showed the piezometric surface to fluctuate between elevations of 179.46 ft above mean sea level (MSL) and 200.86 ft MSL, with an average level of 192.28 ft MSL. An elevation of 180.42 ft MSL, measured in October 2008, was used for the modeling performed by AAI in 2008 and 2009, which is discussed in Section 5.0 of this report. The latter elevation is 50 ft above the top of the Ancell Group, approximately 126 ft below the floor of the bench (lower) cut on the second level, and approximately 51 ft below the floor of the proposed third level. The maximum measured elevation of approximately 200 ft MSL, which has generally occurred in the Second or Third Quarter of the year, represents approximately 106 ft below the floor of the second level and approximately 31 ft below a proposed third level (if the full 50 ft height of a room is maintained). The aquifer within its current range of elevations does not interfere with current or future underground mining activities at the Lafarge Conco Mine.

3.0 Field Inspections

3.1 Joint Inspection

AAI staff visited the Lafarge Conco Mine on several occasions in July and October 2008, and in March and June 2009, to inspect joints in the mine (using Lafarge Conco prior base mapping) and collect samples of joint infilling material for examination and testing. The mapping did not include bedding planes, and the mapped directions of the joints were estimated visually and not measured with a compass. Rooms run approximately north-south and crosscuts approximately east-west so that joints could be separated visually into four groups: northeast-southwest (J1); northwest-southeast (J2); east-west (J3); and north-south (J4)

In July 2008, the mine was visited by Frank Kendorski and Kevin Kovanda to map joints in the walls and roof around the perimeter of the mining area and to collect samples of joint infilling materials. In October 2008, the mine was visited by Doug Hambley and Adam McMullin to map and sample additional joints. In March 2009, at the request of DEI, Doug Hambley and Adam McMullin mapped all visible joints within two crosscuts of the perimeter of the Conco South Mine on both Upper and Lower Levels. On June 2, 2009, accompanied by Marc Fisher of DEI and Richard Stringer of Lafarge Conco, Doug Hambley of AAI mapped the joints in all the accessible areas in the interior of the Second (Lower) Level.

AAI observed both joints that were tightly healed without infillings, and joints that contained infillings. AAI and DEI attempted to measure the apertures of the healed joints that did not contain infillings using automotive valve feeler gages. In all cases, the apertures were less than the 0.0015-inch thickness of the thinnest feeler gage. Three types of joint infillings were noted. These consisted of:

- Breccia or shear zones (Figure 3-1);
- Joints with simple clay infillings (Figure 3-2); and
- Joints with expanded oval pods filled with clay (Figure 3-3).

The breccia or shear zones are characterized by fractured wall rock and are filled with calcite and sulfides. The clay infillings consist of seams of green to gray, moldable clay. Note that Figure 3-2 shows joints from both of the most prominent joint sets typically encountered in the mine. The clay pods are characterized not only by the green clay infilling but also by the large pod formations that develop at intervals in the joints. The pods are round to oval or lenticular in shape and are also filled with the green-colored clay. The pods range in width from 3 inches to 9 inches. The lengths of the pods are roughly proportional to the widths. Each of the joints was covered with a thin film of stone dust from production blasting operations and mine traffic. AAI did not observe any "open" joints with a measurable aperture that were not completely filled with a clay filling, calcite, or a combination of the two. The apertures of clay-filled joints measured by AAI ranged from as little as 0.06 inches (0.005 ft) to as much as 6 inches.

As noted in the introductory paragraph in this subsection, AAI identified four separate joint sets: J1, whose joints trend northeast-southwest; J2, whose joints trend northwest-southeast; J3, whose joints trend approximately east-west; and J4, whose joints trend approximately north-south. As expected, the predominant joint sets are directed in the northeast

Figure 3-1. Example of Shear Zone Containing Calcite and Sulfide Mineralization

Figure 3-2. Example of Clay-Filled Joint

Figure 3-3. Example of Clay-Filled Joint Showing Clay Pod

southwest and northwest-southeast directions. A surprisingly large number of joints were classified as "east-west," or J3; however, many of these joints were intermediate in direction between true east-west and the J1 and J2 directions. Consequently, had the directions been measured accurately and evaluated statistically using a stereonet or clustering computer code, many of the J3 joints might in fact fall into the J1 or J2 joint sets, leaving a relatively minor number of true east-west joints. The north-south or J4 joints were highly localized and appeared to be related to anomalous local structures.

The information on the mapped joint sets is presented in Table 3-1. The joints that were mapped on the Upper Level and Lower Level are presented in Figures 3-4 and 3-5, respectively. As shown in Table 3-1, the lengths of joints average approximately 70 ft on the Upper Level and approximately 80 ft on the Lower Level, with maximum joint lengths of approximately 200 ft on both levels. The spacing between joints, measured perpendicular to the joints, averages approximately 120 ft on the Upper Level and 110 ft on the Lower Level. The maximum spacing between joints in a given direction ranged from 350 to over 500 ft on both levels. Note that the joint spacings and lengths mapped by AAI at Lafarge Conco are consistent with the spacings and lengths reported by others for various locations in the Chicago area in both the Silurian and the Galena-Platteville.

Table 3-1 also presents information on the numbers of each type of joint filling that were mapped. On the Upper Level, clay-filled joints represented 80% of all joints observed. Of the remaining 20%, 16% were closed with no filling, and clay pods and shear zones represented approximately 2% each. On the Lower Level, clay-filled joints accounted for 72% of all joints mapped, one joint or 0.5% was filled with calcite, and the remainder of the joints were closed and unfilled. No clay pods were observed on the Lower Level. The increase in the number of closed joints on the Lower Level is expected and can be explained by the greater depth below the top of the formation, which was eroded before the overlying Maquoketa was deposited. The clay infillings represent deposits carried from surface by seepage and become less common as the depth increases. Similarly, as the depth below surface increases, the lateral stress on joint surfaces increases, so that joint apertures decrease or close completely. The post-depositional pyrite mineralization observed on some surfaces represents precipitation of dissolved material that was transported horizontally.

Table 3-1. Joint Mapping Summary—June 2009

	Upper Level						Lower Level					
Joint Set	**J1**	**J2**	**J3**	**J4**	**Total**	**Percentage**	**J1**	**J2**	**J3**	**J4**	**Total**	**Percentage**
Closed	6	4	5	4	19	16.0%	17	16	13	4	50	27.5%
Clay-filled	38	25	33	0	96	80.7%	31	49	36	15	131	72.0%
Clay pods	1	0	1	0	2	1.7%	0	0	0	0	0	0.0%
Shear zones	2	0	0	0	2	1.7%	0	0	1	0	1	0.5%
Total	47	29	39	4	119		48	65	50	19	182	
					Mean						**Mean**	
Average joint length (ft)	69	67	78	64	71		90	94	62	48	79	
Max. joint length (ft)	210	170	220	140			170	200	200	110		
Average joint spacing (ft)	118	123	136	40	122		134	94	110	60	111	
Max. joint spacing (ft)	560	370	370	70			380	350	500	140		

Some joints in the Lafarge Conco Mine show evidence of hydrothermal chemical alteration by fluid flow in the geologic past. The alteration is characterized by "bleaching" or lightening of the rock mass surrounding the joints for some 3 ft to 5 ft in width. AAI believes that these bleached, hydrothermally-altered joints are similar to (but much lower in metal content than) the lead and zinc mineralization occurring in the vicinity of Galena, Illinois, Dubuque, Iowa and Platteville, Wisconsin, known as the "Upper Mississippi Valley District."

AAI collected fifteen samples of joint infilling from joints containing both the clay and the fractured-rock types of infilling. Approximately 6 ounces (oz.) of infilling material was collected from each joint and sealed in a double Ziploc bag that was labeled with the location from which the sample was collected, referenced to the mine grid. The purpose of sealing the bag was to preserve insofar as practicable the moisture content of the infillings. The sample locations on the upper and second levels are shown on Figures 3-4 and 3-5, respectively. The composition of the infilling material in each sample was evaluated qualitatively by AAI using a stereo microscope. To confirm its qualitative analysis, AAI selected twelve samples for clay-mineralogy determination using X-Ray Diffraction (XRD) analysis and eight samples for hydraulic conductivity determination in the laboratory using the Falling-Head Method. AAI also tested four samples of clay infilling for uniaxial compressive strength testing using a pocket penetrometer. The penetrometer strength results are presented in Table 3-2.

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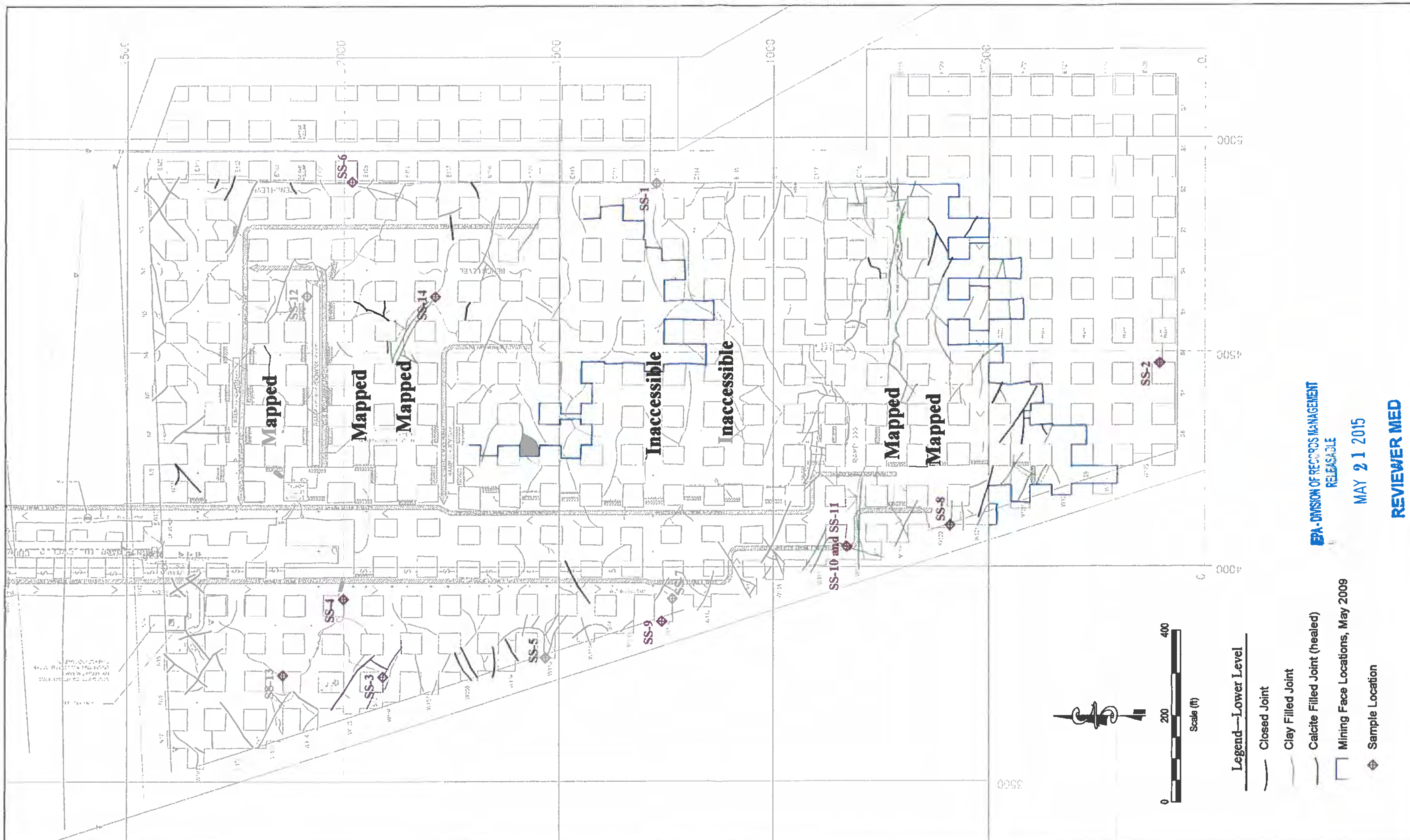
635-01 Deuchler [AAI_CAD dwg 635-01_6-9-09.dwg Layout: Upper Level_May09_3-4]rjl(7-27-2009)
Base map provided by client

Figure 3-4. Plan of Upper Level of Conco South Mine showing Joints Mapped by AAI



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635-01 Deuchler [AAI_CAD dwg 635-08-6-9-09.dwg Layout: Lower Level_May09_3-5]rjl(7-27-2009)
Base map provided by client

Figure 3-5. Plan of Lower Level of Conco South Mine showing Joints Mapped by AAI

Table 3-2. Results of Pocket Penetrometer Compressive Strength Tests

Sample No.	Condition	Joint Type	Compressive Strength (tsf)	Compressive Strength (psi)
N4E104	Dry, stiff	Simple clay-filled joint	4.2	58
LL S10E120	Moist, medium stiff	Simple clay-filled joint	2.0	28
S12E114	Dry, stiff	Simple clay-filled joint	3.0	42
S12W115	Moist, soft	Simple clay-filled joint	1.25	17

Notes: psi = pounds per square inch , tsf = tons per square foot.

3.2 X-Ray Diffraction Analysis of Infilling Samples

AAI contracted with The Mineral Lab, Inc. of Boulder, Colorado, for identification of the components of the joint infilling material using XRD analysis. The purpose of these analyses was to identify the mineralogy of the clay portion, such as kaolinite, illite, or smectite, as well as other constituents of the infillings. Knowledge of which type of clay is present in the infilling is important because the behavior in the presence of water varies markedly. Kaolinite is non-swelling, illite exhibits limited swelling, and smectite exhibits significant swelling. (Bentonite, which is used to seal monitoring wells, consists of smectite minerals, notably montmorillonite.) AAI selected twelve samples of joint infilling material collected from various joints observed on the upper and lower levels of the Lafarge Conco Mine and shipped them in sealed containers with a chain-of-custody to The Mineral Lab, Inc. for analysis. For quality control purposes, a duplicate of each sample was retained by AAI.

Samples were analyzed using the powder method and the oriented-aggregate method. In the powder method, a representative portion of each sample is ground to approximately -400 mesh (38 micrometers [μm]) in a steel swing mill and then placed into a plastic holder. The samples contained in the holders are scanned with a diffractometer using alpha radiation. In the oriented mount method, a portion of each ground sample is mixed with distilled water, drawn onto a cellulose acetate filter and then rolled onto a glass disk. The oriented mounts are scanned; treated with glycol and then re-scanned. With the untreated mounts, the kaolin, illite, and smectites can be differentiated by their different basal spacings. Glycolation serves to further confirm the presence or absence of expansive smectite clays (Mitchell 1993).

Estimates of mineral concentrations were made using X-Ray Fluorescence (XRF) determined elemental compositions together with the relative peak heights/areas on the XRD scans for the various elements. The detection limit for a mineral using XRD/XRF is approximately 1% to 3% by weight. The results of the XRD analyses are presented in Table 3-3, which shows that the eight of the samples consisted predominantly of illite, a mildly expansive clay, and the remaining four samples consisted predominantly of calcite. Pyrite (iron sulfide, FeS_2) was identified in eleven of the twelve samples, with significant contents (greater than 3%) in two samples.

Table 3-3. XRD Analysis Results of Infilling Samples*

Sample	Sample Location	Joint Type**	Mica/ Illite	Quartz	Potassic-Feldspar	Dolomite	Calcite	Pyrite	Material
SS-1	S2E112	SC	68	20	<5	NI	NI	<2	Sandy clay
SS-2	S6W125	SC	39	24	5	14	<5	8	Sandy clay with pyrite and dolomite fragments
SS-3	LL N15W106	SC	53	15	<5	18	6	<3	Sandy clay with calcite and dolomite fragments
SS-4	LL S12W105	SC	44	14	<5	17	16	<3	Sandy clay with calcite and dolomite fragments
SS-5	S15W110	CP	47	26	<5	17	NI	<3	Sandy clay with dolomite fragments
SS-6	LL N2E105	SC	<5	5	<3	33	55	<1	Calcite with dolomite fragments
SS-7	S12W114	SC	43	25	5	20	<3	<3	Sandy clay with dolomite fragments
SS-8	LL S10W120	SC	47	20	5	13	9	<3	Sandy clay with calcite and dolomite fragments
SS-9	S12W114	SH	NI	<3	NI	21	74	NI	Calcite with dolomite fragments
SS-10	S11W118	SH	NI	<3	<3	32	62	<1	Calcite with dolomite fragments
SS-11	S11W118	SH	NI	<5	<3	51	30	12	Calcite with pyrite and dolomite fragments
SS-12	N4E104	SC	55	13	<3	15	7	<2	Sandy clay with calcite and dolomite fragments

* Values shown are approximate percentages in the sample by weight. NI = not identified.
** CP = joints with clay-filled pods; SC = simple clay-filled joint; SH = breccia or shear zone.

3.3 Hydraulic Conductivity Testing of Infilling Samples

The overall hydraulic conductivity of the mine rock depends on the porosity and permeability of the rock matrix together with the permeability and spacing of the rock joints. The hydraulic conductivity of unfractured Galena Group limestones and dolomites is typically less than 10^{-8} centimeters per second (cm/s). (It should be noted that hydraulic conductivities less than 10^{-8} cm/s are too small to measure using normal field methods.) The hydraulic conductivity of the Galena Group as measured in packer tests in borings by the Illinois State Geological Survey (ISGS) ranges from 10^{-5} to 10^{-6} cm/s (Graese et al. 1988; Harza Engineering Co. 1988). The hydraulic conductivity of 20-ft-long rock intervals in the DH-01 drill hole at the site was also measured using packer tests, with the results shown on Figure 1-1 of this report. The conductivity values ranges from a high of 5.92×10^{-5} cm/s in the test interval from 208 to 228 feet bgs (Wise Lake Formation) to a low of 9.89×10^{-8} cm/s in the test interval from 248 to 268 feet bgs (also Wise Lake Formation). These results are consistent with the ISGS results noted above. However, these tests provide a smoothed value that incorporates the effects of both the rock matrix and the rock joints, whereas to perform numerical modeling of the potential for ground-water flow from the mine after sludge placement, separate hydraulic conductivities are required for the joint infilling materials and the rock matrix. The matrix was modeled as impermeable.

AAI transported eight infilling samples to Wang Engineering of Lombard, Illinois, for determination of hydraulic conductivity using the falling-head method. The results of the tests are presented in Table 3-4. As shown in Table 3-4, the samples from S6W125, S15E110, and S5E107 consisted of clay with a mean hydraulic conductivity of 2.7×10^{-8} cm/s. Samples from N15W106 on the lower level, N2E105 on the lower level, and N15E103 consisted of clay with calcite and dolomite fragments with a mean hydraulic conductivity of 2.5×10^{-7} cm/s. The sample from S12E114 consisted of calcite and dolomite fragments and was not suitable for hydraulic conductivity testing using ASTM Method D5084. The sample for S2E112, which appeared to contain more sand-sized material than the others, had an anomalously high mean hydraulic conductivity of 1.95×10^{-5} cm/s. Because this sample appeared to be an outlier, it was not included in calculating the mean values for the clay samples.

Table 3-4. Joint Infill Material Laboratory Hydraulic Conductivity Test Results

Sample No. and Sample Location	Hydraulic Conductivity at 20°C (cm/s)	Estimated Joint Aperture (inch)	Unit Weight (pcf)	Sample Description
SSS-1, S2 E112	1.79E-05		170.9	Sandy clay
SS-2, S6 W125	2.44E-08		144.8	Sandy clay with clay and fractured rocks
SS-3,LL N15 W106	1.94E-07	0.5	143.2	Sandy clay with calcite and fractured rocks
SS-5, S15 E110	4.9E-08	0.5	127.7	Sandy clay with fractured rocks; 3 clay-filled joints spaced 48" to 60" apart
SS-6, LL n2 E105	4.13E-07	<1.0	150.1	Calcite and fractured rocks
SS-8, LL S10 E120	Not analyzed	0.5		Sandy clay
SS-9, S12 E114	Not analyzed			Calcite and fractured rocks
N15 E103	1.67E-07			Sandy clay with calcite, pyrite and fractured rocks
S5 W107	1.44E-08		127.4	Sandy clay, 2 joints
MEAN, Clay	2.72E-08		133.3	Mean hydraulic conductivity excludes outlier SS-1, S2 E112
MEAN, calcite	2.58E-07		146.65	

4.0 STABILITY CALCULATIONS

4.1 Rock Strength Tests

AAI had previously performed unconfined compressive strength (UCS) tests on six samples of dolomite from the upper level of the Lafarge Conco Mine in 2006 for another project. To expand the database to deeper horizons, seven samples were collected by AAI and DEI on September 10, 2008, from depths corresponding to the sill pillar between the upper and lower levels, the lower level, and the unmined rock below the lower level from a vertical core hole drilled by Raimonde Drilling Corp. and logged by GZA GeoEnvironmental, Inc. in July 2008. The samples were shipped by AAI to AAI's laboratory in Grand Junction, Colorado, for testing for unconfined compressive strength (UCS) together with Young's modulus, and Poisson's ratio, Brazilian tensile strength, and bulk density (unit weight). The results of the 2006 and 2008 strength testing are presented in Table 4-1. (For the samples from boring DH-01, the depths of the tops of the samples in the core are indicated.)

Table 4-1. Strength and Deformation Testing Results

Formation	Depth for 2008 Samples (ft)	Density (pcf)	UCS (psi)	Young's Modulus ($\times 10^6$ psi)	Poisson's Ratio	(Brazilian) Tensile Strength (psi)
Wise Lake		171.8	18,145	5.70	0.36	
Wise Lake		161.1	9,205	7.83	0.23	
Wise Lake		165.3	13,687	6.14	0.26	
Wise Lake		169.0	15,734	6.94	0.27	
Wise Lake		166.3	18,316	6.55	0.18	
Wise Lake	262.5	164.9	22,020	8.31	0.24	1,050
Unknown		167.9	21,063	6.56	0.17	
Dunleith	300.1	167.9	17,840	7.47	0.27	560
Dunleith	337.1	158.8	14,220	6.62	0.26	750
Dunleith	318.0	164.2	17,840	7.47	0.27	910
Dunleith	370.1	167.5	15,070	8.01	0.32	1,290
Dunleith	379.2	164.5	14,500	6.71	0.24	1,380
Platteville	395.6	163.9	14,040	7.22	0.30	540

4.2 Pillar Safety Factors

AAI used proprietary AAI-authored spreadsheets for the empirical Hedley and Grant (1972), Stacey and Page (1986), and Hardy and Agapito (1975) pillar-strength formulas to evaluate the stability of existing 50-ft square pillars at the mining depths of the existing first and second levels and the projected third level. AAI has found these three methods to be the most satisfactory for stone-mine pillar evaluations (Kendorski 2007). For square pillars, each of these pillar strength formulas can be expressed in the form:

$$S_p = \beta\, S_c\, W^a / H^b \qquad \text{(Eqn. 4-1)}$$

where S_p = pillar strength (psf)
S_c = uniaxial compressive strength of intact rock (psf)

W = width of pillar (ft)
H = height of pillar (ft)
β = strength reduction factor based on laboratory test sample size
a, b = empirical material constants

For horizontal or almost horizontal beds, the vertical pillar stress due to overburden is:

$$\sigma_v = \frac{[(\gamma / 144)](D)}{1 - E} \qquad \text{(Eqn. 4-2)}$$

where σ_v = vertical stress in pillar (psi)
γ = unit weight of overburden (pcf) (taken here as 165 pcf)
D = depth (ft) to pillar level
E = extraction ratio based on tributary area

where $E = 1 - \left[\frac{wl}{(w+R)(l+C)}\right]$

where w = pillar width (ft)
l = pillar length (ft)
R = room width (ft)
C = crosscut width (ft)

The pillar safety factor is expressed as the ratio of the pillar strength to the pillar stress.

As shown in Tables 4-2 and 4-3, the Hedley and Grant, Stacey and Page, and Hardy and Agapito formulas all result in safety factors (ratio of strength to stress) that exceed 1.79 in all cases. Given that the pillars of concern have a width/height (W/H) ratio of 1 or more for which situation the minimum acceptable safety factor is taken by AAI as 1.3, all three formulas predict that the existing mine pillars should be stable.

4.3 Sill Pillar Safety Factors

Previous studies performed for underground stone mines in the Chicago area and the more than 10 years' experience with multi-level mining at the Conco Mine have demonstrated that, in the dry conditions currently experienced, sill pillars of approximately 25-ft thickness are stable. However, DEI was concerned that the sills would remain stable under the static hydraulic heads that would occur as sludge was placed in the mine. AAI was therefore requested to perform stability calculations for sill pillars with thicknesses of 25 ft or more (if necessary) for uniform loadings of 50 psi and 100 psi (equivalent to approximately 50 ft and 100 ft respectively, of compacted sludge). Note for comparison that the tire load on the ground for a typical haulage truck or wheel loader used underground is 100 to 150 psi, but that is a moving rather than dead load.

To assess the stability of the sill pillars, AAI estimated the bending stresses for a uniformly loaded flat plate supported by equidistant pillars (Timoshenko and Woinowski-

Table 4-2. Empirical Pillar Stability Evaluation—Basic Information

Level	Unconfined Compressive Strength (psi)	Unit Weight (pcf)	Pillar Length (along strike) (ft)	Pillar Width (ft)	Least Pillar Dimension (ft)	Room Width (ft)	Crosscut Width (ft)	Pillar Thickness (ft)	Pillar Height (ft)
Upper Level (Wise Lake)	16,185	166	50	50	50	45	45	50	50
Sill Pillar								25	
Middle Level (Dunleith)	15,894	165	50	50	50	45	45	50	50
Sill Pillar								25	
Lower Level (Platteville)	14,040	164	50	50	50	45	45	50	50

Table 4-3. Pillar Safety Factors and Pillar Strength

		Hedley-Grant Method		Stacey-Page Method		Hardy-Agapito Method	
Level	Pillar Stress	Pillar Strength (psi)	Safety Factor	Pillar Strength (psi)	Safety Factor	Pillar Strength (psi)	Safety Factor
Upper Level	1,360	4,260	3.12	4,860	3.56	4,040	2.96
Middle Level	1,660	4,180	2.52	4,780	2.88	3,970	2.39
Lower Level	1,960	3,700	1.89	4,220	2.15	3,500	1.79

Krieger 1959). The bending stress is calculated from the maximum bending moment and maximum estimated deflection, as follows:

$$f_b = My/I \qquad \text{(Eqn. 4-3)}$$

where f_b = bending stress
M = bending moment
y = deflection of center of plate
I = moment of inertia of the cross-section of the plate.

The bending moment and deflection at the center of a panel in a flat slab supported by equidistant pillars are given using the above notation by (Timoshenko and Woinowski-Krieger 1959):

$$M = 0.0791(wL)L^2 \qquad \text{(Eqn. 4-4a)}$$

$$y = 0.00942\frac{(wL)L^4}{D} \qquad \text{(Eqn. 4-4b)}$$

where w = uniformly applied load (stress)
L = center-to-center spacing of the pillars
D = flexural rigidity = $\frac{Eh^3}{(12[1-\nu^2])}$
E = Young's Modulus

v = Poisson's Ratio
h = thickness of the slab

Analyses were conducted for a sill thickness of 25 ft and uniform loads of 50 psi and 100 psi plus the dead load consisting of the weight of the slab. It should be noted that the Galena-Platteville dolomite is stratified and that separation could occur on bedding planes. However, mine practice is to install 6-ft-long rock bolts in the roof to reinforce it. The calculation results are presented in Table 4-4. Based on the large safety factors, the obvious conclusion is that the 25-ft-thick sill pillars that are currently used are stable. Nevertheless, these analyses do not account for the possible presence of water on bedding planes. To do so, requires the use of numerical modeling. Consequently, the effect of potential water flow in the sill pillars on the stability of the sills will be addressed by the modeling discussed in the next section of the report.

Table 4-4. Loads and Safety Factors for Sill Pillars Analyzed as Uniformly Loaded Flat Slab Supported by Equidistant Pillars

Sill Pillar Thickness (ft)	Brazilian Tensile Strength (psi)	Poisson's Ratio	Young's Modulus (psi)	Distributed load (psi)	Dead Load (psi)	Total Distr. Load (psf)	Center to Center Span (ft)	Max Bending Moment (lb-ft)	Flexural Rigidity (lb-ft)	Max. Deflection (ft)	Moment of Inertia (ft^4)	Max. Bending Stress in Tension (psi)	Safety Factor
25	560	0.24	6.62E+06	50	29	11.325	95	7.68E+08	1.32E+12	6.27E-01	1.24E+05	27	20.7
25	560	0.24	6.62E+06	100	29	18.525	95	1.26E+09	1.32E+12	1.03E+00	1.24E+05	72	7.7

5.0 HYDROMECHANICAL MODELING

5.1 Methodology

Fluid flow from sludge impoundment on the Second Level was simulated using a hydromechanical computer model. The Second Level will be filled gradually while mining is conducted on the Third Level. The sludge at any point in time will consist of a bottom layer of settled solids and a top layer of decanted fluid comprising water and some fraction of suspended solids. Flow of the decanted fluid into the rock mass can occur along natural bedding planes and joints in the rock mass. This fluid will report either to (a) the underlying Third Level or (b) the groundwater table below the deepest part of the mine. Modeling was conducted to estimate the probable rate of flow (seepage) not only into the proposed Third Level but also down to the potentiometric surface of the Cambro-Ordovician aquifer based on the estimated hydro-mechanical properties of the rock mass.

Modeling was performed using UDEC 4.0 (Itasca 2004), a commercially available two-dimensional numerical program based on the distinct element method for discontinuum modeling. UDEC simulates the response of discontinuous media, such as a jointed rock mass, subjected to either static or dynamic loading. The discontinuous medium is represented as an assemblage of discrete blocks where discontinuities are treated as boundary conditions between blocks. Deformable blocks are subdivided into a mesh of finite-difference elements, and each element responds according to a prescribed linear or nonlinear stress-strain law. The relative motion of the discontinuities between blocks is governed by linear or nonlinear force-displacement relations for movement in both the normal and shear directions. UDEC is capable of analyzing fluid flow through the fractures of a system of impermeable blocks. A fully coupled mechanical-hydraulic analysis is performed in which fracture conductivity is dependent on mechanical deformation of the blocks bounding the factures and, conversely, joint water pressures affect the mechanical loads on the blocks.

5.1.1 Model Geometry

The site-specific model geometry, shown in Figure 5-1, represents a two-dimensional vertical profile through the mine extending vertically from the ground surface to 424 feet (ft) below the floor of the Second Level, and laterally from a point near the center of the mine in an east-west cross section to 1,070 ft into solid rock beyond the edge of mining. The model includes the existing First and Second Levels and a planned Third Level separated from the Second Level by a 25-ft-thick sill. The spacing of the joints in the model was based on the mean spacing mapped in the mine as discussed in Subsection 5.1.4 below.

5.1.2 Fluid Flow

Fluid flow in the model was permitted through horizontal bedding planes and vertical joints but restricted through the rock mass matrix itself. This is consistent with numerous field studies in the Galena and Platteville Groups, which have found that the hydraulic conductivity is due to secondary permeability features, namely joints and vugs, rather than the intact rock matrix, which is generally considered impermeable. Fluid flow through the settled solids in the

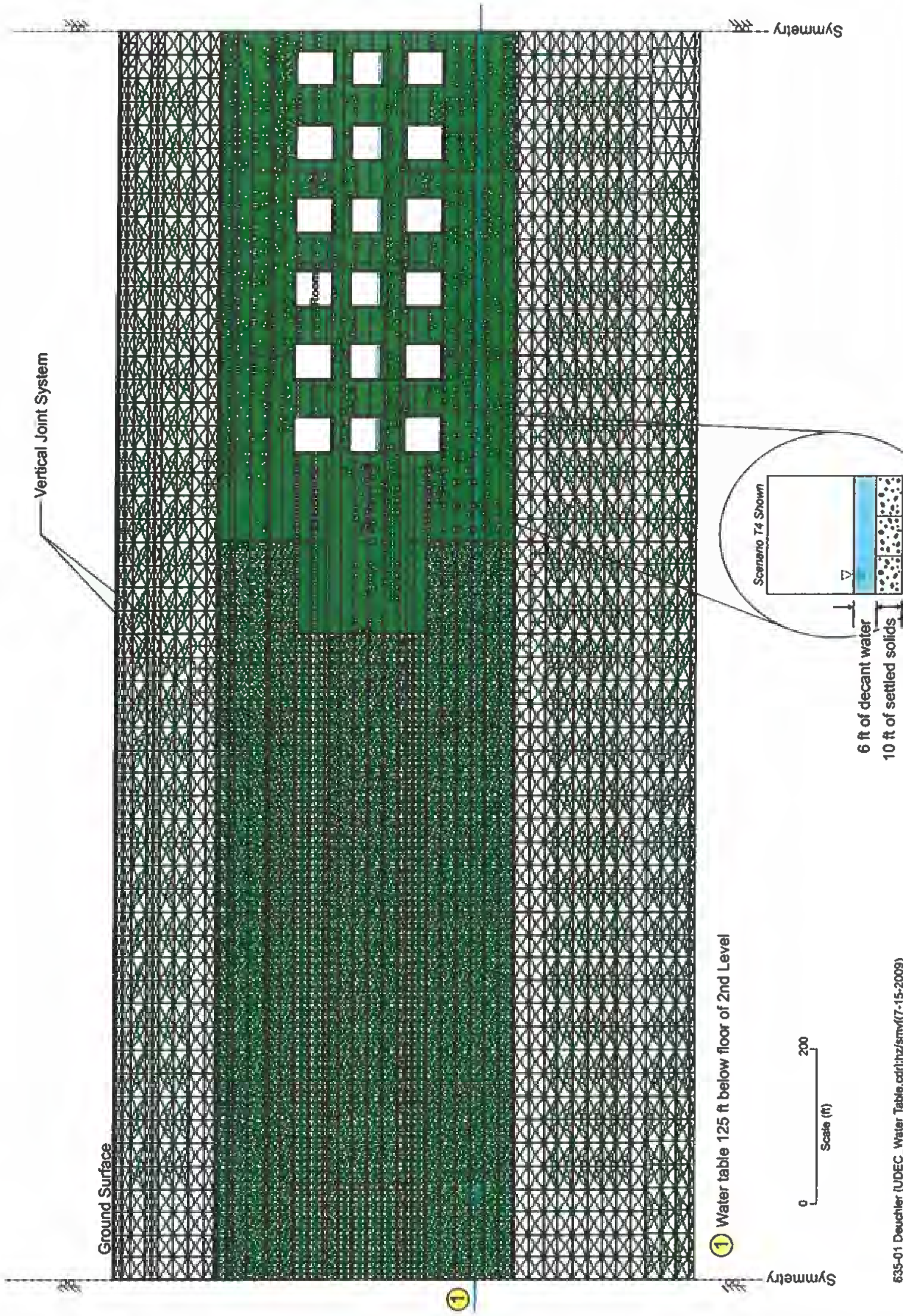


Figure 5-1. UDEC Model Geometry and Deformable Zone Mesh

sludge was accomplished using artificial "joints" or conduits with a hydraulic conductivity equivalent to that of samples of lime sludge solids.

5.1.3 Rock Mass Properties

Specific rock mass properties were prescribed for the different host lithologic members represented in the model (Figure 5-2). Similarly, bedding planes and vertical joints were prescribed unique properties. Three types of naturally occurring vertical "joints" observed underground were simulated: (Type 1) unfilled, but tight "open" joints, (Type 2) joints with simple clay infillings, and (Type 3) breccia or shear zones containing fractured wall rock with calcite and sulfide infilling. Rock mass and joint mechanical properties used in the model are summarized in Tables 5-1 and 5-2.

5.1.4 Bedding Planes and Joints

Bedding planes in the model were repeated on a regular 20-ft vertical spacing for consistency with the 20-ft intervals used during packer testing in 2008. Hydraulic conductivities measured during packer testing are shown in Figure 1-1 in Section 1.2 of this report. The results are considered good measures of bedding plane conductivity. The measured conductivity over each 20 ft packer interval was lumped into a single numerically-equivalent bedding plane in the model located near the midpoint of the actual interval.

The spacing and distribution of vertical joints in the model represents a best estimate of actual conditions derived from in-mine mapping. For modeling, the joint pattern was idealized to a regular geometry with joints spaced 120 ft horizontally apart. Joint length was limited to 200 ft. Joints were assumed to repeat in the same vertical plane separated 100 ft apart between joint ends. The resulting pattern is illustrated in Figure 5-2. Mapping results indicate approximately 27.5% of vertical joints are Type 1 unfilled, tight "open" joints, while the remainder are Type 2 and 3 filled joints. This approximate distribution was honored in the model by repeating one Type 1 open joint for every two Type 2 clay-filled and Type 3 calcite-filled joints. The idealized joint geometry in the model is a synthetic, but numerically accurate, representation of typical mine-wide hydraulic conditions.

5.1.5 Hydraulic Conductivity

Fluid flow in planes and joints was simulated according to Darcy's Law:

$$Q = \frac{KA\Delta h}{L} \qquad \text{(Eqn. 5-1)}$$

where Q = flow rate (ft^3/s)
K = hydraulic conductivity (ft/s)
A = cross-sectional area of flow (ft^2)
Δh = fluid head difference (ft)
L = length of flow (ft)

Table 5-1. UDEC Model Rock Mass Mechanical Properties

			Mohr-Coulomb Strength Parameters		
Lithologic Member*	Poisson's Ratio	Elastic Modulus (10^6 psi)	Cohesion (psi)	Friction Angle (degrees)	Tensile Strength (psi)
Overburden	0.45	0.059	31	5.6	0
Silurian	0.16	0.981	357	43.6	36
Brainard	0.16	0.248	177	27.4	11
Ft. Atkinson	0.24	0.958	292	39.3	22
Scales	0.21	0.550	214	30.0	32
Galena, Wise Lake	0.26	2.970	401	39.1	122
Galena, Dunleith	0.25	3.070	396	39.0	120
Platteville	0.30	2.670	349	40.9	56
St. Peter	0.30	0.535	193	29.9	9

* An equivalent unit weight equal to the 1.09 psi/ft of depth in situ stress gradient (Table 5-6) was assigned to all members: 157.0 pcf.

Table 5-2. UDEC Model Joint Mechanical Properties

			Mohr-Coulomb Strength Parameters						
			Intact			Post-rupture			
Joint Type	Average Aperture (inch)	Dilation Angle (degrees)	Cohesion (psi)	Friction Angle (degrees)	Tensile Strength (psi)	Residual Cohesion (psi)	Residual Friction Angle (degrees)	Normal Stiffness (psf/ft)	Shear Stiffness (psf/ft)
Horizontal Bedding Planes	0.004	0.0	3,452.0	37.5	0.0	0.0	18.8	1.25E+10	1.25E+10
Vertical Joints									
Unfilled, "Open"	0.004	0.0	3,452.0	37.5	0.0	0.0	18.8	1.25E+10	1.25E+10
Clay-filled	0.50	0.0	21.5	15.0	0.0	0.0	7.5	1.25E+10	1.25E+10
Calcite-filled	1.00	0.0	1,050.3	20.0	0.0	0.0	10.0	1.25E+10	1.25E+10

Published ranges of joint hydraulic conductivities for relevant joint types are summarized in Table 5-3. The horizontal matrix conductivities in the table are generally consistent with the results of the on-site packer testing shown in Figure 1-1. The packer results are mostly biased toward the lower end of the reference studies. The packer measurements were directly applied to the model at the test horizons. Bedding planes elsewhere in the model were assigned the mean conductivity from the tests, or 9.26E-06 cm/s. For use in the model, the measured conductivity of the rock mass over each 20-ft test interval was considered to represent flow on a single bedding plane.

The hydraulic conductivity of a Type 1 unfilled, "open" vertical joint of aperture b can be estimated using the so-called cubic law (Snow 1969; Witherspoon et al., 1980):

$$k = b^2 \rho g/(12\mu) \qquad \text{(Eqn. 5-2)}$$

where k = hydraulic conductivity (cm/s)
b = fracture aperture (cm)
g = gravitational acceleration (cm/s^2)
ρ = fluid density in g/cm^3
μ = dynamic viscosity in centipoises

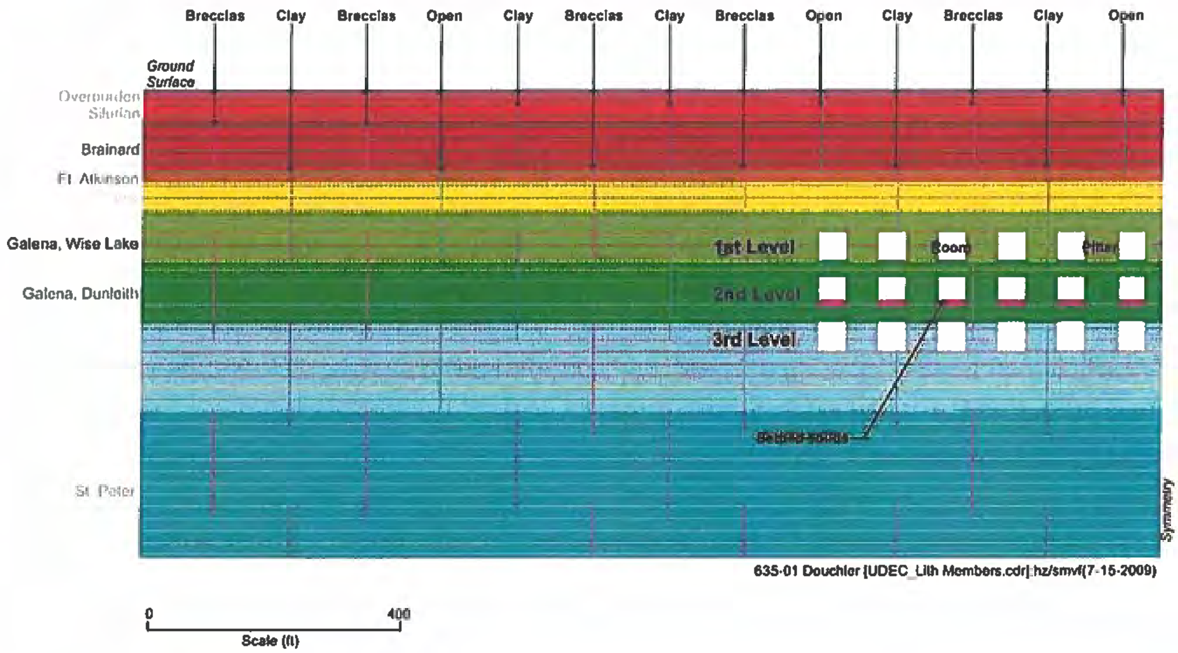


Figure 5-2. Lithologic Members in UDEC Model

The hydraulic conductivity of the open vertical joints at the Lafarge Conco mine is estimated to range from a low of about 5.00E–03 cm/s consistent with the Wehmann et al. (1997) measurements in similar fractures, to a theoretical high of 1.18E–01 cm/s for a 0.0015-in aperture using Equation 5-2. (See Section 3.1 of this report for the source of this aperture value.) The geometric mean of these two values (hydraulic conductivity is log-normally distributed) is 2.43E-02 cm/s, which is consistent with the maximum value reported by Wehmann et al. (1997) as shown in Table 5-3. The median value of 6.16E-02 cm/s was applied to the model to represent typical conditions. Note that for an average joint spacing of 116 ft (Table 3-1), a joint hydraulic conductivity of 6.16E-02 cm/s is equivalent to a hydraulic conductivity in a porous medium of 1.74E-05 cm/s, which is comparable to the highest hydraulic conductivities estimated from the packer tests.

The hydraulic conductivities of the Type 2 and Type 3 filled joints were derived from laboratory falling-head conductivity tests performed on samples of clay and calcite infill material collected in the mine. Test results are summarized in Table 3-4 in Section 3 of this report. Mean laboratory values were applied to the Type 2 and Type 3 joints in the model.

Two constant-head tests were performed by First Environmental Laboratories, Inc. to characterize the hydraulic conductivity of the settled solids in the sludge (Appendix D). Lime sludge samples were collected from the upper and lower levels of a surface lagoon after about 35 days of settling. The sludge was described by Deuchler personnel as "having the consistency of modeling clay." Measured hydraulic conductivity values ranged from 8.79E–06 cm/s to 1.10E–05 cm/s. A median value of 1.00E-05 cm/s was applied to the model.

Table 5-3. Joint Hydraulic Conductivity Values from Reference Studies

Reference Study	Hydraulic Conductivity (cm/s) Low Range	High Range	Typical	Details
Horizontal Matrix Conductivity				
Wehmann et al (1997)	8.00E-06	3.00E-05		**Fort Atkinson Formation** of the Maquoketa Group
	1.20E-06	8.70E-04		**Scales Formation** of the Maquoketa Group; basal dolomitic facies, not shale
Toohig (1995)	1.00E-06	1.00E-05	4.80E-05	**Maquoketa Group**: above Galena in Ordovician (shale and interbedded dolomite); K decreases with depth, sharp transition between weathered and unweathered
Batten et al. (1999)	Very low (unmeasurable)	1.20E-06		**Galena dolomite**
	Very low (unmeasurable)	6.70E-07		**Platteville Formation** (below Galena)
	Very low (unmeasurable)			**Glenwood sandstone** (below Platteville)
Graese et al. (1988)	1.00E-06	1.00E-02		**Silurian dolomite** (above Maquoketa)
	<1.00E-06	1.00E-02		**Maquoketa dolomite** (Fort Atkinson Formation)
	<1.00E-06	1.00E-05		**Maquoketa shale** (Brainard and Scales Formations)
	<1.00E-06	1.00E-03		**Galena-Platteville**: K values range from 10^{-4} to 10^{-5} cm/s if G-P is uppermost bedrock formation; K values range from 10^{-5} to 10^{-6} cm/s or less if overlain by Maquoketa
			3.00E-03	**Ancell sandstone** (St. Peter)
Muldoon et al. (2001)	1.00E-06	1.00E-01		**Silurian dolomite**, matrix K low, high K associated with bedding plane fractures in restricted marine facies
Kay et al. (2004)			5.29E-05 and 9.88E-05	**Galena-Platteville**, aquifer poorly permeable where composed of homogenous, fine-grained dolomite, moderately permeable where increased dolomite granularity and bioturbation, as well as clay beds, vugs, and other forms of secondary porosity; secondary-permeability features associated with solution along bedding planes found in intervals with abundant clay beds and at contact between contrasting lithologies
Vertical Matrix Conductivity				
Kay et al. (2004)	1.20E-08	1.06E-06		
Fracture Conductivity				
Wehmann et al (1997)	5.59E-03	4.27E-02		Actually for Silurian dolomite, but joint pattern, length and spacing in Galena-Platteville is similar

All conductivity values used in the model are summarized in Table 5-4.

Table 5-4. UDEC Model Joint Hydraulic Conductivity Properties

Joint Type	Hydraulic Conductivity
Horizontal Bedding Planes	
Packer-tested horizon	Measured K
Untested horizon	9.26E-06 cm/s
Vertical Joints	
Type 1 Unfilled, "Open"	6.16E-02 cm/s
Type 2 Clay-filled	2.66E-08 cm/s
Type 3 Calcite-filled	2.59E-07 cm/s
Sludge Settled Solids	1.00E-05 cm/s

5.1.6 Water Table

The water table in the model was set at an elevation of 180.4 ft MSL in accordance with the on-site DH-01 monitoring well measurement in October 2008. However, as discussed in Section 2.3 of this report, measurements of the water level in the DH-01 monitoring well have ranged from 179.46 ft MSL to 200.86 ft MSL, which is consistent with the range of water levels interpreted by the Illinois State Water Survey (Visocky 1997, Burch 2002, Burch 2008) for the area of the Lafarge Conco Mine since the 1990s.

5.1.7 In Situ Stress

Table 5-5 summarizes the in situ stress conditions applied to the model. In order to measure the sensitivity of flow to mine orientation within the anisotropic horizontal stress field with a two-dimensional model, simulations were run and compared using the maximum and minimum horizontal stress in the plane of the model.

Table 5-5. UDEC Model In Situ Stress Conditions

	Stress Gradient (psi/ft of depth)
Vertical Stress	1.09
Horizontal Stress	
Major Principal Stress	3.51
Minor Principal Stress	2.11

5.2 Results

5.2.1 Fluid Flow

Table 5-6 summarizes the fluid flow predicted for seven modeling scenarios, ranging from a hypothetical "worst case" (WC) where the Second Level is filled to the roof with water to various heights of sludge impoundment. The worst case scenario represents the maximum anticipated hydraulic head that could develop along the flow paths and, therefore, the upper limit for flow. In practice, decant water levels will be controlled at lower levels up to a maximum height of about 31 ft above the Second Level floor. Suspended solids in the sludge will settle out of solution and deposit on the floor. Decant water will stand on top of the settled solids. Model scenarios T0 through T5 represent progressive levels of filling at various stages over the life of the operation. The thickness of the solids is based on the planned solids content of the injection stream and settling rates projected by Deuchler.

Modeling assumed that, at the beginning of sludge emplacement, the entire impoundment area will be filled to a fluid height of 6 ft, represented by Scenario T0. After nominally one year, 1 ft of consolidated solids were projected to have settled on the mine floor (Scenario T1). Scenarios T2 through T4 represented intermediate stages of filling where the solids are projected to have deposited to thicknesses ranging from 2 to 10 ft. Final conditions at the end of disposal were represented by Scenario T5 where an average of 27 ft of solids were projected to have deposited over the impoundment area.

Table 5-6. UDEC Model Fluid Flow Rates by Vertical Joint Type

Model Scenario	Sludge Thickness (ft)		Total Hydraulic Head on Level 2 Floor (ft)	Total Flow (gpm)	
	Settled Solids	Decant Water		Into Water Table	Into Level 3
WC (Worst Case)	None	50.0	50.0	0.00446	2.34
T0	None	6.0	6.0	0.00169	0.89
T1	1.0	5.0	6.0	0.00149	0.85
T2	2.0	4.0	6.0	0.00143	0.83
T3	5.0	6.0	11.0	0.00224	0.97
T4	10.0	6.0	16.0	0.00245	1.11
T5	27.0	4.0	31.0	0.00313	1.53

Flow is expressed in terms of the rate of total flow (gallons per minute [gpm]) from the entire 42.3-acre impoundment area. Flow from Level 2 reports either to (a) Level 3 or (b) the water table of the Cambro-Ordovician aquifer. Table 5-6 shows that almost all flow is intercepted by Level 3 (when fully mined) and very little will reach the water table. Total flow into Level 3 is predicted to increase from a minimum of about 0.9 gpm to 1.5 gpm (1,300 gallons/day to 2,160 gallons/day) over the life of the operation. These values represent the maximum possible flow rates to the water table if Level 3 were not present. Only negligible flow, on the order of a few gallons *per day*, is expected to reach the water table once Level 3 has been completed. To put these numbers into context, the sump at the midpoint of the decline at the Lafarge Conco mine, which collects surface water that has run down the decline and inflows from the perimeter of the decline, has a pumping rate of 600 gpm.

Predicted flow into Level 3 is dominated by the vertical joints that cut through the sills. The model includes two Type 1 "open" unfilled joints (four total with symmetry) through the sills, which is statistically consistent with the frequency of occurrence mapped in the mine. These provide direct flow paths from Level 2 to 3. Figure 5-3 illustrates the simulated flow pattern through the bedding planes and joints for Scenario WC. Very minor flow occurs along other bedding planes and filled vertical joints due to comparatively low hydraulic conductivity.

The settled solids help to reduce flow by restricting fluid flow into the natural joints. This is evidenced by the comparison of Scenarios T0 and T1 which have the same hydraulic head driving flow. T0 has 6 ft of standing water and T1 has 5 ft of solids plus 1 ft of water above the solids. The increased resistance to flow through the 5 ft of solids is responsible for about a 4.4% reduction in flow. The model shows increased flow as fluid levels rise due to the increased hydraulic head on the system. However, flow rates are slightly less than they would be if no solids were present.

Grain size analysis suggests that the settled solids are likely to fill and plug leaking joints (Appendix D). This effect is difficult to quantify and was not considered in the model. It is possible that joint plugging could contribute more to restricting flow than the hydraulic resistance to flow through the settled solids. The potential for partial or complete plugging of the joints is considered an important potential factor mitigating the risk of flow.

Actual flow could be greater or less than predicted depending upon the actual geologic conditions and characteristics of the sludge. The model results represent a "best estimate" (i.e., most accurate estimate possible) of actual conditions on average throughout the mine based on the disposal plans, underground observations, laboratory and field measurements, and relevant published data. Significant local variation from the average is possible at any location throughout the mine. Risk exists that the total flow from the impoundment area could be greater than predicted because of unknown or unobservable joints, vugs, or other conduits, as is typical of most geologic systems. Experience and observations in the mine, and in similar mines operating in the same stratigraphy, suggest that the hydrologic regime is of low permeability and that the risk of problematic flow is limited. This risk is partially offset by the probability that the solids will plug drainage paths and the majority of flow will be intercepted by Level 3 before entering the water table. To provide an added level of , Lafarge will seal all of the Type 1 unfilled joints identified on the floor, roof and perimeter walls of Levels 1 and 2 using shotcrete, bentonite or grout prior to the emplacement of lime sludge.

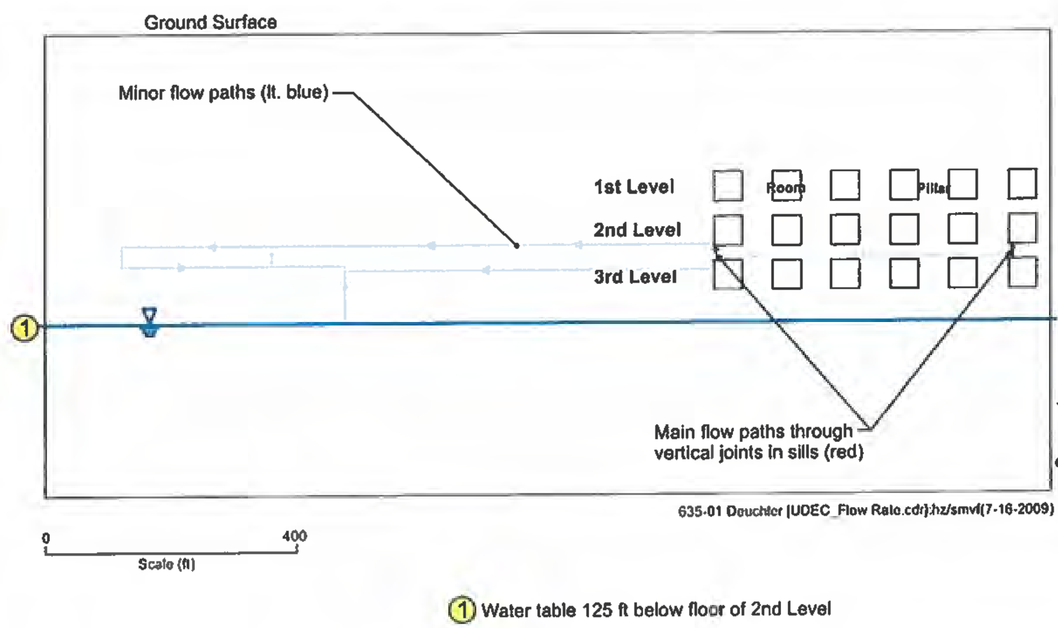
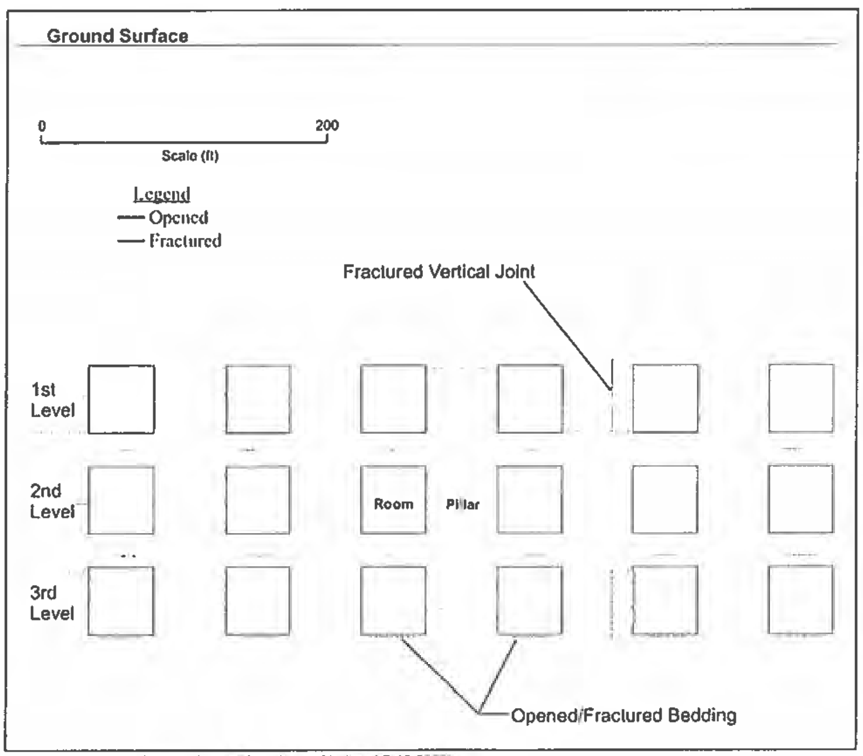


Figure 5-3. Fluid Flow Pathways from Level 2 Sludge Impoundment—Scenario WC

The flow rates predicted by "best estimate" modeling are low to negligible compared to the normal pumping rate in the mine of 600 gpm. Modeling indicates that flows into Level 3 would require a nominal pumping capacity less than 5 gpm. Pumping capacities in limestone mines in the Chicago area are typically on the order of 500 to 1,000 gpm. Worst case flow could, therefore, increase two orders of magnitude above "best estimate" predictions and still be considered readily manageable using common mine dewatering systems. Although considered as very low probability, flows into Level 3 in excess of 1,000 gpm could be managed by adding pumping capacity and/or using localized grouting, drilling of interceptor drains, or other flow control techniques. Flow and any flow control system would be temporary until the sludge reservoir was fully drained or flow pathways were self-sealed.

5.2.2 Stability

The hydro-mechanical model was also used to assess global rock mass stability for worst case Scenario WC. Ground stability is controlled by both the strength of the solid rock mass and natural joints and the stresses induced by mining and sludge emplacement. The model accounts for effective stresses in joints caused by fluid pressurization. The joints are permitted to rupture and slip where joint strength is exceeded. Figure 5-4 shows the pattern of joint failure around the mining horizon for Scenario WC. The model simultaneously accounts for plastic yielding in the solid where the rock mass strength is exceeded.



635-01 Deuchler [UDEC Jointing and Bedding.cdr]:hz/smvl(7-15-2009)

Figure 5-4. Pattern of Joint Failure Around the Mining Horizon for Scenario WC

Global stability is quantified in terms of a "critical" or global minimum stability factor. The stability factor was calculated using a "strength reduction" method where the strength parameters (cohesion and friction angle) of the rock mass and joints were incrementally reduced from their estimated values until uncontrollable plastic failure was induced somewhere in the model. This approach allows the weakest part of the mine to be identified, whether an individual pillar, sill, roof span, floor, or a combination of components. The ratio of the actual strength to the reduced strength represents the factor of safety in the system, whereby larger ratios imply greater stability.

A critical safety factor of 1.89 was calculated for Scenario WC, indicating the mine is stable under "best estimate" conditions. Risk exists that the ground could be weaker than estimated and, therefore, less stable than indicated by modeling. A safety factor of 1.89 suggests that ground with pressurized joints, on average, is slightly less than twice as strong as the loads that will be imposed on it by mining and sludge emplacement. Modeling suggests that joint pressurization from sludge flow will have a minor impact on global stability.

6.0 WETTING AND DRYING EFFECTS

Water is well known for its ability to erode rocks as a result of alternating wetting and drying cycles. To gather data on the effects of wetting and drying on limestones and dolomites, AAI consulted with representatives of the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), the webpage of the Milwaukee Metropolitan Sewerage District (MMSD), and professional colleagues knowledgeable concerning other tunnels in limestone or dolomite. AAI also performed a search of the tunneling literature regarding water problems in tunnels.

The MWRDGC is responsible for the deep tunnel system designed to collect water from sewers in Cook County during heavy rainstorms. The tunnels, which vary in diameter from 6.5 ft to 35 ft, were constructed in Silurian dolomite at depths of up to 250 ft below surface and are generally concrete-lined; however, a few tunnel sections are unlined. In telephone conversations with AAI, Chief Engineer Joseph Sobanski of the MWRDGC indicated that he had not noticed any erosion in the sections that are unlined.

The MMSD is responsible for a deep tunnel system designed to collect water from sewers in Milwaukee County during heavy rainstorms. The tunnels, which vary in diameter from 17 ft to 32 ft, were constructed in Silurian dolomite at depths of 300 ft below surface. Fifty-five percent of the tunnels are unlined. In 2002, an inspection of the tunnel system found little erosion had occurred in the 8 years since the system was commissioned. The inspection team also found that joints that had been mapped as weeping at the time of construction had healed as a result of calcification (MMSD 2008).

AAI's contacts with professional colleagues who have worked on tunnels in limestone for water supply and pumped-storage hydroelectric projects in the United States of America and Canada indicated that the tunnels for both water supply and pumped storage projects were generally lined. One respondent indicated that if the limestone or dolomite was "vuggy," there could be some issues but did not elaborate further (Mukherjee, A., personal communication, October 2008).

With unlined hydroelectric power tunnels, rockfalls often occur when the tunnels are dewatered for inspection. The primary cause of the falls is the loosening of small blocks bounded by joint planes. This same phenomenon has been observed by AAI personnel in newly dewatered, unsupported mine tunnels that had been water-filled for a number of years. However, such rockfalls do not result in water inflows or significant tunnel instability unless other conditions such as joints filled with soft gouge are also present.

A rockfall that blocked the New Colgate Tunnel of the Yuba County Water Agency in California in 1974 was found to have been caused by erosion of the gouge material in a shear zone. Observation of the failed zone as well as other shear zones in the tunnel showed that, with flow and pressure fluctuations in the tunnel, shear zones containing sandy gouge eroded to a considerable extent, whereas those containing wholly clay gouge showed little signs of erosion (Lang, Kendorski and Chawla 1976). It was concluded that clays were less susceptible to erosion due to pressure fluctuations because the cohesive strength exceeded the relatively small pressure fluctuations.

Rockfalls encountered in the tunnels of the Snowy Mountains Hydroelectric Power Scheme in New South Wales, Australia, were due mainly to clay-coated joints or washouts of clay or other soft materials from shear zones (Dann, Hartwig, and Hunter 1964). The type of clay involved was not mentioned; however, as the rocks in which the tunnels were constructed were mainly volcanic, the clays were likely kaolinite. In the Eucumbene-Tumut Tunnel, the main cause of rockfalls was loosening of blocks bounded by joint planes after the joints became water-saturated.

7.0 CHEMICAL EFFECTS

Aurora drinking water is obtained from the Fox River and from supply wells that pump from the Cambro-Ordovician aquifer below the Galena-Platteville Group. Results of water-supply well sample analyses reported by Woller and Sanderson (1978) indicated that the pH of the water was 8.6, the hardness averaged 250 milligrams per liter (mg/L), and the total dissolved minerals averaged 345 mg/L. More recent measurements indicated that the pH of tap water in Aurora ranges from 9.1 to 9.3 and the average hardness of tap water ranges from 120 to 140 mg/L (Aurora 2007).

The pH and hardness concentrations discussed in the previous paragraph are indicative of water that has been in contact with carbonate rocks such as the Galena-Platteville Group. Consequently, few, if any, adverse chemical interactions can be expected due to the chemistry of the water. Inspections of hydroelectric power plant tunnels have shown that over time, thin coatings of black organic slimes (Mirza et al. 2001) can occur as can buildups of calcium carbonate precipitates at seepage locations (Prokopovich and Boll 1985). According to Brown (1903), black organic slimes form in acidic waters; in alkaline waters, the coatings consist of calcium carbonate precipitates. Consequently, calcium carbonate precipitation can be expected on the pillars of the mine over time. These precipitates will serve to reduce the hydraulic conductivity of joints and thereby reduce the potential for outflows from the water-filled mine.

8.0 CONCLUSIONS AND RECOMMENDATIONS

In this study, AAI inspected and sampled the joints on both levels of the south half of the Lafarge Conco Mine, performed pillar stability calculations and hydro-geomechanical modeling of the filled mine, and examined the potential of erosion from wetting and drying cycles and chemical interactions. As a result of these investigations, AAI concludes the following:

- Modeling of the mine hydro-geomechanical system with UDEC indicates that mining has not and will not in the future have a significant influence on the hydraulic conductivity of the natural system. Mining results in a localized perturbation of the in situ stress state in close proximity to the mine openings. Results indicate that mining is likely to cause some fracturing of healed joints and dilation of unfilled joints several feet into the roof, rib, or floor. However the change in natural hydraulic conductivity extends a negligible distance into the rock mass when compared to the distance to the water table.
- Fluid flows out of the sludge impoundment area are predicted to be very low relative to the rate of groundwater inflow into the mine (historically on the order of 600 gpm) due to the low permeability of the geologic system. Total fluid flow from Level 2 into Level 3 is predicted to increase from about 0.9 to 1.5 gpm over the life of the operation based on simulated "best estimate" (i.e., most accurate possible) conditions. Only negligible flow, on the order of a few gallons per day, is expected to reach the water table of the Cambro-Ordovician aquifer.
- Potential exists that the total flow from the impoundment area could be greater than predicted because of unknown or unobservable joints, vugs, or other conduits, as is typical of most geologic systems. Experience and observations in the mine, and in similar mines operating in the same stratigraphy, suggest that the risk of problematic flow is limited. Risk is partially offset by the probability that the solids in the sludge will plug drainage paths and that the majority of flow will be intercepted by Level 3 before entering the water table. Worst case flow could increase two orders of magnitude above "best estimate" predictions and still be considered readily manageable with the mine's existing pumping system. Although considered as very low probability, flows into Level 3 in excess of 1,000 gpm could be managed by adding pumping capacity and/or using localized grouting, drilling of interceptor drains, or other flow control techniques. Flow and any flow control system would be temporary until the sludge reservoir was fully drained or flow pathways were self-sealed.
- Hydro-mechanical modeling indicates that the potential for joint pressurization from fluid flowing from the sludge impoundment area poses minimal risk to global geomechanical stability in the mine.
- The Hedley and Grant, Stacey and Page, and Hardy and Agapito pillar-stability formulas result in safety factors that exceed 2.0 in all cases. Given that the mine pillars have a width to height (W/H) ratio of 1 or more and that the minimum acceptable safety factor taken by AAI in that situation is 1.3, all three formulas predict that the existing mine pillars should be stable. The sill stability calculations resulted in safety factors greater than 1.85 in all cases.

- Based on experience in unlined sewer and wastewater tunnels sited in similar rocks elsewhere in the Chicago area, wetting and drying cycles are unlikely to cause significant erosion of the roof and walls of the mine openings. Internet and telephone contacts indicated that little erosion has occurred in unlined portions of the deep (250 to 300 ft below surface) tunnels of the MWRDGC and MMSD that are sited in Silurian dolomites similar to the Ordovician Galena-Platteville Groups. Inspection of the MMSD tunnels some years after construction found that joints that had been mapped as weeping at the time of construction had healed as a result of calcification.
- Aurora water is obtained from the Fox River and from supply wells that pump from the Cambro-Ordovician aquifer below the Galena and Platteville Groups. Results of water-supply well sample analyses showed that its pH and hardness concentrations are indicative of water that has been in contact with carbonate rocks such as the Galena and Platteville Groups. Consequently, few, if any, adverse chemical interactions can be expected due to the chemistry of the water.
- Inspections of hydroelectric power plant tunnels have shown that, over time, buildups of calcium carbonate precipitates occur when the water is alkaline. Consequently, calcium carbonate precipitation can be expected on the pillars of the mine over time. These precipitates will serve to reduce the hydraulic conductivity of joints and thereby reduce the potential for outflows from the water-filled mine.

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APPENDIX A

Results of X-Ray Diffraction Tests on Joint Infilling Materials

November 12, 2008
Lab no. 208810

Mr. Adam McMullin
Agapito Associates, Inc
715 Horizon Drive, Suite 340
Grand Junction, Colorado 81506

Dear Mr. McMullin:

Enclosed are the x-ray diffraction (XRD) analytical results for 12 "Deuchler SS" samples. This report will be mailed and emailed to you. A signed acknowledgment of our, "New Client Credit Application" will be mailed with the report. Thank you for your patience with our slow turnaround time while we moved our lab to its new location.

A representative portion of each sample was ground to approximately -400 mesh in a steel swing mill, packed into a well-type plastic holder and then scanned with the diffractometer over the range, 3-61° 2θ using Cu-Kα radiation. Each ground sample was also prepared as an oriented mount by mixing ground sample with distilled water, drawing the mixture onto a cellulose acetate filter and then rolling the deposited material onto a glass disk. The oriented mounts were scanned over the range 2-30°; treated with glycol and then re-scanned over the range 2-22°. Analysis of oriented mounts aids in the identification of clay minerals. Estimates of mineral concentrations were made using our XRF-determined elemental compositions and the relative peak heights/areas on the XRD scans. The detection limit for an average mineral in these samples is ~1-3% and the analytical reproducibility is approximately equal to the square root of the amount. "Unidentified" accounts for that portion of the XRD scan which could not be resolved and a "?" indicates doubt in both mineral identification and amount.

Thank you for the opportunity to be of service Agapito Associates.

Sincerely,

Peggy Dalheim

Agapito Associates, Inc
XRD Results for 12 “Deuchler SS” Samples
Page 1 of 2

November 12, 2008
Lab no. 208810

Mineral Name	Chemical Formula	Approx. Wt %					
		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6
Mica/illite	$(K,Na,Ca)(Al,Mg,Fe)_2(Si,Al)_4O_{10}(OH,F)_2$	68	39	53	44	47	<5
Quartz	SiO_2	20	24	15	14	26	5
K-feldspar	$KAlSi_3O_8$	<5	5	<5	<5	<5	<3?
Dolomite	$Ca(Mg,Fe)(CO_3)_2$	—	14	18	17	17	33
Calcite	$CaCO_3$	—	<5	6	16	—	55
Pyrite	FeS_2	<2	8	<3	<3	<3	<1?
Gypsum	$CaSO_4 \cdot 2H_2O$	<3	<5	—	<3	<5	—
Apatite	$Ca_5(PO_4)_3(OH,F,Cl)$	<2?	<3	<3?	—	—	—
Kaolinite	$Al_2Si_2O_5(OH)_4$	—	—	—	—	—	—
“Unidentified”	?	<5	<5	<5	<5	<5	<5

Initial_______

Date_________

Analysis performed by The Mineral Lab, Inc

Agapito Associates, Inc
XRD Results for 12 "Deuchler SS" Samples
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November 12, 2008
Lab no. 208810

Mineral Name	Chemical Formula	Approx. Wt %					
		SS-7	SS-8	SS-9	SS-10	SS-11	SS-12
Mica/illite	$(K,Na,Ca)(Al,Mg,Fe)_2(Si,Al)_4O_{10}(OH,F)_2$	43	47	—	—	—	55
Quartz	SiO_2	25	20	<3	<3	<5	13
K-feldspar	$KAlSi_3O_8$	5	5	—	<3?	<3?	<3?
Dolomite	$Ca(Mg,Fe)(CO_3)_2$	20	13	21	32	51	15
Calcite	$CaCO_3$	<3?	9	74	62	30	7
Pyrite	FeS_2	<3	<3	—	<1?	12	<2
Gypsum	$CaSO_4 \cdot 2H_2O$	<5	—	—	—	—	—
Apatite	$Ca_5(PO_4)_3(OH,F,Cl)$	—	<3	—	—	—	—
Kaolinite	$Al_2Si_2O_5(OH)_4$	—	—	—	—	—	<5
"Unidentified"	?	<5	<5	<5	<5	<5	<5

Initial_______

Date_________

Analysis performed by The Mineral Lab, Inc

APPENDIX B

RESULTS OF FALLING-HEAD HYDRAULIC CONDUCTIVITY TESTS ON JOINT INFILLING MATERIALS

Wang Engineering

1145 North Main Street
Lombard, Illinois 60148
Phone (630) 953-9928
www.wangeng.com

December 9, 2008

To: Mr. Douglas Hambley, Ph.D., P.E., P.Eng., P.G.
Agapito Associates, Inc.
2 East 22nd Street, Suite 307
Lombard, IL 60148

RE: Hydraulic Conductivity Testing
LaFarge Project
Wang #: 162-02-01

Dear Mr. Hambley:

As requested by Agapito Associates, Inc., Wang Engineering, Inc. (Wang) has completed the hydraulic conductivity testing program for the LaFarge Project. To determine the as-received bulk unit weight, Wang performed density testing in accordance with ASTM WK3158. The samples were then hand-tamped to as close to the bulk unit weight as possible. Table 1 summarizes the bulk unit weight, as-tested unit weight, and the measured hydraulic conductivity per ASTM D 5084.

Sample ID	Sample Description	Measured Bulk Wet Density, γ_{t1} (pcf)	As-Tested Wet Sample Density, γ_{t2} (pcf)	Hydraulic Conductivity, k (cm/sec)
15S 110E	Brown LEAN CLAY	127.7	130.4	4.47E-08
2S E112	Brown SANDY CLAY	170.9	145.3	1.95E-05
S6 W125	Brown LEAN CLAY	144.8	152.6	2.53E-08
LL N2 E105	Gray CLAY SHALE	150.1	125.6	4.39E-07
LL N15/16 W106	Gray CLAY SHALE	143.2	126.7	2.04E-07
N15 103E	Gray CLAY SHALE w/ Limestone Fragments	N/A 1)	108.3	1.77E-07
S5 107E	Gray CLAY SHALE	127.4	127.1	1.51E-08
S12 114E	Gray LIMESTONE FRAGMENTS	N/A 2)	N/A 2)	N/A 2)

1) Unsuitable to test via ASTM WK3158.
2) Limestone fragments unsuitable to test via ASTM D 5084.

Please feel free to contact us if there are any further questions or comments.

Sincerely,

Wang Engineering, Inc.

Mickey Snider, P.E.
Project Geotechnical Engineer

Attachments: Laboratory Test Results
Cc: Corina T. Farez, Senior Vice President, Wang Engineering, Inc.
Liviu Iordache, Project Manager, Wang Engineering, Inc.

FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: N15 103E

Analyst name: *Mickey Snider*
Test date: *10-Nov-08*
Sample description: *Remolded Gray CLAY SHALE*

Initial height =	9.719	cm
Initial diameter =	7.690	cm
Initial mass =	630.50	g
Final height =	10.224	cm
Final diameter =	7.895	cm
Final mass & tare=	1031.30	g
Final mass=	867.90	g
Dry mass and tare =	787.8	g
Dry mass =	624.40	g
Tare mass =	163.4	g
Estimated G_{sp} =	2.7	
Burette area =	0.196	cm^2

Inital water content =	1.0%	
Initial void ratio =	0.952	
Initial degree of saturation =	2.8%	
Initial dry unit weight =	13.57	kN/m^3
	86.4	pcf
Final water content =	39.0%	
Final void ratio =	1.164	
B coefficient =	95.0%	
Final degree of saturation =	90.4%	
Final dry unit weight =	12.24	kN/m^3
	77.9	pcf
Bias pressure =	70.37	cm H_2O
Hydraulic gradient =	7	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	k_{20}°c cm/s
	11/14/08 12:45		4.33	9.85	28.16	22.1		
1	11/14/08 14:24	5940	4.91	9.50	23.42	23.6	1.70E-07	1.56E-07
2	11/14/08 15:51	5220	5.34	9.17	19.54	23.2	1.66E-07	1.54E-07
3	11/14/08 17:33	6120	5.80	8.79	15.26	24.0	1.64E-07	1.49E-07
4	11/15/08 10:40	61620	10.05	5.45	-23.47	20.3	2.00E-07	1.99E-07

Average permeability, k_t = **1.77E-07 cm/s**
Average permeability, k_{20}°c = **1.67E-07 cm/s**

Prepared by: [signature] Date: 11/18/08
Checked by: [signature] Date: 11/18/08

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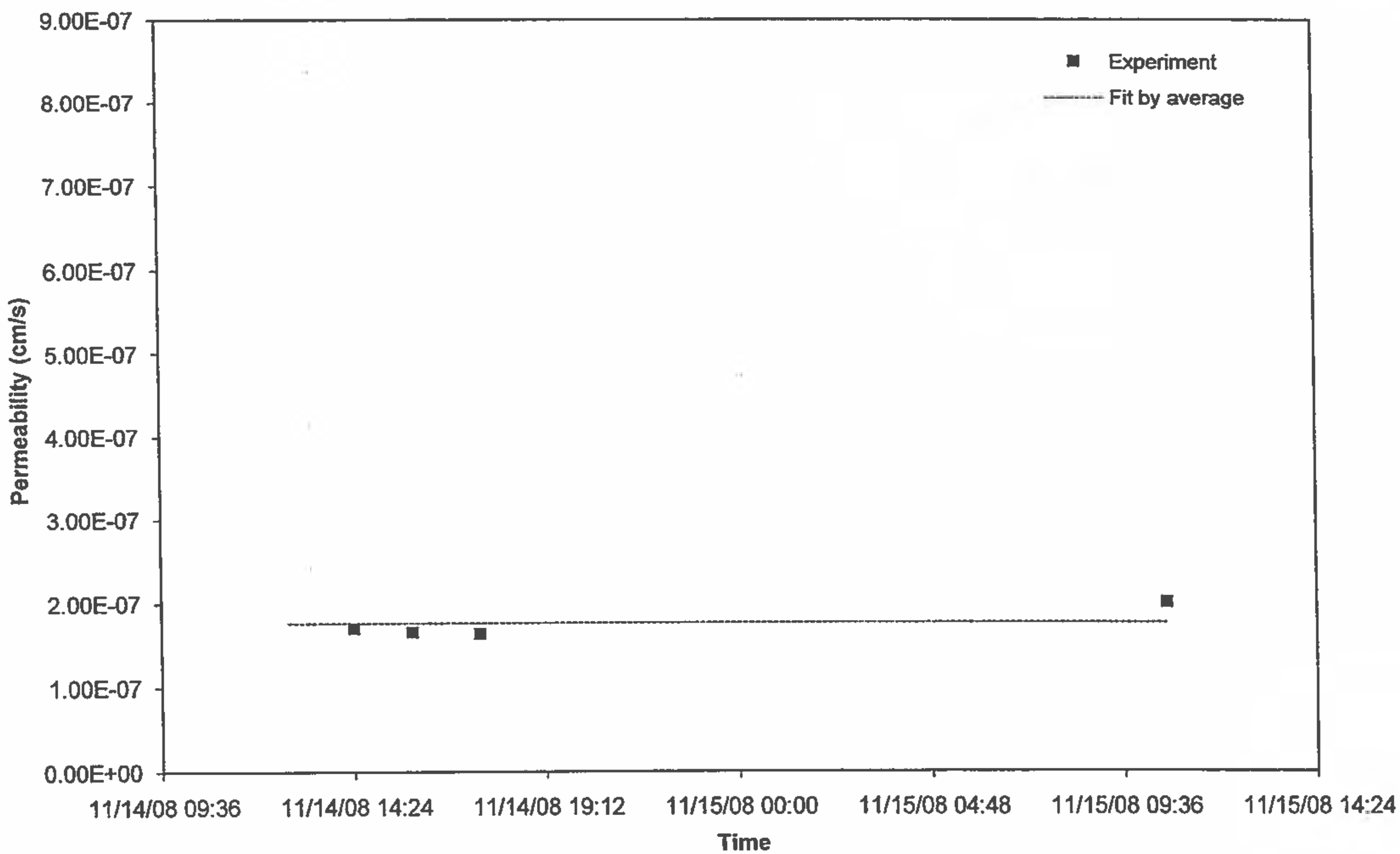
WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample N15 103E



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

FALLING HEAD PERMEABILITY

ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: LL N15/N16 W106

Analyst name: *Mickey Snider*
Test date: *10-Nov-08*
Sample description: *Remolded Gray CLAY SHALE*

Initial height =	*7.920*	cm
Initial diameter =	*7.112*	cm
Initial mass =	*560.30*	g
Final height =	*8.095*	cm
Final diameter =	*7.357*	cm
Final mass & tare=	*884.90*	g
Final mass=	*698.14*	g
Dry mass and tare =	741.5	g
Dry mass =	*554.74*	g
Tare mass =	*186.76*	g
Estimated G_{sp} =	2.8	
Burette area =	*0.196*	cm^2

Inital water content =	1.0%	
Initial void ratio =	0.588	
Initial degree of saturation =	4.8%	
Initial dry unit weight =	17.30	kN/m^3
	110.1	pcf
Final water content =	25.8%	
Final void ratio =	0.737	
B coefficient =	95.0%	
Final degree of saturation =	98.2%	
Final dry unit weight =	15.82	kN/m^3
	100.7	pcf
Bias pressure =	70.37	cm H_2O
Hydraulic gradient =	9	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	$k_{20°C}$ cm/s
	11/14/08 12:46		*4.65*	*9.51*	24.80	*22.1*		
1	*11/14/08 14:25*	*5940*	*5.30*	*9.29*	20.36	*23.6*	1.57E-07	1.44E-07
2	*11/14/08 15:51*	*5160*	*5.76*	*8.90*	16.02	*23.2*	1.85E-07	1.72E-07
3	*11/14/08 17:34*	*6180*	*6.26*	*8.46*	11.22	*24.0*	1.81E-07	1.64E-07
4	*11/15/08 10:48*	*62040*	*10.92*	*4.43*	-33.11	*20.3*	2.47E-07	2.45E-07

Average permeability, k_t = **2.04E-07 cm/s**
Average permeability, $k_{20°C}$ = **1.94E-07 cm/s**

Prepared by: [signature] Date: 11/18/08

Checked by: [signature] Date: 11/18/08

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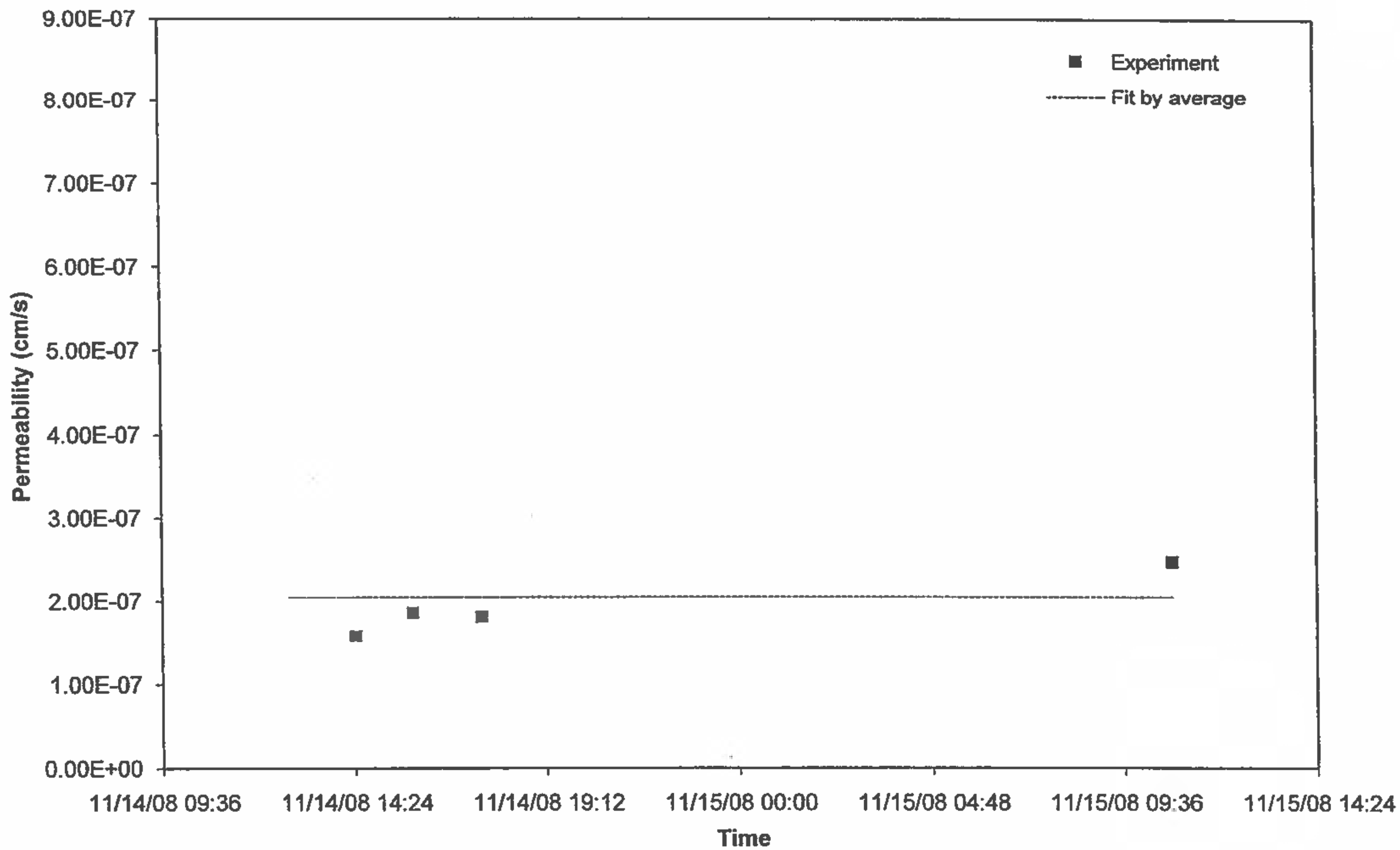
WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample LL N15/N16 W106



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: S6 W125

Analyst name: *Mickey Snider*
Test date: *30-Oct-08*
Sample description:

Remolded Brown CLAY

Initial height =	*3.823* cm		Inital water content =	17.6%
Initial diameter =	*3.608* cm		Initial void ratio =	0.410
Initial mass =	*90.63* g		Initial degree of saturation =	100.0%
Final height =	*3.669* cm		Initial dry unit weight =	19.34 kN/m^3
Final diameter =	*3.604* cm			123.2 pcf
Final mass & tare=	*162.68* g		Final water content =	18.7%
Final mass=	*91.49* g		Final void ratio =	0.350
Dry mass and tare =	148.28 g		B coefficient =	95.0%
Dry mass =	*77.09* g		Final degree of saturation =	100.0%
Tare mass =	*71.19* g		Final dry unit weight =	20.20 kN/m^3
				128.6 pcf
Estimated G_{sp} =	2.78		Bias pressure =	70.37 cm H_2O
Burette area =	*0.906* cm^2		Hydraulic gradient =	18

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	k_{20}°c cm/s
	11/6/08 14:48		*9.20*	*24.00*	16.34	*24.0*		
1	*11/7/08 08:43*	*64500*	*9.60*	*23.60*	15.45	*21.4*	2.69E-08	2.60E-08
2	*11/7/08 13:37*	*17640*	*9.70*	*23.50*	15.23	*23.2*	2.47E-08	2.29E-08
3	*11/7/08 17:32*	*14100*	*9.80*	*23.40*	15.01	*22.9*	3.10E-08	2.90E-08
4	*11/10/08 08:43*	*227460*	*10.90*	*22.10*	12.36	*21.0*	2.35E-08	2.29E-08
5	*11/10/08 15:49*	*25560*	*11.05*	*22.00*	12.09	*22.3*	2.21E-08	2.10E-08

Average permeability, k_t =	**2.53E-08 cm/s**
Average permeability, k_{20}°c =	**2.39E-08 cm/s**

Prepared by: [signature] Date: 11/18/08

Checked by: [signature] Date: 11/18/08

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WANG ENGINEERING, INC.
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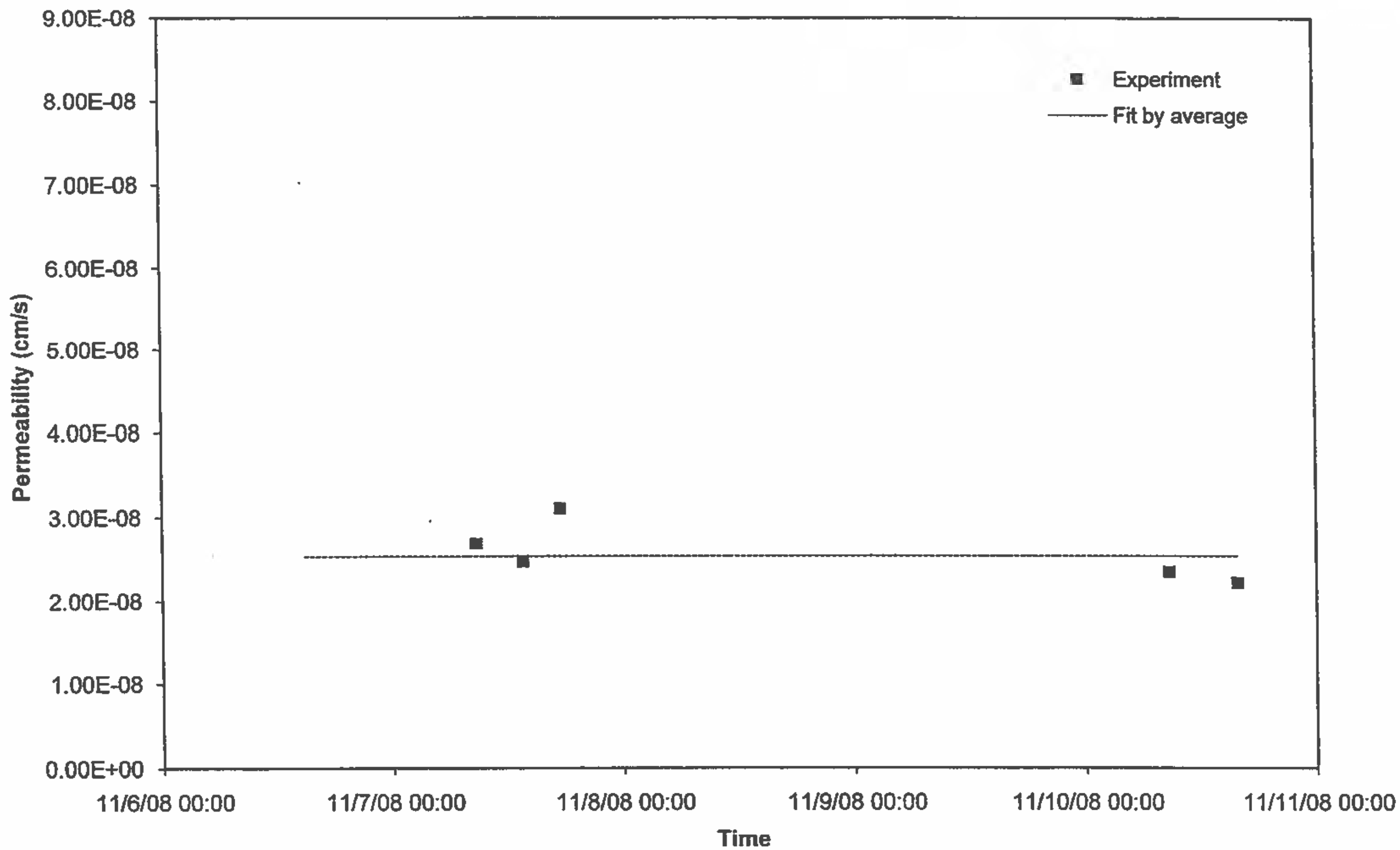
Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample S6 W125



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: 2S E112

Analyst name: *Mickey Snider*
Test date: *30-Oct-08*
Sample description:

Remolded Brown SANDY CLAY

Initial height =	*6.624*	cm
Initial diameter =	*3.592*	cm
Initial mass =	*113.85*	g
Final height =	*6.597*	cm
Final diameter =	*3.247*	cm
Final mass & tare=	*244.18*	g
Final mass=	*127.05*	g
Dry mass and tare =	214.71	g
Dry mass =	*97.58*	g
Tare mass =	*117.13*	g
Estimated G_{sp} =	2.68	
Burette area =	*0.906*	cm^2

Inital water content =	16.7%	
Initial void ratio =	0.843	
Initial degree of saturation =	53.0%	
Initial dry unit weight =	14.26	kN/m^3
	90.8	pcf
Final water content =	30.2%	
Final void ratio =	0.500	
B coefficient =	95.0%	
Final degree of saturation =	100.0%	
Final dry unit weight =	17.53	kN/m^3
	111.6	pcf
Bias pressure =	35.185	cm H_2O
Hydraulic gradient =	5	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	$k_{20^\circ C}$ cm/s
	11/6/08 11:24		*5.20*	*23.90*	20.64	*23.5*		
1	*11/6/08 12:36*	*4320*	*10.55*	*18.80*	9.11	*23.7*	1.59E-05	1.45E-05
2	*11/6/08 13:36*	*3600*	*14.50*	*14.90*	0.44	*23.8*	1.79E-05	1.64E-05
3	*11/6/08 14:48*	*4320*	*18.40*	*11.00*	-8.17	*24.0*	1.90E-05	1.73E-05
4	*11/6/08 15:50*	*3720*	*21.15*	*8.20*	-14.29	*23.7*	2.05E-05	1.88E-05
5	*11/6/08 16:57*	*4020*	*23.50*	*5.90*	-19.43	*23.4*	2.08E-05	1.92E-05

Average permeability, k_t = **1.95E-05 cm/s**
Average permeability, $k_{20^\circ C}$ = **1.79E-05 cm/s**

Prepared by: [signature] Date: 11/18/08

Checked by: [signature] Date: 11/18/08

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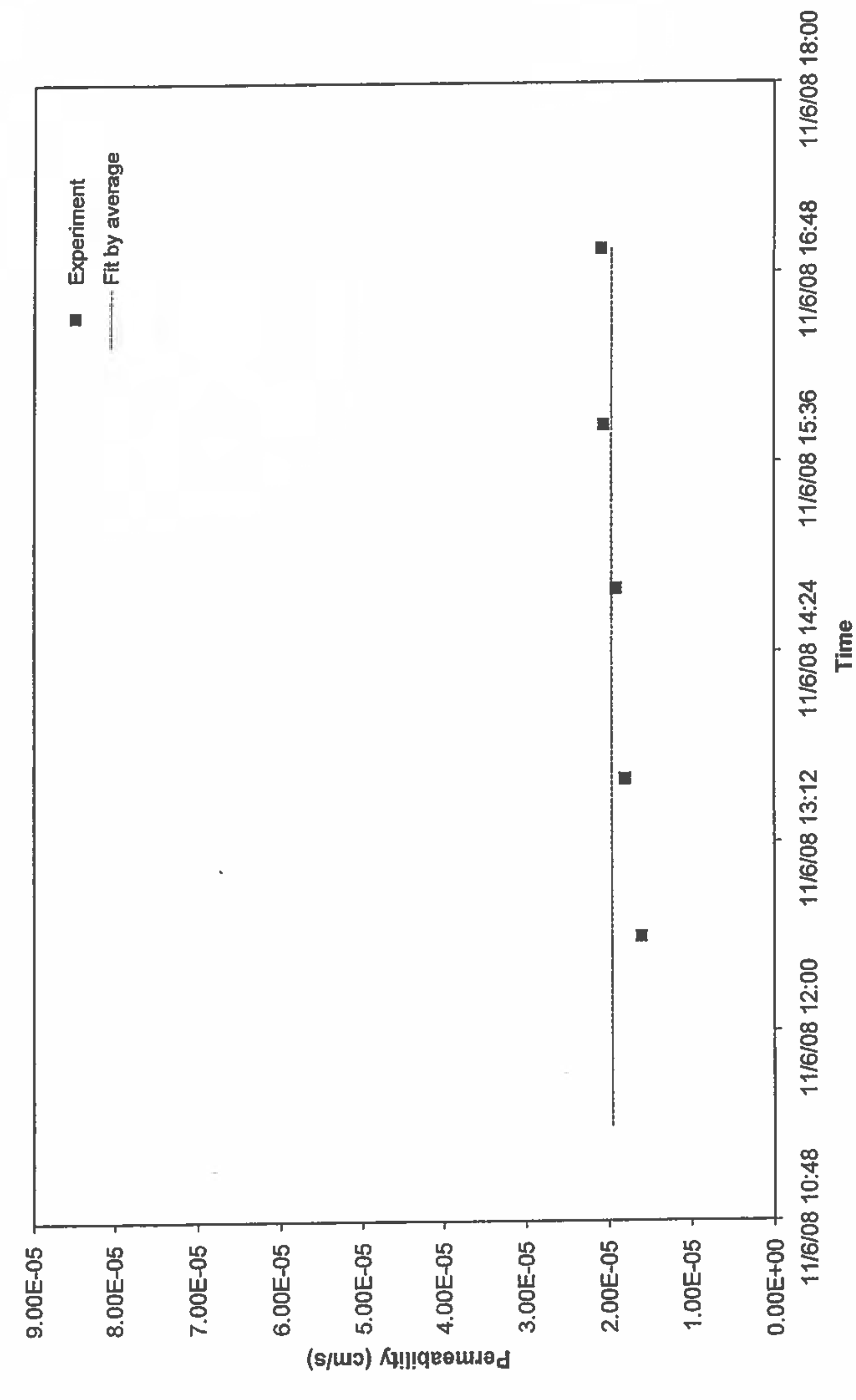
WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

AASHTO R18

Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample 2S E112



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1145 N. Main Street, Lombard, IL 60148

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FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: 15S 110E

Analyst name: *Mickey Snider*
Test date: *10-Nov-08*
Sample description:

Remolded Brown CLAY

Initial height =	4.664 cm	Inital water content =	23.4%	
Initial diameter =	3.549 cm	Initial void ratio =	0.583	
Initial mass =	96.40 g	Initial degree of saturation =	107.5%	
Final height =	4.664 cm	Initial dry unit weight =	16.61	kN/m^3
Final diameter =	3.590 cm		105.8	pcf
Final mass & tare=	285.30 g	Final water content =	26.1%	
Final mass=	98.55 g	Final void ratio =	0.619	
Dry mass and tare =	264.88 g	B coefficient =	95.0%	
Dry mass =	78.13 g	Final degree of saturation =	100.0%	
Tare mass =	186.75 g	Final dry unit weight =	16.24	kN/m^3
			103.4	pcf
Estimated G_{sp} =	2.68	Bias pressure =	70.37	cm H_2O
Burette area =	0.906 cm^2	Hydraulic gradient =	15	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	$k_{20°C}$ cm/s
	11/14/08 12:46		6.30	24.90	20.53	22.1		
1	11/14/08 15:51	11100	6.41	24.81	20.31	23.2	4.68E-08	4.34E-08
2	11/14/08 17:33	6120	6.50	24.76	20.15	24.0	5.95E-08	5.42E-08
3	11/15/08 10:49	62160	6.95	24.21	19.05	20.3	4.21E-08	4.19E-08
4	11/17/08 08:45	165360	7.90	23.15	16.83	19.7	3.24E-08	3.27E-08

Average permeability, k_t = 4.47E-08 cm/s
Average permeability, $k_{20°C}$ = 4.29E-08 cm/s

Prepared by: [signature] Date: 11/18/08
Checked by: [signature] Date: 11/18/08

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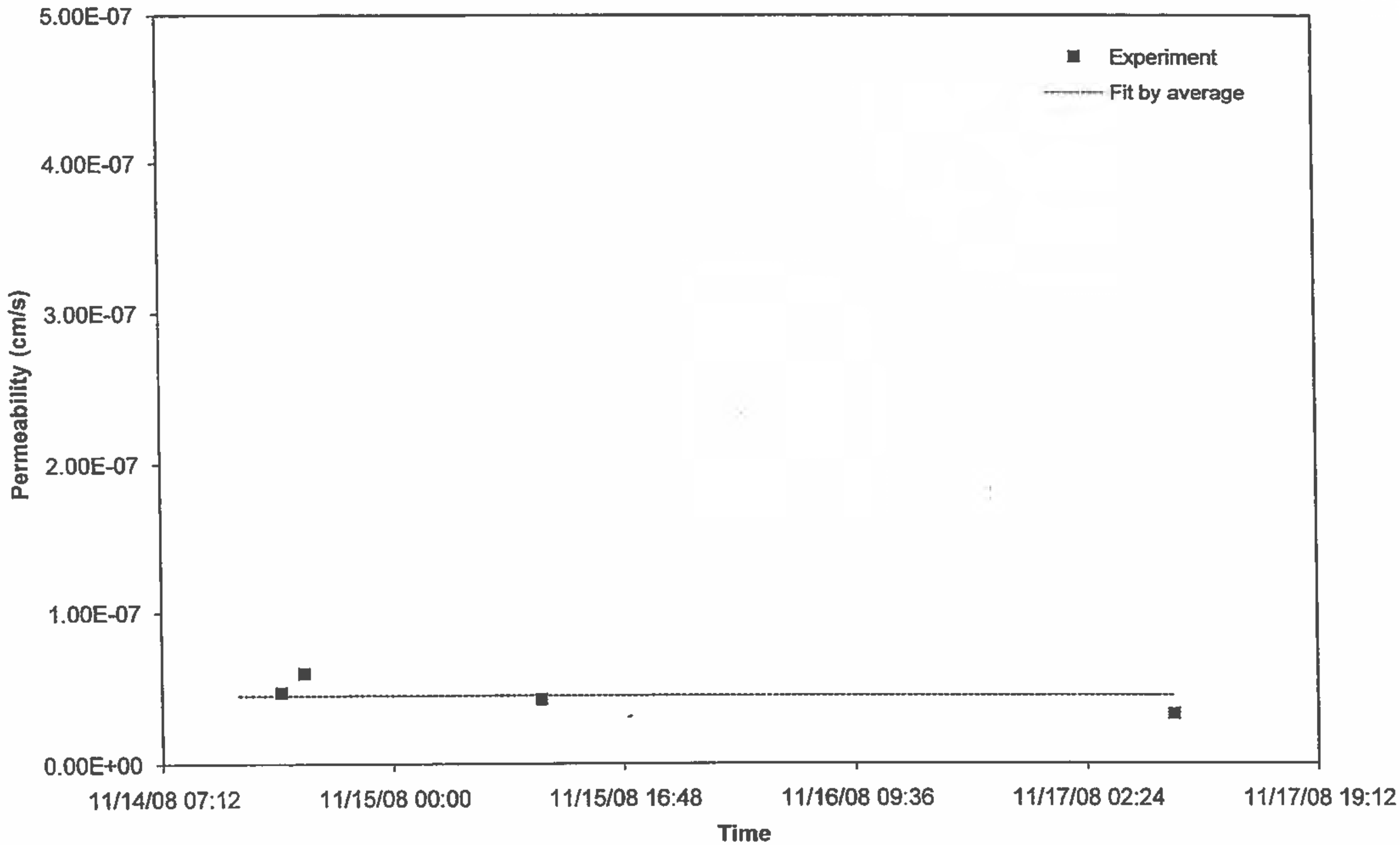
WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample 15S 110E



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: 5S 107E

Analyst name: *Mickey Snider*
Test date: *10-Nov-08*
Sample description:
Remolded Gray CLAY SHALE

Initial height =	5.618	cm
Initial diameter =	3.665	cm
Initial mass =	82.30	g
Final height =	4.992	cm
Final diameter =	3.701	cm
Final mass & tare=	123.38	g
Final mass=	109.28	g
Dry mass and tare =	94.82	g
Dry mass =	80.72	g
Tare mass =	14.1	g
Estimated G_{sp} =	2.78	
Burette area =	0.906	cm^2

Inital water content =	2.0%	
Initial void ratio =	1.041	
Initial degree of saturation =	5.2%	
Initial dry unit weight =	13.36	kN/m^3
	85.1	pcf
Final water content =	35.4%	
Final void ratio =	0.850	
B coefficient =	95.0%	
Final degree of saturation =	100.0%	
Final dry unit weight =	14.74	kN/m^3
	93.9	pcf
Bias pressure =	70.37	cm H_2O
Hydraulic gradient =	13	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	$k_{20°C}$ cm/s
	11/18/08 17:26		8.10	24.38	17.97	22.1		
1	11/19/08 13:46	73200	8.25	24.18	17.58	22.6	1.44E-08	1.36E-08
2	11/20/08 08:52	68760	8.45	24.10	17.27	20.6	1.23E-08	1.22E-08
3	11/20/08 17:32	31200	8.50	23.98	17.09	21.9	1.66E-08	1.58E-08
4	11/21/08 09:38	57960	8.68	23.85	16.74	22.8	1.63E-08	1.53E-08

Average permeability, k_t = 1.51E-08 cm/s
Average permeability, $k_{20°C}$ = 1.44E-08 cm/s

Prepared by: [signature] Date: 12/3/08
Checked by: [signature] Date: 12/03/08

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WANG ENGINEERING, INC.
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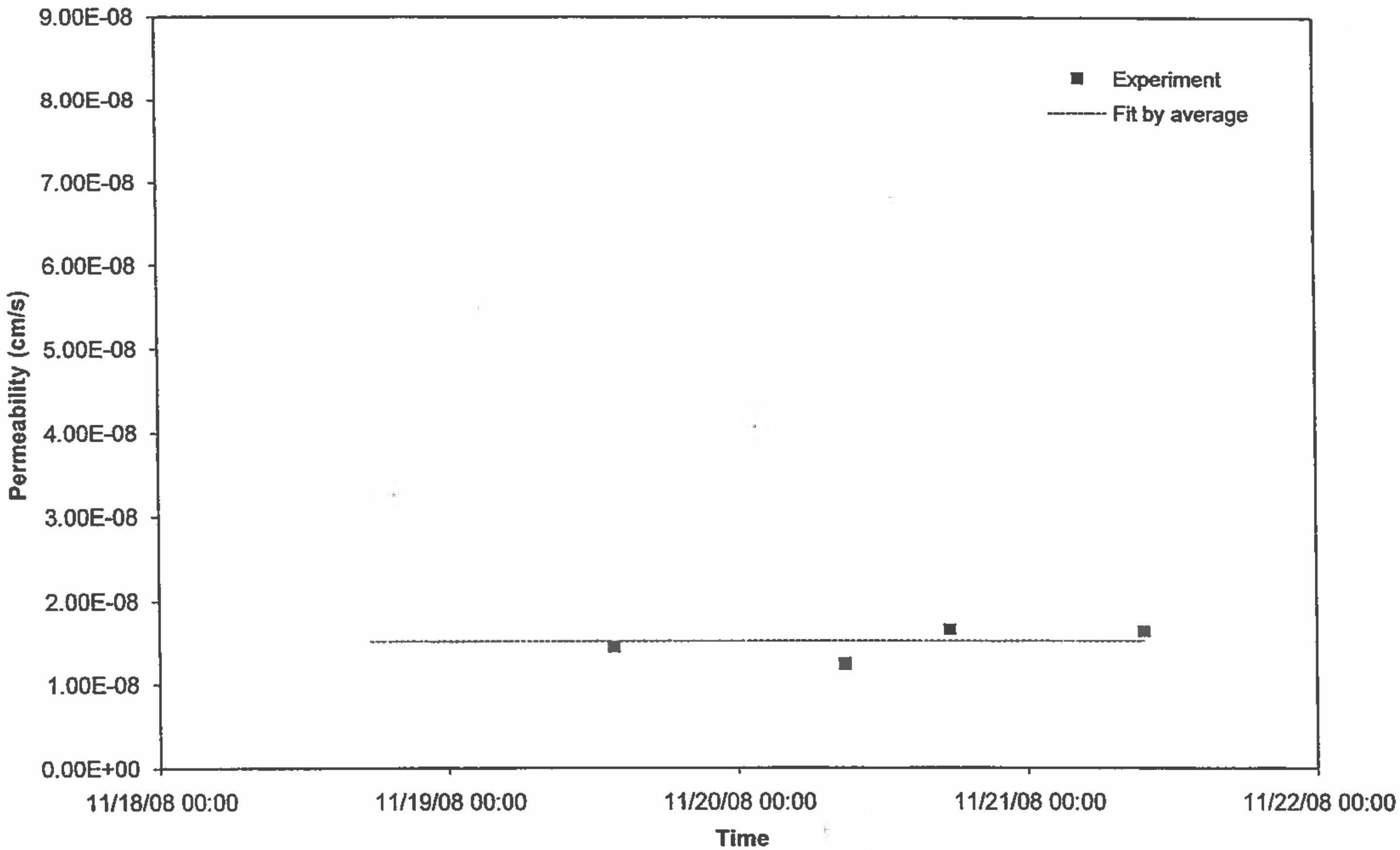
Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample 5S 107E



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

FALLING HEAD PERMEABILITY
ASTM D 5084 Method C

Client: Agapito Associates
Project: Lafarge
WEI Job No: 162-02-01
Soil Sample: LL N2 E105

Analyst name: *Mickey Snider*
Test date: *10-Nov-08*
Sample description:

Remolded Gray
CLAY SHALE

Initial height =	*5.513*	cm
Initial diameter =	*7.112*	cm
Initial mass =	*382.14*	g
Final height =	*5.791*	cm
Final diameter =	*7.215*	cm
Final mass & tare=	*639.50*	g
Final mass=	*475.98*	g
Dry mass and tare =	535.8	g
Dry mass =	*372.28*	g
Tare mass =	*163.52*	g
Estimated G_{sp} =	2.8	
Burette area =	*0.196*	cm^2

Inital water content =	2.6%	
Initial void ratio =	0.647	
Initial degree of saturation =	11.5%	
Initial dry unit weight =	16.67	kN/m^3
	106.2	pcf
Final water content =	27.9%	
Final void ratio =	0.781	
B coefficient =	95.0%	
Final degree of saturation =	99.9%	
Final dry unit weight =	15.43	kN/m^3
	98.2	pcf
Bias pressure =	70.37	cm H_2O
Hydraulic gradient =	13	

Run No.	Date and time	Δt sec	V_U cm^3	V_L cm^3	h cm	t °C	k_t cm/s	$k_{20°C}$ cm/s
	11/18/08 09:08		*0.72*	*9.97*	47.19	*22.1*		
1	*11/18/08 10:06*	*3480*	*2.27*	*8.93*	33.98	*23.6*	4.66E-07	4.28E-07
2	*11/18/08 11:40*	*5640*	*4.15*	*7.40*	16.58	*23.2*	4.40E-07	4.08E-07
3	*11/18/08 13:29*	*6540*	*5.82*	*5.74*	-0.41	*24.0*	4.52E-07	4.12E-07
4	*11/18/08 14:57*	*5280*	*6.86*	*4.70*	-11.02	*20.3*	4.24E-07	4.21E-07

Average permeability, k_t =	**4.39E-07 cm/s**
Average permeability, $k_{20°C}$ =	**4.13E-07 cm/s**

Prepared by: MSJ Date: 12/3/08

Checked by: [signature] Date: 12/03/08

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WANG ENGINEERING, INC.
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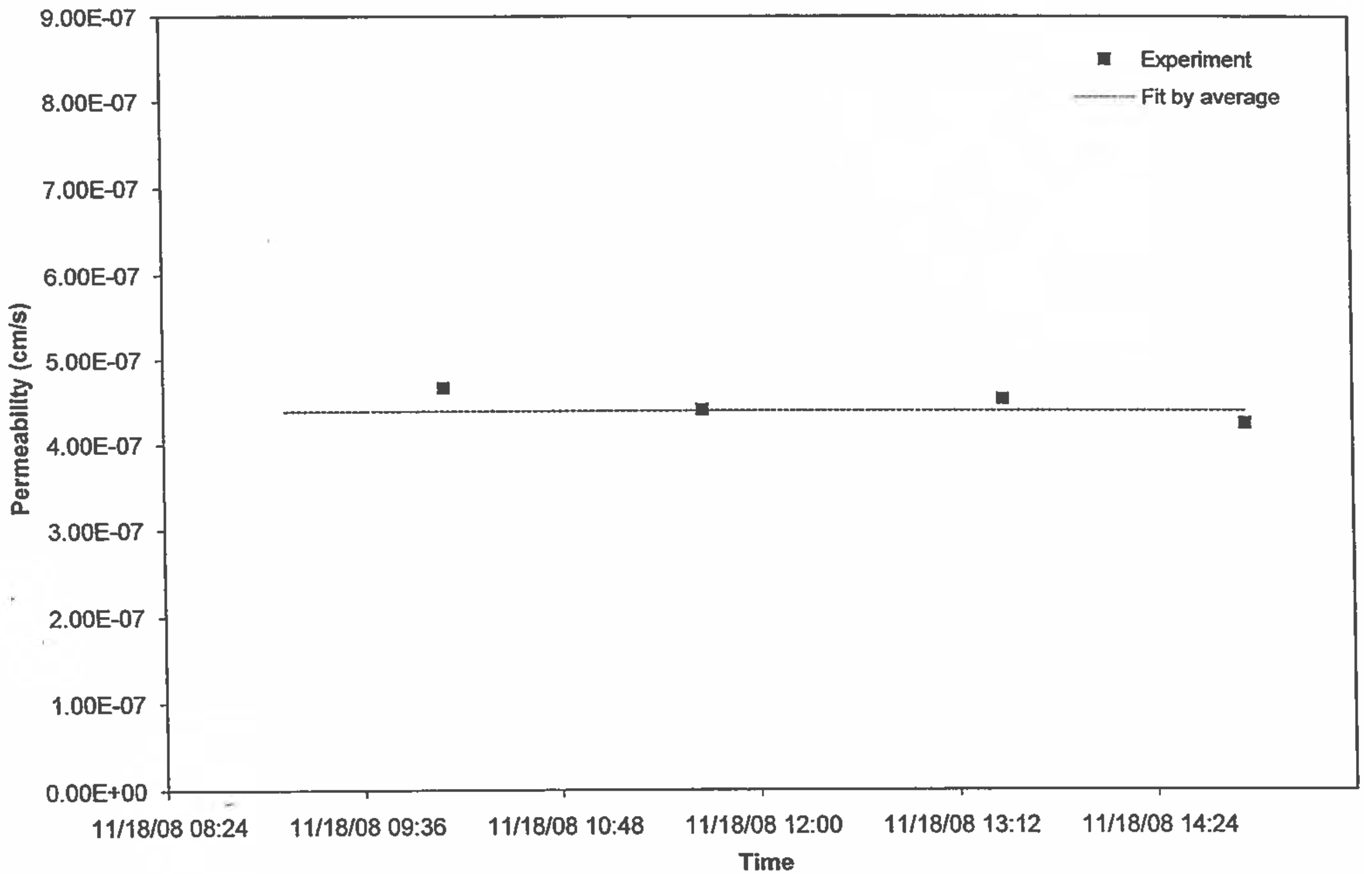
Permeability coefficient vs. time
Agapito Associates, Lafarge Project
Sample LL N2 E105



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Wang Engineering, INC.
1145 N. Main Street, Lombard, IL 60148

AASHTO R18

DENSITY-UNIT WEIGHT- SOIL POROSITY DETERMINATION ASTM WK3158

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: S5 107E
Sample Description: Gray CLAY SHALE

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	**54.7**

Soil Unit Weight	S5 107E
Mass of soil sample (g) M =	20.51
Mass of waxed soil (g) M_p =	20.84
Mass of immersed waxed soil (g) M_i =	10.42
Bulk unit weight (pcf) γ_{total} =	127.4

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: M. S. [signature] Date: 12/3/08
Checked by: [signature] Date: 12/03/08

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WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

AASHTO R18

DENSITY-UNIT WEIGHT-
SOIL POROSITY DETERMINATION
ASTM WK3158

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: LL N15/16 W106
Sample Description: Gray CLAY SHALE

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	**54.7**

Soil Unit Weight	LL N15/16 W106
Mass of soil sample (g) M =	24.91
Mass of waxed soil (g) M_p =	25.25
Mass of immersed waxed soil (g) M_l =	14.01
Bulk unit weight (pcf) γ_{total} =	143.2

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: [signature] Date: 12/8/08
Checked by: [signature] Date: 12/03/08

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WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

AASHTO R18

DENSITY-UNIT WEIGHT-
SOIL POROSITY DETERMINATION
ASTM WK3158

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: LL N2 E105
Sample Description: Gray CLAY SHALE

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	**54.7**

Soil Unit Weight	LL N2 E105
Mass of soil sample (g) M =	11.14
Mass of waxed soil (g) M_p =	11.07
Mass of immersed waxed soil (g) M_l =	6.52
Bulk unit weight (pcf) γ_{total} =	150.1

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: [signature] Date: 12/3/08
Checked by: [signature] Date: 12/03/08

WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

s:\netprojects\1620201\density_2s e112.xls

AASHTO R18

DENSITY-UNIT WEIGHT-
SOIL POROSITY DETERMINATION
ASTM WK3158

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: S6 W125
Sample Description: Brown LEAN CLAY

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	**54.7**

Soil Unit Weight	S6 W125
Mass of soil sample (g) M =	19.85
Mass of waxed soil (g) M_p =	20.30
Mass of immersed waxed soil (g) M_i =	11.23
Bulk unit weight (pcf) γ_{total} =	144.8

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: [signature] Date: 12/3/08

Checked by: [signature] Date: 12/03/08

s:\netprojects\1620201\density_2s e112.xls

WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

DENSITY-UNIT WEIGHT-
SOIL POROSITY DETERMINATION
ASTM WK3158

AASHTO R18

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: 2S E112
Sample Description: Brown SANDY CLAY

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	**54.7**

Soil Unit Weight	2S E112
Mass of soil sample (g) M =	1.79
Mass of waxed soil (g) M_p =	2.05
Mass of immersed waxed soil (g) M_i =	1.10
Bulk unit weight (pcf) γ_{total} =	170.9

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: [signature] Date: 12/1/08
Checked by: [signature] Date: 12/03/08

s:\netprojects\1620201\density_2s e112.xls

WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

AASHTO R18

DENSITY-UNIT WEIGHT-
SOIL POROSITY DETERMINATION
ASTM WK3158

Client: Agapito Associates
Project: LaFarge
WEI Job No: 162-02-01

Analyst name: S. Sugiarto
Test date: 10/28/2008
Sample ID: 15S 110E
Sample Description: Brown LEAN CLAY

Wax Unit Weight

Mass of immersed iron block (g) M_{wi} =	175.9
Mass of wax block (g) M_{wb} =	55.62
Mass of immersed iron and wax blocks (g) M_{wbi} =	168.1
Unit weight of wax (pcf) γ_p =	54.7

Soil Unit Weight	15S 110E
Mass of soil sample (g) M =	12.97
Mass of waxed soil (g) M_p =	13.35
Mass of immersed waxed soil (g) M_i =	6.58
Bulk unit weight (pcf) γ_{total} =	127.7

Water content (%) w =
Specific gravity G_s =
Dry unit weight (pcf) γ_d =
Soil porosity (%) n=

Prepared by: [signature] Date: 12/3/08
Checked by: [signature] Date: 12/3/08

s:\laboratory\labforms\bulkdensity-porosity-waxmethod.xls

WANG ENGINEERING, INC.
1145 N. Main Street, Lombard, IL 60148

APPENDIX C

RESULTS OF LABORATORY PHYSICAL PROPERTY TESTS ON ROCK CORE SAMPLES

Table C-1. Summary of Geotechnical Mechanical Properties Test Results

Hole No.	Test Type	Sample No.	Weight (oz)	Average Diameter (inches)	Length (inches)	Density (pcf)	Failure Load (lbs)	UCS w/Properties: UCS (psi)	UCS w/Properties: Young's Modulus ($\times 10^6$ psi)	UCS w/Properties: Poisson's Ratio	Brazilian Splitting Tensile	Depth (ft)	Formation
DH-01	UCS	DH-01-U-01	38.010	2.500	5.070	164.9	108,070	22,020	8.31	0.24		262.5	Wise Lake
DH-01	UCS	DH-01-U-02	38.010	2.490	5.190	162.4	86,890	17,840	6.97	0.18		300.1	Dunleith
DH-01	UCS	DH-01-U-03	37.600	2.495	5.230	158.8	69,535	14,220	6.62	0.26		337.0	Dunleith
DH-01	UCS	DH-01-U-04	39.610	2.490	5.350	164.2	86,870	17,840	7.47	0.27		318.0	Dunleith
DH-01	UCS	DH-01-U-05	40.200	2.495	5.300	167.5	73,670	15,070	8.01	0.32		370.1	Dunleith
DH-01	UCS	DH-01-U-06	39.600	2.490	5.340	164.5	70,590	14,500	6.71	0.24		379.2	Dunleith
DH-01	UCS	DH-01-U-07	37.680	2.490	5.100	163.9	68,350	14,040	7.22	0.30		395.6	Platteville
DH-01	Brazilian	DH-01-B-01	7.380	2.490	1.100	148.8	5,115				1,050		
DH-01	Brazilian	DH-01-B-02	7.820	2.485	1.170	148.8	2,720				560		
DH-01	Brazilian	DH-01-B-03	8.180	2.495	1.220	148.1	3,685				750		
DH-01	Brazilian	DH-01-B-04	8.330	2.490	1.220	151.4	4,425				910		
DH-01	Brazilian	DH-01-B-05	8.640	2.495	1.210	157.7	6,330				1,290		
DH-01	Brazilian	DH-01-B-06	9.430	2.495	1.360	153.2	6,770				1,380		
DH-01	Brazilian	DH-01-B-07	7.500	2.485	1.180	141.5	2,640				540		
Mean Values for Dunleith								**15,894**	**7.16**	**0.25**	**978**		

APPENDIX D

SLUDGE SETTLED SOLIDS HYDRAULIC CONDUCTIVITY TESTING AND GRAIN SIZE ANALYSIS

First Environmental Laboratories, Inc. IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

June 08, 2009

Ms. Carrie Carter
DEUCHLER ENVIRONMENTAL
230 Woodlawn Ave.
Aurora, IL 60506

Project ID: 07002-02 Lime Sludge
First Environmental File ID: 9-1796
Date Received: May 08, 2009

Dear Ms. Carrie Carter:

The above referenced project was analyzed as directed on the enclosed chain of custody record.

All Quality Control criteria as outlined in the methods and current IL ELAP/NELAP have been met unless otherwise noted. QA/QC documentation and raw data will remain on file for future reference. Our accreditation number is 100292 and our current certificate is number 002205: effective 02/06/09 through 02/28/10.

I thank you for the opportunity to be of service to you and look forward to working with you again in the future. Should you have any questions regarding any of the enclosed analytical data or need additional information, please contact me at (630) 778-1200 or stan@firstenv.com.

Sincerely,

Stan Zaworski
Project Manager

First Environmental Laboratories, Inc.

IL ELAP / NELAC Accreditation # 100292

1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Case Narrative

DEUCHLER ENVIRONMENTAL

Project ID: **07002-02 Lime Sludge**

First Environmental File ID: **9-1796**

Date Received: **May 08, 2009**

Flag	Description	Flag	Description
<	Analyte not detected at or above the reporting limit.	L+	LCS recovery outside control limits; high bias.
B	Analyte detected in associated method blank.	L-	LCS recovery outside control limits; low bias.
C	Identification confirmed by GC/MS.	M	MS recovery outside control limits; LCS acceptable
D	Surrogates diluted out; recovery not available.	M+	MS recovery outside control limits high bias; LCS acceptable.
E	Estimated result; concentration exceeds calibration range.	M-	MS recovery outside control limits low bias; LCS acceptable.
F	Field measurement.	N	Analyte is not part of our NELAC accreditation.
		ND	Analyte was not detected using a library search routine; No calibration standard was analyzed.
G	Surrogate recovery outside control limits; matrix effect.	P	Chemical preservation pH adjusted in lab.
H	Analysis or extraction holding time exceeded.	Q	The analyte was determined by a GC/MS database search.
J	Estimated result; concentration is less than calib range.	S	Analyte was sub-contracted to another laboratory for analysis.
K	RPD outside control limits.	T	Sample temperature upon receipt exceeded 0-6°C
RL	Routine Reporting Limit (Lowest amount that can be detected when routine weights/volumes are used without dilution.)	W	Reporting limit elevated due to sample matrix.

All quality control criteria, as outlined in the methods, have been met except as noted below or on the following analytical report.

Sample Batch Comments:

Sample acceptance criteria were met.

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Analytical Report

Client: DEUCHLER ENVIRONMENTAL
Project ID: 07002-02 Lime Sludge
Sample ID: K-2
Sample No: 9-1796-001

Date Collected: 05/08/09
Time Collected: 11:10
Date Received: 05/08/09
Date Reported: 06/08/09

Results are reported on a dry weight basis.

Analyte		Result	R.L.	Units	Flags
Solids, total	**Method: 2540B**				
Analysis Date: 05/11/09					
Total Solids		29.53		%	
Hydraulic Conductivity	**Method: ASTM D-5084**				
Analysis Date: 06/05/09					
Hydraulic Conductivity		Attached			N S
Grain Size (seive)	**Method: ASTM D-422**				
Analysis Date: 06/05/09					
Grain Size (Seive)		Attached			N S
Density	**Method: 2710F**				
Analysis Date: 05/14/09					
Density		1.24	1.00	g/cc	N
pH @ 25°C, 1:10	**Method: 4500H+B**				
Analysis Date: 05/11/09 13:10					
pH @ 25°C, 1:10		10.12		Units	

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Analytical Report

Client: DEUCHLER ENVIRONMENTAL
Project ID: 07002-02 Lime Sludge
Sample ID: K-1
Sample No: 9-1796-002

Date Collected: 05/08/09
Time Collected: 11:25
Date Received: 05/08/09
Date Reported: 06/08/09

Results are reported on a dry weight basis

Analyte		Result	R.L.	Units	Flags
Solids, total	**Method: 2540B**				
Analysis Date: 05/11/09					
Total Solids		23.84		%	
Hydraulic Conductivity	**Method: ASTM D-5084**				
Analysis Date: 06/05/09					
Hydraulic Conductivity		Attached			N S
Grain Size (seive)	**Method: ASTM D-422**				
Analysis Date: 06/05/09					
Grain Size (Seive)		Attached			N S
Density	**Method: 2710F**				
Analysis Date: 05/14/09					
Density		1.16	1.00	g/cc	N
pH @ 25°C, 1:10	**Method: 4500H+B**				
Analysis Date: 05/11/09 13:10					
pH @ 25°C, 1:10		10.28		Units	

First Environmental Laboratories, Inc. IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Analytical Report

Client: DEUCHLER ENVIRONMENTAL
Project ID: 07002-02 Lime Sludge
Sample ID: S-1/S-2
Sample No: 9-1796-003

Date Collected: 05/08/09
Time Collected: 14:00
Date Received: 05/08/09
Date Reported: 06/08/09

Results are reported on a dry weight basis.

Analyte		Result	R.L.	Units	Flags
Solids, total	**Method: 2540B**				
Analysis Date: 05/11/09					
Total Solids		32.24		%	
Grain Size (seive)	**Method: ASTM D-422**				
Analysis Date: 06/05/09					
Grain Size (Seive)		Attached			N S
Density	**Method: 2710F**				
Analysis Date: 05/14/09					
Density		1.21	1.00	g/cc	N
pH @ 25°C, 1:10	**Method: 4500H+B**				
Analysis Date: 05/11/09 13:10					
pH @ 25°C, 1:10		9.66		Units	

First Environmental Laboratories, Inc.

First Environmental Laboratories
1600 Shore Road, Suite D
Naperville, Illinois 60563
Phone: (630) 778-1200 • Fax: (630) 778-1233
E-mail: firstinfo@firstenv.com
IEPA Certification #100292

CHAIN OF CUSTODY RECORD

Page____ of ____ pgs

Company Name: Deuchler Environmental
Street Address: 230 WOODLAWN AVE
City: AURORA State: IL Zip: 60506
Phone: 630-897-8380 Fax: 630-897-5696 e-mail: mfisher@deuchler.com
Send Report To: MARC FISHER Via: Fax ☐ e-mail ☑
Sampled By: MRF/PFM

Project I.D.: 07002-02
P.O. #: LIME SLUDGE

Matrix Codes: S = Soil W = Water O = Other

Date/Time Taken	Sample Description	Matrix	Hydraulic Conductivity	Grain size Distribution	% Solids	pH	Density				Comments	Lab I.D.
1110	K-2	S	✓	✓	✓	✓	✓					9-1796-001
1125	K-1	S	✓	✓	✓	✓	✓					002
1400	S-1 } 33	S		✓	✓	✓	✓					003
	S-2											

FOR LAB USE ONLY:

Cooler Temperature: 0.1-6ºC Yes__ No.__ N/A ºC
Received within 6 hrs. of collection:______
Ice Present: Yes__ No__

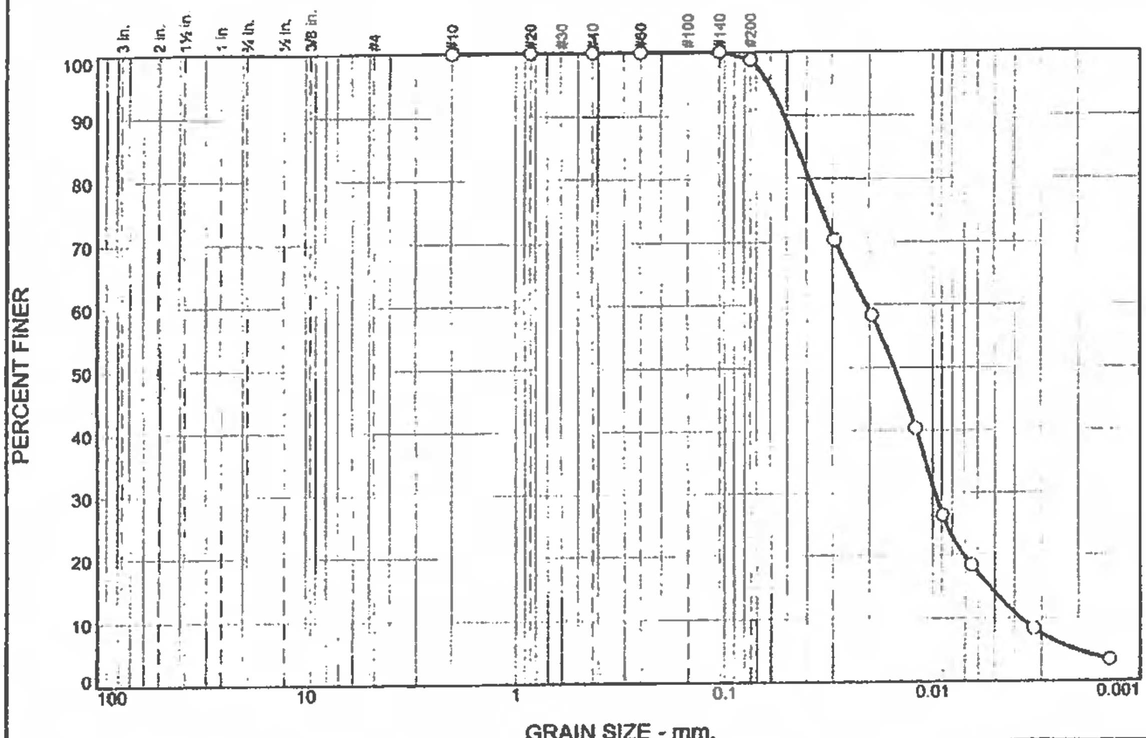
Sample Refrigerated: Yes__ No__
Refrigerator Temperature:______ºC
5035 Vials Frozen: Yes__ No__
Freezer Temperature:______ºC

Containers Received Preserved: ☐ Yes ☐ No
Need to meet: IL. TACO ☐ IN. RISC ☐

Notes and Special Instructions: FOR SAMPLES K-1 ; K-2 run analyses other than Hydraulic Conductivity only if sufficient sample is present ; PRIORITY BEING ① HYD. COND ② GRAIN SIZE ③ DENSITY ④ pH ⑤ % SOLIDS

Relinquished By: [signature] Date/Time 5/8/09 1450 Received By: [signature] Date/Time 5/8/09 1450
Relinquished By: ______ Date/Time ______ Received By: ______ Date/Time ______
Rev. 9/08

Grain Size Distribution Report



% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
0.0	0.0	0.0	0.0	0.0	1.2	93.9	4.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	100.0		
#140	100.0		
#200	98.8		

* (no specification provided)

Material Description

Dark Gray K-2

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0515 D_{85}= 0.0444 D_{60}= 0.0207
D_{50}= 0.0152 D_{30}= 0.0097 D_{15}= 0.0053
D_{10}= 0.0038 C_u= 5.50 C_c= 1.22

Classification

USCS= AASHTO=

Remarks

Lab # 9-1796-001

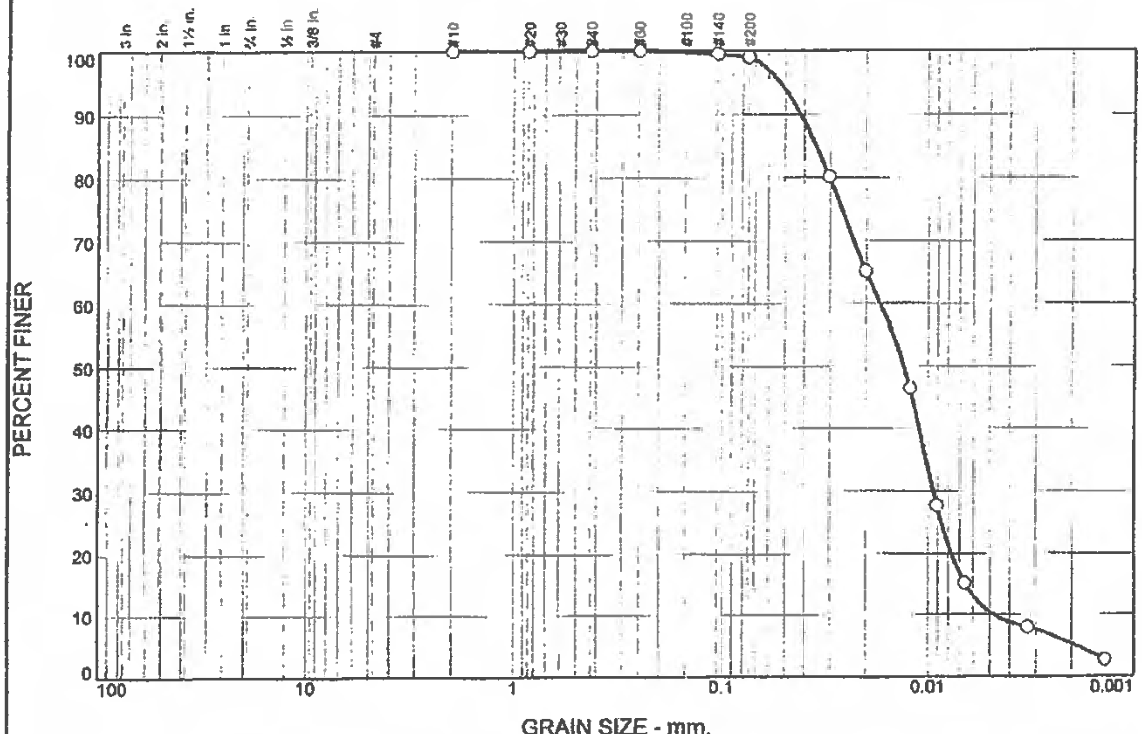
Location: Lab # 9-1796-001

Date: 6-5-09

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS
www.whitneyassociates.com

Client: First Environmental Laboratories
Project: FIRST ENVIRONMENTAL LABORATORIES
Naperville, Illinois
Project No: **Figure** GS-1

Grain Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	1.0	88.6	10.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	100.0		
#140	99.5		
#200	99.0		

* (no specification provided)

Material Description

Dark Gray K-1

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0420 D_{85}= 0.0351 D_{60}= 0.0171
D_{50}= 0.0131 D_{30}= 0.0094 D_{15}= 0.0066
D_{10}= 0.0048 C_u= 3.55 C_c= 1.09

Classification

USCS= AASHTO=

Remarks

Lab # 9-1796-002

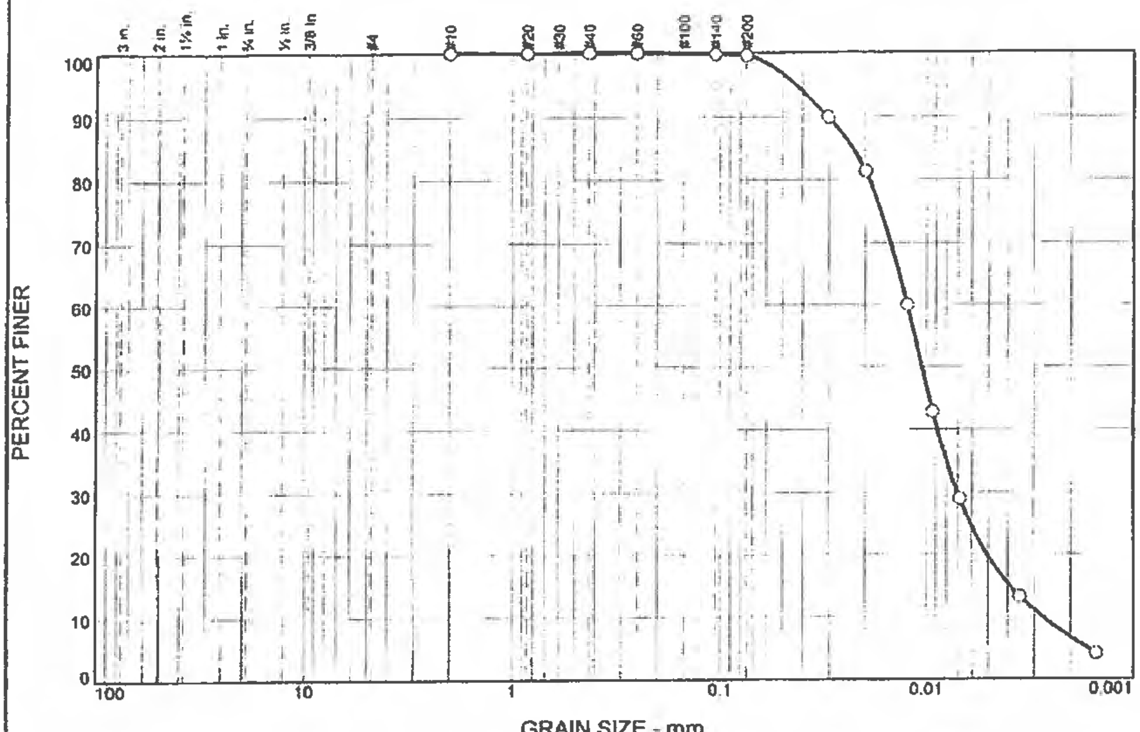
Location: Lab # 9-1796-002

Date: 6-5-09

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS
www.whitneyassociates.com

Client: First Environmental Laboratories
Project: FIRST ENVIRONMENTAL LABORATORIES
Naperville, Illinois
Project No: **Figure** GS-2

Grain Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.4	79.9	19.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	100.0		
#140	99.8		
#200	99.6		

* (no specification provided)

Material Description

Gray S-2

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0305 D_{85}= 0.0228 D_{60}= 0.0124
D_{50}= 0.0105 D_{30}= 0.0071 D_{15}= 0.0039
D_{10}= 0.0027 C_u= 4.56 C_c= 1.47

Classification

USCS= AASHTO=

Remarks

Lab # 9-1796-003

Location: Lab # 9-1796-003

Date: 6-5-09

WHITNEY & ASSOCIATES PEORIA, ILLINOIS www.whitneyassociates.com	**Client:** First Environmental Laboratories **Project:** FIRST ENVIRONMENTAL LABORATORIES Naperville, Illinois **Project No:** **Figure** GS-3

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 7.62
Specimen Diameter (cm): 4.45
Dry Unit Weight (pcf): 24.9
Moisture Before Test (%): 229.3
Moisture After Test (%): 135.2
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 4.0
Test Pressure (psi): 2.0
Back Pressure (psi): 0.0
Diff. Head (psi): 2.0
Flow Rate (cc/sec): 3.29 x 10^-3
Perm. (cm/sec): 1.10 x 10^-5

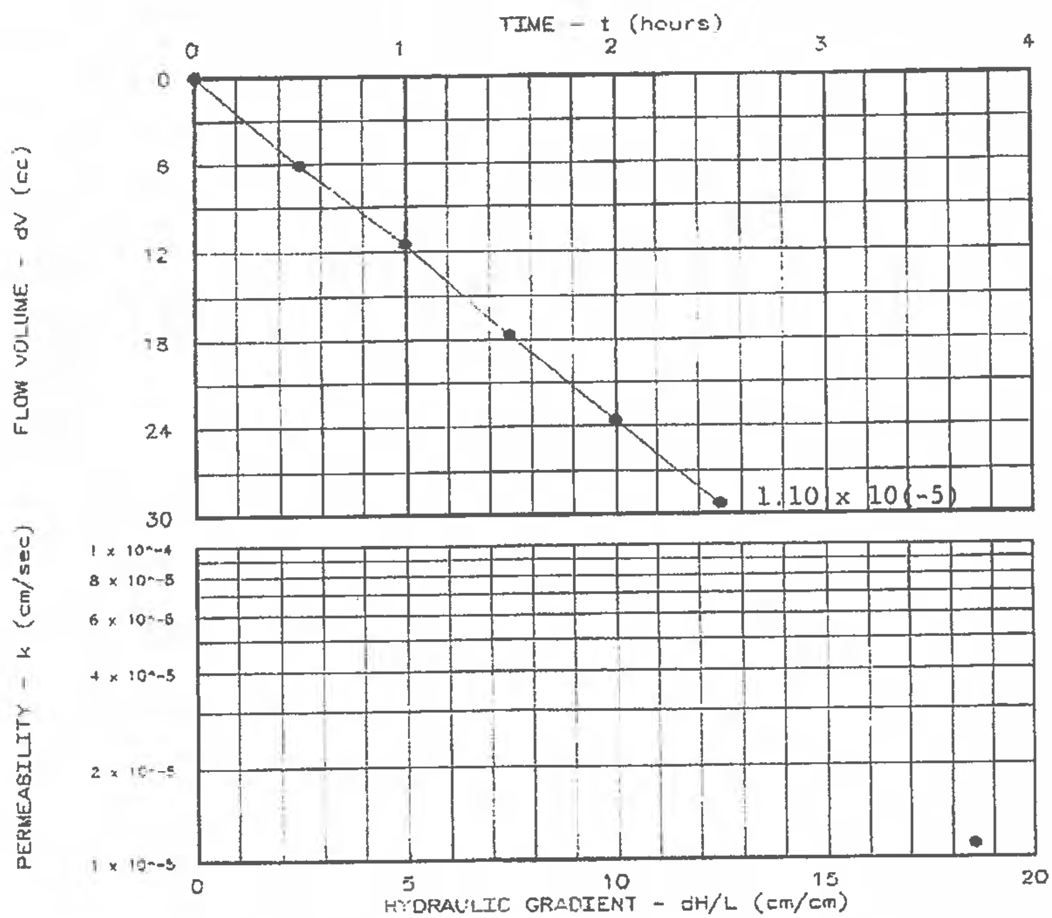
SAMPLE DATA:

Sample Identification. 9-1786-001

Visual Description: Dark Gray, K-2

Remarks: ASTM D-5084 & IEPA Test Procedures
Maximum Dry Density (pcf): -
Optimum Moisture Content (%): -

Percent Composition:
Permeometer type: B-K Fle wall
Sample type: 1.5" Remold



Project: FIRST ENVIRONMENTAL LABORATORIES
Location: Naperville, Illinois
Date: 6-5-09

Project No.: FEL-1
File No.: 1173
Lab No.: 4
Tested by: JRK
Checked by: JRK
Test: CH – Constant head

PERMEABILITY TEST REPORT
WHITNEY & ASSOCIATES

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 7.62
Specimen Diameter (cm): 4.32
Dry Unit Weight (pcf): 25.8
Moisture Before Test (%): 233.2
Moisture After Test (%): 139.6
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 4.0
Test Pressure (psi): 2.0
Back Pressure (psi): 0.0
Diff. Head (psi): 2.0
Flow Rate (cc/sec): 2.49 x 10^-3
Perm. (cm/sec): 8.79 x 10^-6

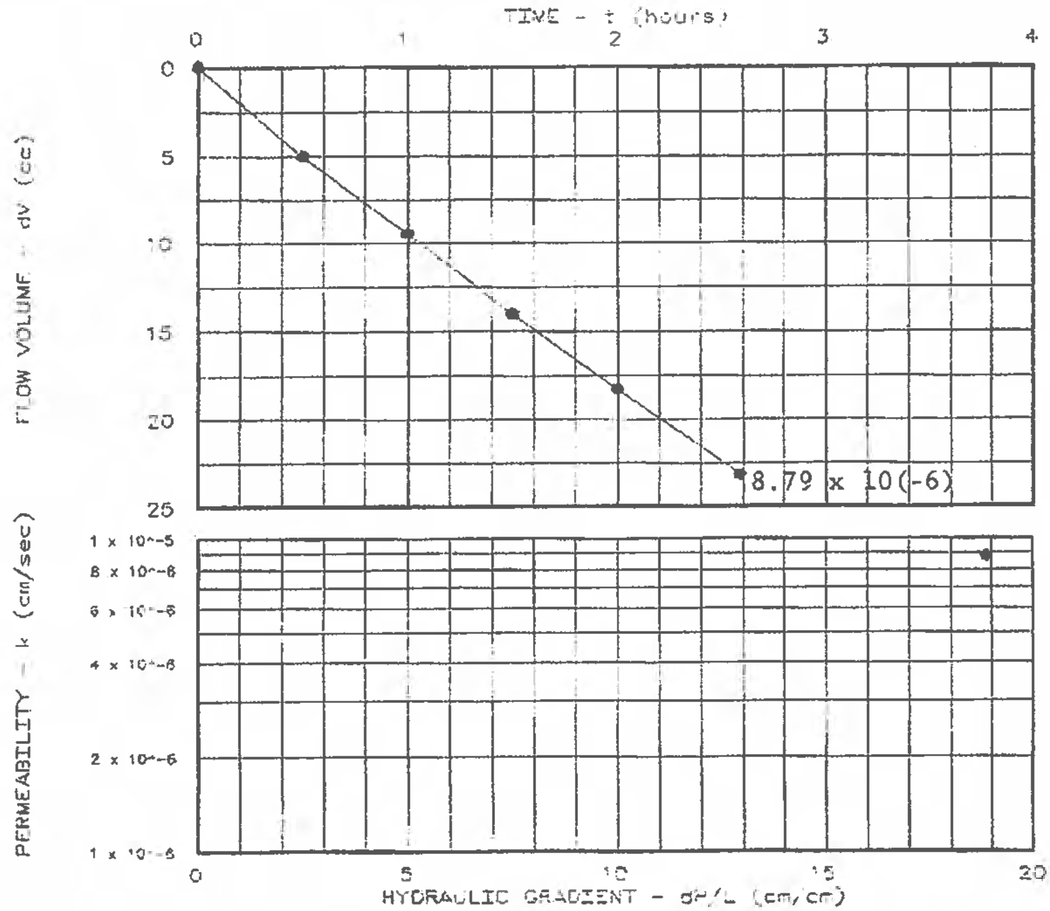
SAMPLE DATA:

Sample Identification: 9-1796-002

Visual Description: Dark Gray [illegible] #-1

Remarks: ASTM D-5084 & IEPA Test Procedures
Maximum Dry Density (pcf): -
Optimum Moisture Content (%): -

Percent Compaction:
Permeameter type: B-K Flexwall
Sample type: 1.8" Remold

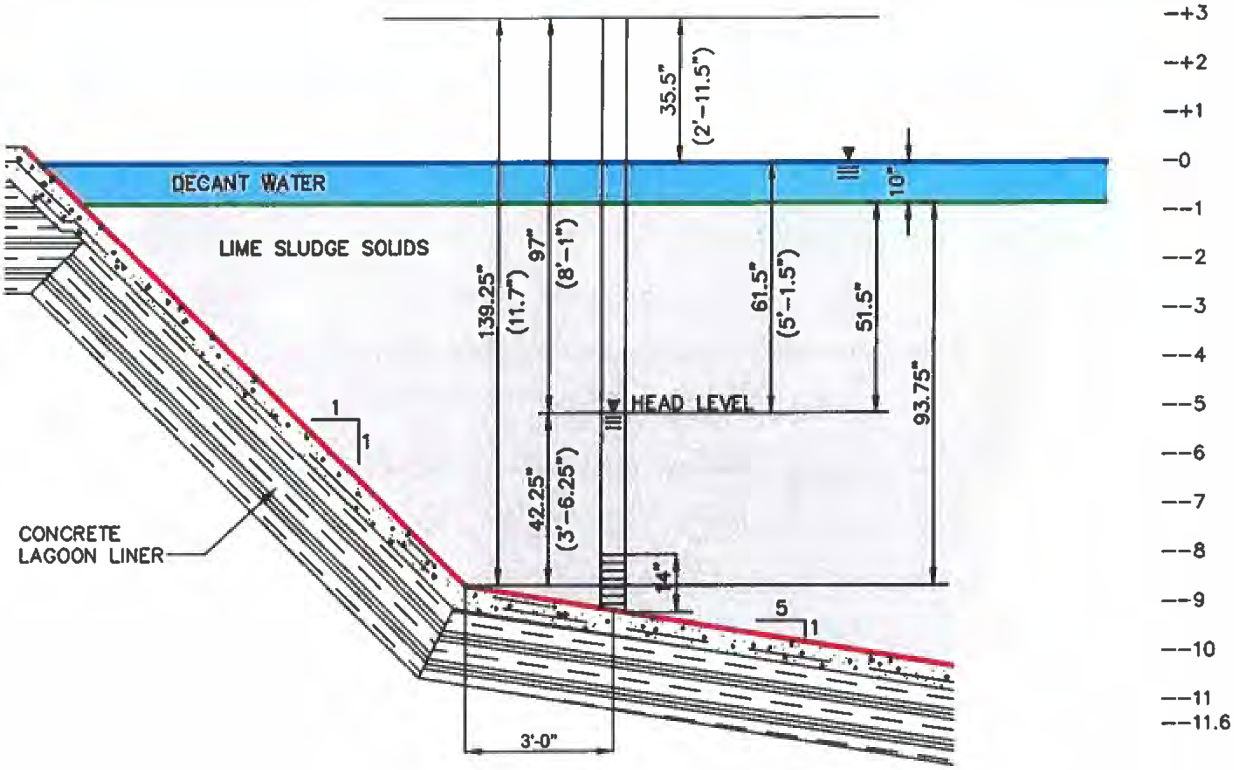


Project: FIRST ENVIRONMENTAL LABORATORIES
Location: Naperville, Illinois
Date: 6-5-09

PERMEABILITY TEST REPORT

WHITNEY & ASSOCIATES

Project No.: FEL-2
File No.: 1174
Lab No.: 5
Tested by: JRK
Checked by: JRK
Test: CH - Constant head



F:\DEI\08030-02\LAGOON 2

DEUCHLER ENVIRONMENTAL, INC.
Consulting Engineers – Aurora, Illinois ©

SHEET	1
OF	1

REVISIONS

DESIGNED MRF	APPROVED MRF	BOOK XXX	JOB NUMBER
DRAWN JES	DATE 11/2/12	SCALE 1"=40'	160/08030-02

LIME SLUDGE DEPOSITION AND HEAD MEASUREMENTS

Appendix B

APPENDIX B:

GZA Report

JOB COMPLETION REPORT
DEEP CORE BORING AND
MONITORING WELL INSTALLATION

CITY OF AURORA
ROUTE 25 REPOSITORY SITE
AURORA, ILLINOIS

PREPARED FOR:

City of Aurora
c/o Deuchler Environmental, Inc.
230 South Woodlawn Avenue
Aurora, Illinois 60506

PREPARED BY:

GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

December 10, 2008
GZA File No. 20.0152025.00

GZA
GeoEnvironmental, Inc.

Engineers and Scientists

December 10, 2008
File No. 20.0152025.00

City of Aurora
c/o Deuchler Environmental, Inc.
230 South Woodlawn Avenue
Aurora, Illinois 60506

20900 Swenson Drive
Suite 150
Waukesha
Wisconsin
53186
262-754-2560
FAX 262-754-9711
www.gza.com

Attention: Mr. Marc R. Fisher

Re: Job Completion Report
Deep Core Boring and Monitoring Well Installation
City of Aurora
Route 25 Repository Site
Aurora, Illinois

Dear Mr. Fisher:

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide this Job Completion Report to Deuchler Environmental, Inc. (Deuchler), on behalf of the City of Aurora, for the deep core boring and monitoring well installation project at the Route 25 Repository Site located in Aurora, Illinois ("Site"). This report summarizes our observations collected during the field activities and testing and presents the results of that testing. Please note that this report is subject to the Limitations provided in Appendix A.

Should you have any questions regarding this report, please feel free to contact the undersigned at (262) 754-2560.

Very truly yours,

GZA GeoEnvironmental, Inc.

Erick J. Staley
Project Manager

Mark J. Krumenacher, P.G.
Principal

J:\152000to152099\152025 Aurora\AURORA REPORT\Job Completion Report.doc

Attachments

JOB COMPLETION REPORT
DEEP CORE BORING AND MONITORING WELL INSTALLATION
CITY OF AURORA
ROUTE 25 REPOSITORY SITE
AURORA, ILLINOIS

TABLE OF CONTENTS

JOB COMPLETION REPORT
DEEP CORE BORING AND MONITORING WELL INSTALLATION
CITY OF AURORA
ROUTE 25 REPOSITORY SITE
AURORA, ILLINOIS

TABLE OF CONTENTS

1.0 INTRODUCTION

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide this Job Completion Report to Deuchler Environmental, Inc. (Deuchler), on behalf of the City of Aurora ("City"/"Client"), for the deep core boring and monitoring well installation project at the Route 25 Repository Site located in Aurora, Illinois ("Site"). The work described was performed at the Site from July to October 2008, in general accordance with the Contract Documents provided by the City dated April 2008. This report summarizes our observations collected during the field activities and testing and presents the results of that testing. Please note that this report is subject to the Limitations provided in Appendix A.

2.0 OBJECTIVE

GZA prepared this report to summarize rock core drilling and installation of a deep monitoring well in the Silurian and Ordovician bedrock at the Site. The work included aquifer testing of the Ordovician Galena-Platteville bedrock units. The Site is located southeast of the intersection between Illinois Route 25 and Mettel Road in Aurora, Illinois, as shown on Figure 1. The Site consists of an inactive surface quarry in Silurian bedrock underlain by active underground mining operations in Ordovician bedrock. The Site plan on Figure 2 shows the monitoring well location with respect to surrounding physical features.

3.0 SCOPE OF WORK

To accomplish the above stated objective, Raimonde Drilling Corporation (Raimonde) and their subcontractors provided personnel and equipment to advance one deep borehole at the Site, collect data related to physical and hydrogeological characteristics of the underlying bedrock units and install a monitoring well within the borehole screened in the St. Peter Sandstone aquifer. In accordance with the Contract Documents provided by the City for the project, the work included the tasks described in the following sections.

3.1 ROCK CORE DRILLING

Raimonde provided drilling services to complete one rock core boring (boring DH-01) to a depth of approximately 545.7 feet below ground surface (bgs) to characterize the subsurface materials underlying the Site. GZA was on-Site full-time during rock core drilling to observe drilling activities and provide geological services. GZA documented drilling activities on daily field reports, copies of which are included in Appendix B. Continuous core samples were collected and were described in the field, as summarized on the boring log included in Appendix C. GZA also measured water levels in the corehole each day during rock coring. Measurements were completed using a Heron dipper-T water level meter.

To correlate the retrieved rock core to established regional geologic units, GZA reviewed readily available geologic literature and discussed the geology with regional experts, including discussions in the field with Dr. Don Mikulic of the Illinois State Geological Survey on July 17, 2008. Dr. Mikulic is a regional expert in Silurian stratigraphy and the underlying Ordovician Maquoketa Group.

Drilling methods used to complete the corehole included using several steel casings and coring techniques to varying depths, including the following:

- Initial drilling was completed through the soil overburden and the uppermost Silurian bedrock using an 8-inch diameter tricone bit to a depth of approximately 19 feet bgs, followed by installation of a 6-inch outside diameter (OD) steel casing advanced through the borehole. This casing was used to protect the boring from excessive sloughing of loose soil overlying the bedrock at the Site.

- PQ core casing (4.8-inch OD) was advanced to a depth of 48 feet bgs, or approximately 10 feet below the lowest elevation of the Fox River located west of the Site.

- HQ wire-line core drilling (3.8-inch hole diameter, 2.5-inch core sample diameter) was completed to a depth of approximately 518 feet bgs. HQ coring was used to collect core for bedrock identification and characterization, and the corehole was used for in situ permeability testing of the Galena-Platteville Groups.

- NQ wire-line core drilling (3-inch hole diameter, 2-inch core sample diameter) was completed to a depth of approximately 545.7 feet bgs, which terminated in the Ancell Group underlying the Platteville Group.

Rock cores were placed in wooden boxes oriented such that the uppermost core for each box is located in the upper left corner of the box (as viewed when opening the lid away from the viewer). The boxes were sequentially numbered and labeled outside and inside the lid of each box. Detailed core data on the inside lid of each box include core run numbers, coring depths, percent recovery and rock-quality designation (RQD) for each core run, as well as project-related information and the date of drilling.

GZA transported the core boxes to Deuchler's storage facility on a daily basis. After completion of the borehole, GZA reviewed the core for documentation purposes and reorganized the core boxes onto pallets for efficient storage in Deuchler's facility.

3.2 WATER PRESSURE TESTING

Water pressure testing was completed in the HQ borehole at intervals while drilling through the Ordovician Galena-Platteville bedrock units. Sixteen water pressure tests (packer tests) were performed at 20-foot intervals from 208 to 508 feet bgs and in the 10-foot interval from 508 to 518 feet bgs using a sliding-head inflatable packer assembly suspended by the wireline for the core system. A schematic diagram of the inflatable packer assembly is included as Figure 3.

For each water pressure test interval, the rock was first cored using the HQ wire-line system. After coring through the rock, the HQ casing was raised from the bottom of the borehole to expose the desired cored interval for water pressure testing (for example, after coring from 208 to 228 feet, the casing was pulled upward to expose 20 feet of cored rock in the borehole, plus 2 feet to accommodate the lower packer). The packer assembly was then lowered down the HQ casing to rest on the drill bit at the lower terminus of the casing.

The packer assembly has two inflatable packers. The lower packer protrudes with the assembly center tube below the HQ casing and inflates to seal off the top of the exposed rock interval. The upper packer inflates within the HQ casing, sealing off the casing. The upper terminus of the HQ casing is sealed with a threaded steel lid and rubber gasket. The lid has sealed ports for the steel cable that suspends the packer assembly, the air line that fills the packers, and a high-pressure water hose. During a test, the HQ casing is filled with pressurized water, which then enters the test zone through the center tube of the packer assembly.

Each test was performed for approximately 5 to 20 minutes. Water pressures were applied using the high-pressure water hose in increments of approximately 10 pounds per square inch (psi), ranging from 20 to 40 psi at the shallowest depths and from 40 to 60 psi at the deepest depths. Because the casing and borehole are sealed using this system, it was not possible to directly measure water level or pressure head in the test zone during testing.

The water pressure test data are provided on Packer Testing Data Sheets and a Packer Testing Summary table included in Appendix D. Water pressure test results are discussed in the Bedrock Hydrogeology section of this report.

3.3 BOREHOLE GEOPHYSICAL TESTING

GZA reviewed the borehole geophysical data and report provided to Raimonde by Hager-Richter Geoscience, Inc. (HRG). The data were collected from the borehole using down-hole geophysical techniques, including measurements of borehole diameter using an acoustic caliper; borehole structure using an acoustic televiewer (ATV); natural gamma ray; spontaneous potential; electrical resistivity and single-point resistance; and borehole verticality using inclination survey. The focus of our review was on parameters to assist in our interpretation of the hydrogeologic characteristics of the subsurface. The geophysical data and report provided by HRG are included in Appendix E.

3.4 MONITORING WELL INSTALLATION

Groundwater monitoring well MW-1 was constructed in the borehole for DH-01 from August to October 2008. Albrecht Well Drilling, Inc. (Albrecht) of Ohio, Illinois provided well construction and development services. Albrecht over-drilled the borehole to 10 inches in diameter and to a depth of approximately 606 feet bgs to set the well screen within the St. Peter Sandstone aquifer. Raimonde was on-Site part-time during Albrecht's activities. GZA was on-Site full-time to observe and document well construction and development after Albrecht finished over-drilling the borehole. GZA also measured water levels daily prior to installation and development activities. Measurements were completed inside and outside of the well using a Heron dipper-T water level meter and a Solinst Model 101 water level meter provided by Deuchler. The Solinst instrument had a 650-foot tape to read water levels deeper than the reach of the Heron instrument. Copies of GZA's daily field reports are included in Appendix B. Details of the well installation are summarized on the Groundwater Monitoring Well Installation Log included in Appendix F.

3.4.1 Well Construction

Albrecht installed the well screen, well casing and most of the annular materials from September 29 to October 8, 2008. Albrecht placed the well screen and casing to depth on September 29, 2008. The well screen and casing consist of 4-inch inside diameter (ID), Schedule 80 polyvinyl chloride (PVC) pipe in 10-foot segments with flush-threaded ends and nitrile rubber o-rings. The screen is 20 feet long and was machine-slotted at 0.010-inch slot size by the manufacturer. A threaded end cap was installed at the base of the screen. Stainless steel centralizers designed for the 4-inch PVC pipe were attached to the screen and casing at approximately the following depths (from bottom up): 604, 594, 584, 554, 534, 504 and in 30-foot increments up to 24 feet bgs. The centralizers are attached to span across the couplings between the pipe segments. The well pipe was lowered in the borehole until the bottom encountered resistance at approximately 602 to 603 feet bgs. Subsequent measurement of the casing depth using a Solinst 650-foot water level meter indicates that the bottom of the well is at 604.5 feet bgs. The difference between the depth measurements could be from small variations in the pipe lengths and joints of the well segments.

Albrecht placed the annular materials using tremie pipe on September 30 and October 1, 2008. The tremie pipe consisted of threaded, 1¼-inch diameter PVC in 20-foot segments with steel couplers. This pipe also served as a sounding rod for determining the depth of materials in the annulus. Materials were placed into the tremie through a hopper at the top and a stream of water was used to transport the materials down the tremie pipe. The water was supplied through a side port in the hopper from a tanker truck that Albrecht filled from a City water hydrant. Annular materials were placed in lifts and the tremie pipe was used to check material height in the annulus at intervals during construction.

Annular materials placed using the hopper include (from bottom up): filter sand around the screen consisting of silica sand sized between #10 and #20 sieves; fine silica sand above the filter sand to protect the filter sand from the overlying bentonite; coated bentonite tablets (3/8-inch diameter size) above the fine sand as an annular seal; and high-solids bentonite grout to form a seal in the remaining annulus. Using the tremie pipe, we measured the layer thicknesses of each material, as summarized in the table below, which also compares the theoretical versus the actual amount of materials placed. These data are also shown on the well installation log included in Appendix F.

Annular Materials Summary

Annular Material	Depth Range[1]	Layer Thickness	Theoretical Amount	Actual Amount	Percent Difference
Filter Sand	603 to 575.5	27.5 feet	89 gallons	82 gallons	9%
Fine Sand	575.5 to 574	2 feet	6.6 gallons	6.5 gallons	1%
Bentonite Tablets	574 to 570	4 feet	138 pounds[2]	100 pounds[2]	28%
Grout	570 to surface	570 feet	1855 gallons	1875 gallons	1%

Notes:
1. The depth ranges are based on depths measured using the tremie pipe as a probe rod.
2. The bentonite tablet theoretical amount is based on manufacturer's recommendations (79.4 pounds per cubic foot).

The most significant difference between theoretical and actual quantities placed is the 28 percent (%) difference for bentonite tablets (annular seal). Albrecht did not initially have sufficient coated tablets to place all of the annular seal at once. Albrecht placed approximately half of the tablets on September 30, 2008, then returned on October 1, 2008, to place the remaining portion of the annular seal. The first layer of bentonite tablets would have hydrated and expanded overnight. The resulting measurement of the full layer thickness would have been impacted by swelling of the first layer during hydration.

While preparing to place grout on October 2, 2008, Albrecht pumped water into the annulus to test the pump system for grout placement. Soon after, water began to rise in the well and eventually poured out the top. This caused concern for the integrity of the well casing. Albrecht checked the diameter of the pipe by advancing a 3.25-inch diameter plug attached to a 1¼-inch PVC pipe down to the bottom of the well. After running down and back up the well, it was determined there was no sign of significant constrictions in the casing. To check for possible leaks or holes in the well segments, the inside of the well was inspected on October 3, 2008, using a down-hole camera by Municipal Well and Pump of Waupun, Wisconsin. Based on the video collected by the camera, no significant defects in the pipe were observed.

After checking the casing with the camera, Albrecht, placed high-solids bentonite grout in the annulus on October 3 and 6, 2008, which was greater than 24 hours after placement of the bentonite tablets. The grout was injected into the annulus using the tremie pipe and the pump from the drill rig. Albrecht used a mixing tank to mix approximately 75-gallon batches of grout and then tremie pumped the grout into the annulus. Grout was placed for most of the annulus using at least a 10-foot head of grout over the outlet of the tremie pipe, based on conservative estimates for theoretical volume. Albrecht placed 25 tanks of grout in the annulus before grout was observed at the ground surface. Albrecht filled the well with water from the tank truck prior to finishing on October 6, 2008, because of concern for the pipe integrity against the pressures of the grout outside the well casing. The theoretical versus actual volumes of grout are shown in the Annular Materials Summary table above.

On October 7, 2008, Albrecht placed a 3-inch diameter Grundfos submersible pump into the well attached to a threaded, 1-inch diameter, schedule 80 PVC discharge pipe. The pipe was connected in 20-foot segments using PVC couplers and Teflon® thread tape. The electrical cable for the pump was attached to the PVC pipe at approximately 10-foot intervals using plastic zip ties. Electrical tape was used near where the cables attached to the pump.

3.4.2 Well Development

Albrecht began pumping from the well on October 7, 2008. The water pumped on October 7, 2008, consisted of water that was placed by Albrecht into the well on October 6, 2008. The pump was initially set at a depth of 440 feet bgs. A shut-off valve and narrow PVC pipe were attached to the top of the pump outlet at the surface to control water flow and divert water away from the well head. The pumped water was allowed to flow on the ground and drain into the nearby pond south of the well location. Flow was estimated using a 5-gallon bucket with marked 1-gallon increments. The pump initially discharged at approximately 5.5 to 6 gallons per minute (gpm), gradually decreased to approximately 3.5 gpm, at which point the pump was dry. Water measurement using a Solinst water level meter indicated a water level at 439 feet bgs in the well.

After approximately 15 minutes, another water measurement indicated a water level of 440 feet bgs in the well, indicating that the well was not recharging. The pump was then lowered to 480 feet bgs and pumping resumed. Initial pump production was approximately 3 gpm decreasing to 2.5 gpm, until the pump again ran dry, indicating a water level of approximately 480 feet bgs. Albrecht was concerned for collapse of the well and further pumping was suspended until the next day.

GZA measured the water level in the well on October 8, 2008, at 484.8 feet bgs, prior to any pumping, a decrease of approximately 5 feet overnight. Albrecht lowered the pump to approximately 588 feet bgs in the well, within the screened interval of the well, and began pumping. At 11:27 a.m., after approximately 16 minutes of pumping, the pump water turned cloudy suggesting that the water may be from the screened interval of the well. This marked the start of development of the well by pumping three well-volumes out of the screened interval of the well. GZA measured water level in the well using the Solinst instrument, pump rate and turbidity using a MicroTPW portable turbidity meter. The turbidity readings are in nephelometric turbidity units (ntu). The table below summarizes the collected data. The well development data are also shown on the well installation log included in Appendix F.

Well Development Data, October 8, 2008

Time	Pump Rate (gpm)	Water Level (feet bgs)	Turbidity (ntu)
11:23 a.m.	1.8	500.1	356.5
11:43 a.m.	1.7	500.6	74.42
11:57 a.m.	1.7	500.7	44.07
12:20 p.m.	1.7	500.6	21.82
12:45 p.m.	1.7	500.6	10.74
1:20 p.m.	1.7	500.7	5.99
1:42 p.m.	1.7	500.7	9.16
1:55 p.m.	1.7	500.7	5.70
2:03 p.m.	1.7	500.7	4.55

During development, the turbidity of the pumped water gradually decreased with time. The pumping rate remained fairly constant at 1.7 gpm and was run for 2 hours and 40 minutes, for an estimated total volume of approximately 270 gallons. The theoretical well volume for the well with an assumed static groundwater head at 485 feet bgs (as suggested by the morning water level measurement on October 8, 2008) is approximately 78 gallons, and three well volumes would be approximately 234 gallons.

On October 10, 2008, Raimonde pumped the water for 46 minutes at 1.5 gpm and measured the turbidity of the water at 22.87 ntu after developing the well on October 8, 2008.

3.4.3 Surface Completion

The grout placed to ground surface on October 6, 2008, gradually settled to approximately 20 feet bgs. Albrecht placed bentonite chips on October 8, 2008, above the grout to a depth of 7 feet bgs, leaving room for surface monument construction.

The well head and surface protection were constructed on October 9 and 10, 2008. Albrecht cut the well casing to approximately 2 feet above ground surface and installed an expanding steel cap in the casing. The cap has port for the electric cable that extends from the pump near the bottom of the well. Albrecht installed a 10-foot-long, 6-inch-diameter steel casing around the well to a depth of 7 feet bgs, leaving 3 feet above the ground surface as a protective monument. The casing was set in concrete below ground from 0 to 7 feet bgs. The casing has a steel lid with a tab that receives a padlock to secure the lid.

To finish the well head, Albrecht constructed an approximately 2-foot by 2-foot pad around the well monument and installed four steel bollards around the pad. The bollards extend to a depth of 4 feet bgs and rise approximately 3 to 4 feet above the ground surface. These bollards were filled with concrete.

4.0 SUBSURFACE CHARACTERIZATION

The following descriptions of the bedrock geology and hydrogeology are based on review of regional geologic literature and maps, on-Site discussions with Dr. Mikulic and Site-specific data recently collected. This discussion is included to aid the City with their interpretation of the bedrock and groundwater data.

4.1 GENERAL REGIONAL BEDROCK GEOLOGY

The uppermost bedrock in the Site vicinity consists of Silurian dolomite overlain by a thin mantle (less than 20 feet) of granular fill and glacial soils. The former surface mine at the Site was excavated into the Silurian bedrock. The Silurian dolomite typically is subdivided into several formations; from top to bottom these include the Sugar Run, Joliet, Kankakee, Elwood and Wilhelmi Formations. However, this ideal sequence may not be present at all localities due to surface erosion or omission of some of these rock units.

Underlying the Silurian dolomite is the Ordovician Maquoketa Group consisting of the Brainard Formation, the Fort Atkinson Formation and the Scales Shale. The Brainard and Fort Atkinson Formations are lithotypes related to depositional environment. They can occur either below and/or above one another depending on the locality. The Scales Shale occurs below these two units.

The Ordovician Galena Group and Platteville Group underlie the Maquoketa Group. These are the geologic units that currently are mined underground at the Site. The Galena and Platteville Groups are subdivided into several Formations. The Galena and Platteville bedrock lithology includes limestone and dolomite (dolostone). Below the Platteville Group is the Ordovician Ancell Group.

The strata at the Site are relatively flat-lying. Stratigraphic complexities that occur in the region are typically a consequence of depositional environment and ancient topography; however, several regional structural features bound the area. Such structural features include the Kankakee Arch and Michigan Basin to the east, the LaSalle Anticlinal Belt to the southwest, the Illinois Basin to the south and the Wisconsin Arch to the north. Local structural features within the Site vicinity include the Aurora Syncline within 20 miles to the southwest and the Sandwich Fault Zone approximately 15 miles to the southwest.

4.2 SITE BEDROCK GEOLOGY

The following discussion summarizes our observations of the rock core during drilling of boring DH-01 and correlates the observed lithologies to regional geologic units. Depths are reported to the nearest foot.

4.2.1 Silurian Dolomite

Silurian dolomite was encountered below glacial soils at a depth of approximately 12 to 53 feet bgs at the contact with the underlying Ordovician Maquoketa Group. The interpreted upper contact of the Silurian dolomite is based on significant increase in drill resistance and cuttings retrieved during drilling. The cored rock interval from 48 to 53 feet bgs consists of very strong to strong, light gray to greenish-gray dolomite of the Elmwood Formation. The dolomite is generally fresh with minor pitting and rare vugs. Chert pods occur throughout the formation as white, deleterious chert up to several inches in length and a few inches thick.

4.2.2 Ordovician Maquoketa Group

The Ordovician Maquoketa Group was encountered below the Silurian dolomite at 53 feet bgs to 207 feet bgs at the contact with the underlying Ordovician Galena Group. We observed the following sequence of rocks in the Maquoketa Group:

- Upper Fort Atkinson Formation - The Fort Atkinson Formation was encountered at two depth intervals, one from 53 to 58 feet bgs and the other from 139 to 140 feet bgs. These two intervals overlie and underlie the Brainard Formation. The Fort Atkinson and Brainard Formations are lithotypes within the Maquoketa Group and can be time-transgressive, meaning they can occur above or below one another depending on changes in the ancient depositional environment. The upper Fort Atkinson consists of strong, gray dolomite with some orange-oxide staining. The dolomite had abundant, interconnected vugs and several green clay beds less than ¼-inch thick. The dolomite is intensely fractured mostly along horizontal partings.

- Brainard Formation - The Brainard Formation was encountered from 58 to 139 feet bgs. The upper portion of the Brainard consists of strong, light green to light gray, dolomitic shale interbedded with argillaceous dolomite with white chert pods up to 2 inches in diameter. The upper Brainard is intensely to moderately fractured, especially near contacts between the shale and dolomite and near chert pods. The Brainard becomes less calcareous without chert and loses its green color from approximately 80 to 100 feet bgs. Below this depth, the formation consists of light to dark gray, unfractured, laminated shale.

- Lower Fort Atkinson Formation - The lower Fort Atkinson Formation was encountered from 139 to 140 feet bgs and consists of strong, gray to dark gray, argillaceous limestone that is thinly bedded and is fresh to slightly decomposed. The limestone is slightly disintegrated with some pits and pyrite mineralization.

- Transition Zone: Fort-Atkinson Formation/Scales Shale - From 140 to approximately 155 feet bgs, the rock consists of a transitional sequence of interbedded, dark gray, laminated shale and fossiliferous shale with calcite-filled burrows. This rock is similar to both the Fort Atkinson Formation and the Scales Shale and is strong, fresh, competent and unfractured.

- Scales Shale - The Scales Shale was encountered below the transitional unit at approximately 155 feet bgs to 207 feet bgs. The Scales Shale consists of strong to moderately strong, dark gray, laminated shale without fractures. The shale was brecciated during coring from approximately 206 to 207 feet bgs. Consequently, the contact with the underlying Ordovician Galena Group is approximately located at 207 feet bgs.

4.2.3 Ordovician Galena Group

The Ordovician Galena Group was encountered below the Ordovician Maquoketa Group at approximately 207 feet bgs to 394 feet bgs at the contact with the underlying Ordovician Platteville Group. We observed the following sequence of rocks in the Galena Group:

- Wise Lake Formation - The Wise Lake Formation was encountered from approximately 207 to 280 feet bgs. The Wise Lake consists of very strong to strong, light brownish-gray limestone. The limestone is fresh to slightly decomposed with some pitting. Rare vugs generally less than 1 inch in diameter occur in approximately the upper 25 feet of the formation. Abundant stylolites form irregular, horizontal partings in the rock; but the rock mass is mostly unfractured. Where stylolites are clustered tightly together, the rock mass is moderately disintegrated and pitted.

- Dunleith Formation - The Dunleith Formation underlies the Wise Lake Formation and was encountered from approximately 280 to 394 feet bgs, including a transitional zone between the Wise Lake and Dunleith Formations from 280 to 290 feet bgs. These formations are lithologically close to one another and were differentiated by the observed presence of dolomitization in the Dunleith Formation. The Dunleith consists of very strong to strong, brown and gray limestone that is thinly bedded along stylolitic bed partings. Clustered stylolites commonly occur at horizontal fractures in the rock (produced by coring), but the rock core was otherwise unfractured. The limestone ranges from fresh to slightly disintegrated with dolomitized zones several inches thick, some calcite-filled vugs up to 1 inch in diameter, and rare silicified zones several inches in diameter. Dolomitization increases at a depth of approximately 370 feet bgs and the rock grades into dolomite at approximately 387 feet bgs. The dolomite below 387 feet bgs is slightly decomposed, pitted to varying extent and has vugs up to 2 inches in diameter that are interconnected in the retrieved core samples. The core was moderately fractured within the pitted and vuggy zones.

- Guttenberg Formation - the Guttenberg Formation underlies the Dunleith Formation and was encountered as a thin bed from 393.6 to 394.3 feet bgs. The Guttenberg consists of strong, reddish-brown, slightly decomposed and disintegrated dolomite that is thinly bedded along abundant stylolites. This unit represents the base of the Galena Group encountered at the Site.

4.2.4 Ordovician Platteville Group

The Ordovician Platteville Group was encountered below the Ordovician Galena Group at 394 feet bgs down to 538 feet bgs at the contact with the underlying Ordovician Ancell Group. We observed the following sequence of rocks in the Platteville Group:

- Quimbys Mill Formation - The Quimbys Mill Formation was encountered from 394 to 403 feet bgs. The Quimbys Mill consists of very strong, tan, massive to thickly bedded dolomite. The dolomite is fresh, competent and moderately fractured along vertical planes that are healed. Rare vugs less than ¼-inch in diameter and white, deleterious chert pods less than 1 inch thick are scattered throughout the formation.

- Nachusa Formation - the Nachusa Formation was encountered from 403 to approximately 438 feet bgs. The Nachusa is distinguished from the overlying Quimbys Mill based on the appearance of stylolites and gray and brown mottling in the rock cores. The Nachusa consists of very strong to strong, mottled gray and brown dolomite that is fresh, competent to pitted, and has vugs up to 1 inch in diameter to varying extent. The mottling is not consistent throughout the formation. Stylolites gradually increase in frequency with depth. White to gray chert pods are uncommon. The dolomite is slightly to moderately fractured at clusters of stylolites and at chert-dolomite contacts.

- Grand Detour Formation - The Grand Detour Formation underlies the Nachusa Formation and was encountered from approximately 438 to 481 feet bgs, including a transitional zone between the Nachusa and Grand Detour Formations from 438 to 444 feet bgs. These formations are lithologically similar and were differentiated by the absence of chert pods and the consistently mottled coloration in the Grand Detour Formation below the contact. The Grand Detour consists of very strong to strong, brown and gray mottled, thinly to moderately bedded dolomite that is fresh and competent. The rock is relatively unfractured and has few vugs or pits. The mottled coloration grades out from 460 to 465 feet bgs, resulting in tan dolomite that has similar strength and texture to the overlying rock. The dolomite becomes medium to thinly bedded starting approximately 460 feet along wavy shale partings less than 1 millimeter (mm) thick.

- Mifflin Formation - The Mifflin Formation was encountered from 481 to 503 feet bgs. The Mifflin is distinguished from the overlying Grand Detour Formation based on the increased abundance of thin, green shale partings and the significant increase in stylolites. The Mifflin consists of very strong, gray, thinly bedded to laminated dolomite with abundant stylolites and wavy shale partings less than 1 mm thick. The dolomite is generally fresh and competent with some pits and vugs.

- Pecatonica Formation - The Pecatonica Formation was encountered from 503 to 540 feet bgs. The Pecatonica represents the base of the Platteville Group and overlies the Ordovician Ancell Group. The Pecatonica immediately below the Mifflin Formation consists of very strong, light brown, massive dolomite that is fresh and competent without obvious shale partings or significant pitting. Chert pods, lenticular siliceous zones and vugs up to 1 inch in diameter occur throughout the unit. The dolomite is moderately fractured along vug-rich zones and near the boundaries of chert/siliceous pods. Vugs increase in size and abundance with depth. At approximately 525 feet bgs, the dolomite is vuggy and moderately fractured, including unhealed, rough fractures at angles 60 to 65 degrees from horizontal. The rock texture becomes heavily pitted and recrystallized with shale partings and stylolites down to the bottom of the formation. The dolomite has fine sand starting at 539 feet bgs, less than 1 foot above the contact with the underlying sandstone.

4.2.5 Ancell Group

The Glenwood Formation of the Ordovician Ancell Group was encountered below the Platteville Group from 540 to at least 544 feet bgs, which was the limit of core recovery. The Glenwood consists of moderately strong, gray, fine-grained sandstone that is massively bedded, fresh and competent to slightly disintegrated. The core was retrieved in well cemented segments of sandstone generally less than 3 inches long due to mechanical breaks during coring. Approximately 1.5 feet of core were not recovered at the base of the last core run, but we retrieved light gray to white, fine sand in the core barrel below the Glenwood Formation, which may be the St. Peter Sandstone that underlies the Glenwood. The St. Peter Sandstone is generally not cemented and would more easily be washed out of the core barrel.

4.3 BEDROCK HYDROGEOLOGY

In general, groundwater within the Silurian bedrock is an unconfined, local groundwater resource. The Maquoketa Group forms an aquitard between the unconfined Silurian aquifer and the carbonate rock of the Galena and Platteville Groups. The Galena and Platteville Groups are not typically targeted as a groundwater supply; however, wells are commonly completed within these Groups for storage or where relatively small (non-industrial or commercial) volumes of groundwater are required. Groundwater within the Ancell Group (primarily the St. Peter Sandstone) is targeted for potable and commercial/industrial uses. The St. Peter Sandstone is a significant potable-water resource for the City of Aurora and is the target aquifer for the monitoring well installed at the Site.

4.3.1 Groundwater Levels

GZA measured water levels in the borehole each day during coring. Morning readings were made prior to disturbing the water column each day and are considered more reliable indicators of groundwater level in the Silurian aquifer than the evening readings. Our morning measurements of groundwater levels ranged from 47.2 to 48.1 feet bgs during coring. Water level measurements over successive days during drilling did not indicate significantly different depths, suggesting infiltration of water into the Maquoketa and Galena-Platteville Groups through the borehole did not significantly lower the groundwater table of the Silurian aquifer. The data are summarized in the table of Water Level Readings below.

GZA also measured water levels each morning prior to well installation and development activities. Water level measurements in the annulus outside the well ranged from 49 to 50.8 feet bgs. Water level measurements inside the well casing ranged from 50.8 feet bgs when only the pipe was installed (without annular backfill, so the water columns inside and outside the casing were still hydraulically connected) to 484.8 feet bgs after the annular sand, seal and grout had been placed and the water stabilized overnight. The 484.8-foot measurement may actually be slightly higher than the static water level for the St. Peter Sandstone. The well casing was filled with water the day before our measurement and may still have been infiltrating into the St. Peter Sandstone aquifer at the time of our measurement. However, during development, the water level was pumped down to near steady-state at approximately 500.7 feet bgs. This steady state is where the groundwater recharge from the St. Peter Sandstone equals the pumping rate, which was approximately 1.7 gpm. We interpret the static water level for the St. Peter Sandstone aquifer to be between 485 and 500 feet bgs. This indicates that the groundwater in the St. Peter Sandstone aquifer is confined in the vicinity of the Site, since the estimated static water level is at least 40 feet above the upper boundary of the Ancell Group. Water level data collected during well installation are also summarized in the Water Level Readings table below.

Water Level Readings – During Rock Coring and Well Installation

<table>
<tr><th>Date</th><th>Time</th><th>Depth (feet bgs)</th><th>Location of Reading</th><th>Notes</th></tr>
<tr><td colspan="5">During Rock Coring</td></tr>
<tr><td rowspan="2">7/17/08</td><td>6:40 a.m.</td><td>48.0</td><td rowspan="2">Open borehole</td><td>Boring depth at 118 feet bgs (bottom in Maquoketa Group, Brainard Formation)</td></tr>
<tr><td>5:45 p.m.</td><td>45.5</td><td rowspan="2">Boring depth at 268 feet bgs (bottom in Galena Group, Wise Lake Formation)</td></tr>
<tr><td rowspan="2">7/18/08</td><td>6:39 a.m.</td><td>48.1</td><td rowspan="2">Open borehole</td></tr>
<tr><td>4:29 p.m.</td><td>49.2</td><td>Boring depth at 378 feet bgs (bottom in</td></tr>
</table>

Date	Time	Depth (feet bgs)	Location of Reading	Notes
7/21/08	9:15 a.m.	47.3	Open borehole	Galena Group, Dunleith Formation)
	6:34 p.m.	42.7		Boring depth at 468 feet bgs (bottom in Platteville Group, Grand Detour Formation)
7/22/08	6:21 a.m.	47.2	Open borehole	
	11:09 a.m.	50.1		Boring depth at 518 feet bgs (bottom in Platteville Group, Pecatonica Formation)
7/24/08	2:35 p.m.	51.0	Open borehole	Boring depth at 545.7 feet bgs (bottom in Ancell Group, St. Peter Sandstone?)
During Well Installation				
9/29/08	10:45 a.m.	50.8	Open borehole	Boring depth 606 feet bgs
9/30/08	10:12 a.m.	50.8	Inside well	No annular backfill placed
10/1/08	9:55 a.m.	62.3	Inside well	Half of annular seal in place, no grout
	9:55 a.m.	49.3	Outside well	
10/3/08	9:10 a.m.	103.8	Inside well	Full annular seal in place, no grout
	9:10 a.m.	49.0	Outside well	
10/6/08	12:45 p.m.	> 385	Inside well	Water level below instrument reach, annulus partially grouted
10/7/08	11:35 a.m.	199.1	Inside well	Water infiltrated out through screen overnight starting at top of well
10/8/08	9:42 a.m.	484.8	Inside well	Water infiltrated out through screen overnight starting at 480 feet bgs
	1:20 p.m.	500.7	Inside well	Approximately steady-state water level during development pumping

4.3.2 Hydraulic Conductivity

We completed 16 water pressure tests within the Galena-Platteville Groups while coring DH-01 using a sliding-head inflatable packer assembly. The test data are provided on a summary table and data sheets included in Appendix D. Using the water pressure test data, we calculated average hydraulic conductivities for each test interval. The hydraulic conductivity data are presented on the summary table in Appendix D.

Based on the test data, we interpret the variation in hydraulic conductivities to correspond to the lithology and fabric of the bedrock, particularly the degree of dissolution and fracturing. The following discusses the hydraulic conductivities with respect to the Galena-Platteville stratigraphy:

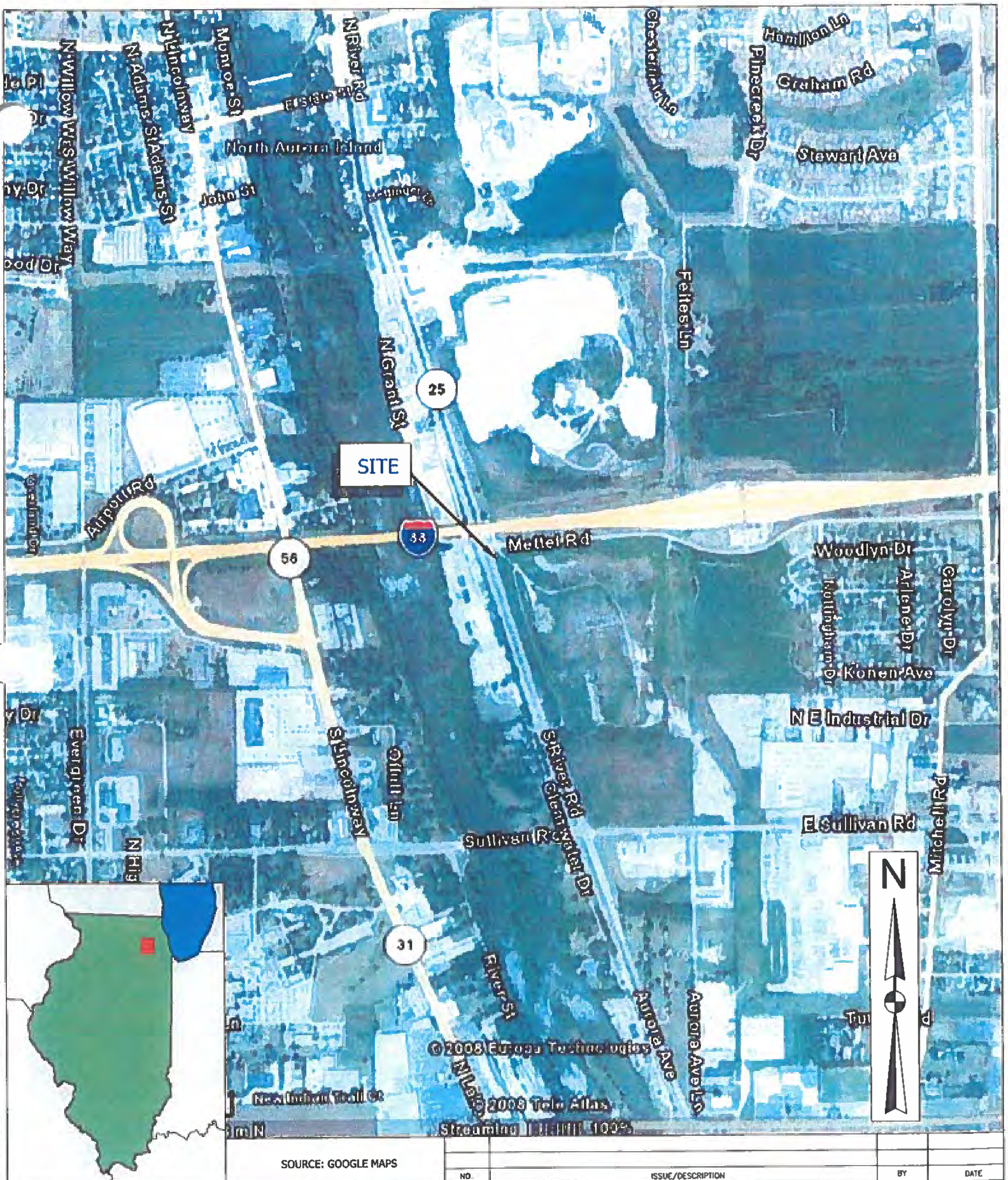
- Galena Group - Water pressure tests for most of the Galena Group limestones indicate hydraulic conductivities ranging from approximately $1x10^{-7}$ to $2x10^{-6}$ centimeters per second (cm/sec) except for the upper 40 feet of the Wise Lake formation. Testing of the upper Wise Lake from 208 to 228 feet bgs indicates a conductivity of $6x10^{-5}$ cm/sec, followed by a conductivity of $8x10^{-6}$ cm/sec between 228 and 248 feet bgs. We interpret this gradual reduction in conductivity to result from the increasing depth of limestone away from the upper boundary of the Galena Group, which has an unconformable contact with the overlying Maquoketa Group. The uppermost Wise Lake Formation is dolomitized and has abundant vugs and mineralization, indicating it is significantly less competent than the underlying strata.

- Galena-Platteville Contact - The water pressure test from 388 to 408 feet bgs crosses the Galena-Platteville contact and includes dolomite of the lowermost Dunleith Formation with large, interconnected vugs; disintegrated dolomite of the Guttenberg Formation; and moderately fractured Quimbys Mill dolomite along vertical planes. The conductivity for this interval is approximately $2x10^{-5}$ cm/sec, significantly higher than the strata bounding this interval.

- Platteville Group - Water pressure tests for the Platteville Group show a gradually decreasing trend with depth. Testing in the Nachusa Formation indicates conductivities ranging from $1x10^{-5}$ cm/sec to $9x10^{-6}$ cm/sec, while testing in the underlying Grand Detour and Mifflin Formations indicates conductivities ranging from $7x10^{-6}$ cm/sec to $9x10^{-7}$ cm/sec. These dolomites are lithologically similar, but the Nachusa is more pitted and has vugs up to 1 inch in diameter. Similarly, a water pressure test at 508 to 518 feet bgs in the upper Pecatonica Formation indicates a conductivity of $2x10^{-5}$ cm/sec. The upper Pecatonica has vugs similar to the Nachusa Formation.

These observations suggest that the hydraulic conductivity of the bedrock is related to the abundance of vugs and other dissolution features, or where the rock is less confined and potentially broken near the main contacts between the Ordovician groups (Maquoketa/Galena, Galena/Platteville, Platteville/Ancell).

FIGURES



SOURCE: GOOGLE MAPS

NO.	ISSUE/DESCRIPTION	BY	DATE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
20900 SWENSON DRIVE, SUITE 150
WAUKESHA, WISCONSIN 53186
(262) 754-2560

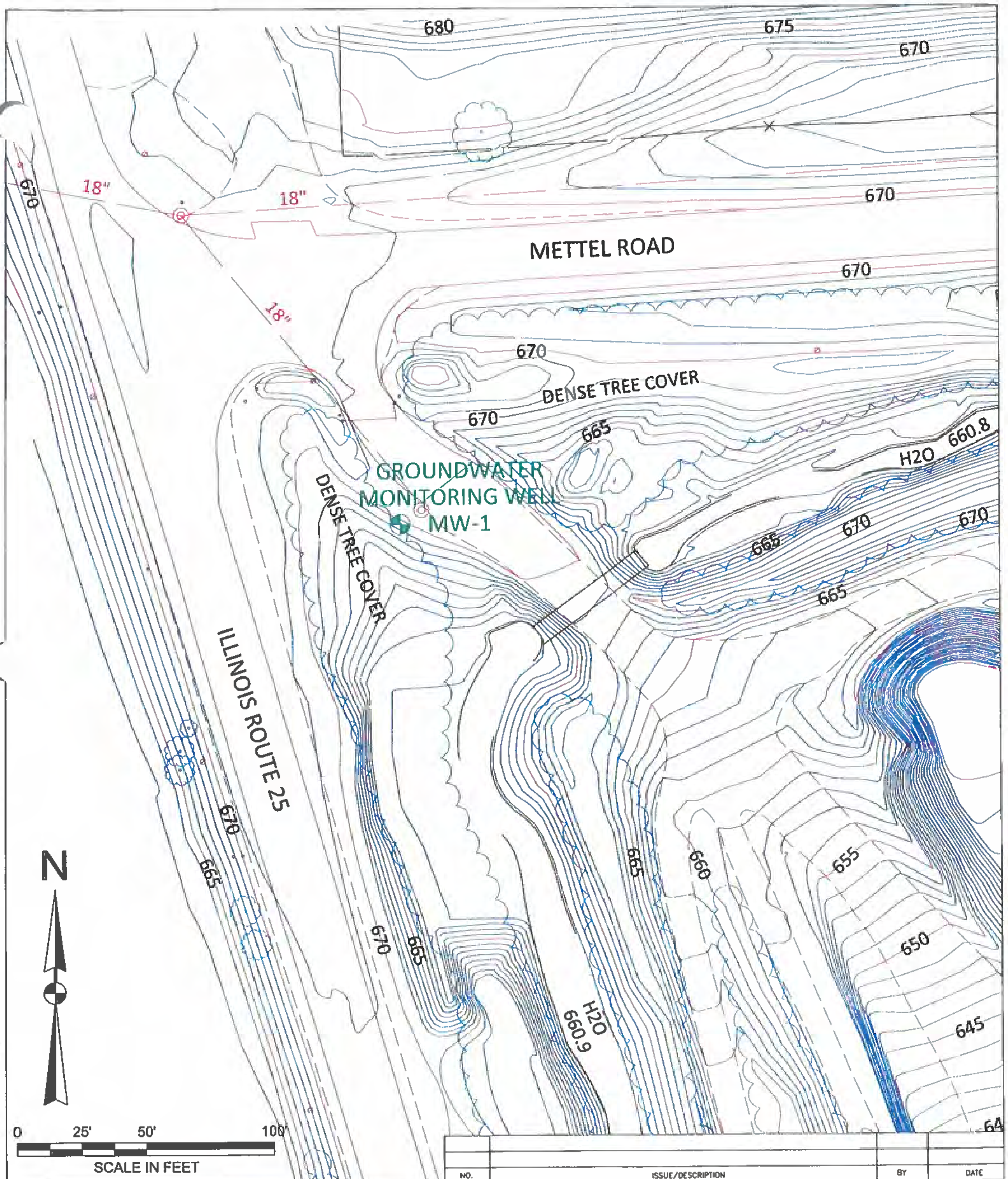
PREPARED FOR:

DEEP CORE BORING AND MONITORING WELL INSTALLATION SITE
SITE LOCATION MAP

SITE NAME: ROUTE 25 RESPOSITORY SITE
AURORA, ILLINOIS

FIGURE 1

PROJ MGR:	EJS	REVIEWED BY:	EJS	CHECKED BY:	EJS	DATE	PROJECT NO.	REVISION NO.	SHEET NO.
DESIGNED BY:	EJS	DRAWN BY:	JAH	SCALE:	NTS	10/17/08	20.0152025		



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PREPARED FOR:

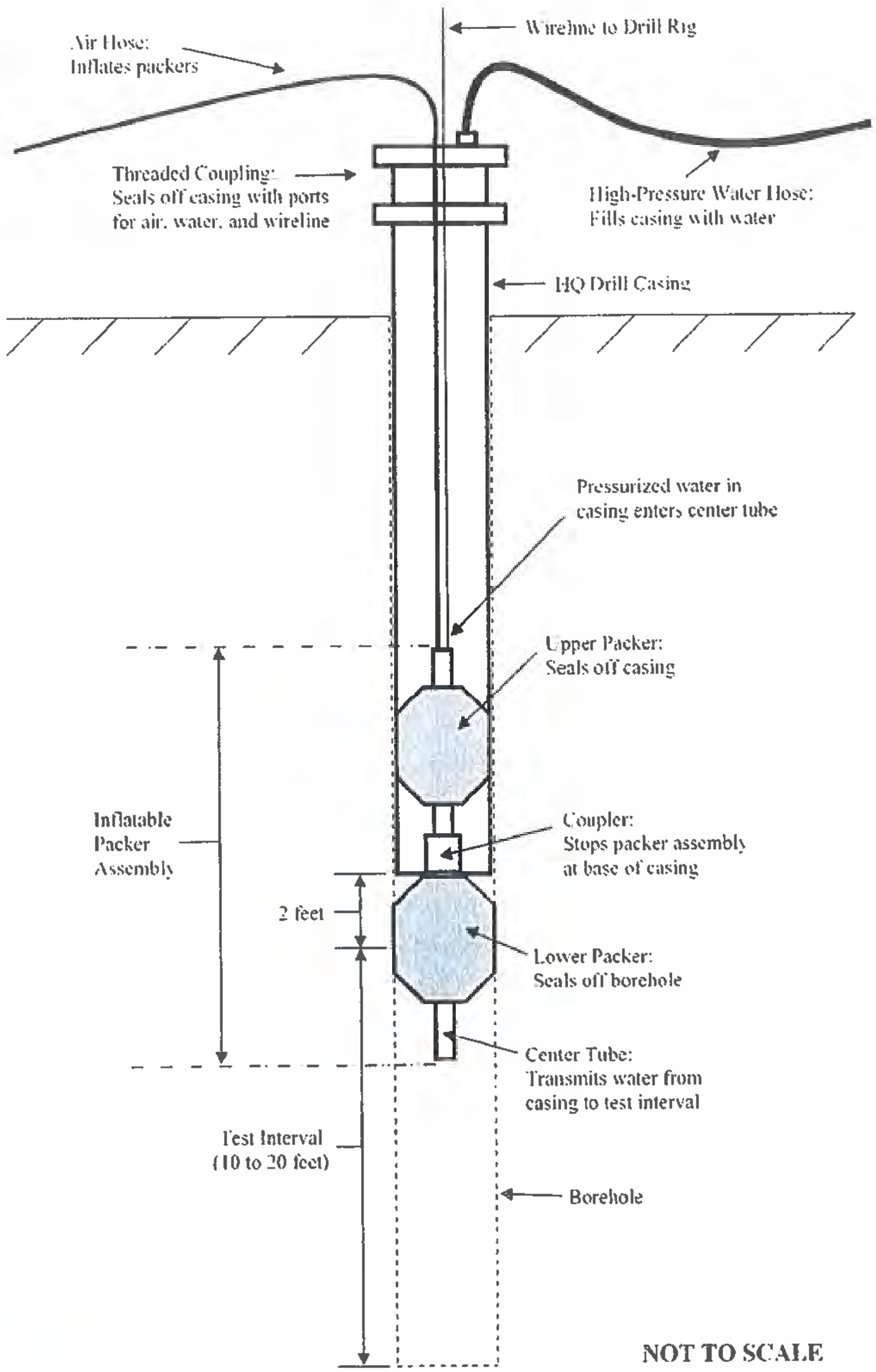
NO.	ISSUE/DESCRIPTION	BY	DATE

SITE PLAN

ROUTE 25 REPOSITORY SITE
AURORA, ILLINOIS

FIGURE 2

PROJ MGR: EJS	REVIEWED BY: MJK	CHECKED BY: EJS	DATE 11/5/08	PROJECT NO. 20.0152025	REVISION NO.	SHEET NO.
DESIGNED BY: EJS	DRAWN BY: JAH	SCALE:				



GZA-J:\152000to152999\152025 Aurora\DRAWINGS\AutoCAD\FIGURE 3.dwg [FIG ...ber 24, 2008 - 5:15pm jason.hegarty

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PREPARED FOR:

NO.	ISSUE/DESCRIPTION	BY	DATE

INFLATABLE PACKER ASSEMBLY SCHEMATIC DIAGRAM

SITE NAME: ROUTE 25 RESPOSITORY SITE
AURORA, ILLINOIS

PROJ MGR: EJS	REVIEWED BY: EJS	CHECKED BY: EJS	DATE	PROJECT NO.	REVISION NO.	FIGURE	3
DESIGNED BY: EJS	DRAWN BY: JAH	SCALE: NTS	10/24/08	20.0152025		SHEET NO.	

APPENDIX A

Limitations

LIMITATIONS

1. This report is intended for the use of Raimonde Drilling Corporation, the City of Aurora, their attorneys, advisors, and consultants in support of the Deep Core boring and Monitoring Well Installation project located at the Route 25 Repository Site in Aurora, Illinois ("Site"). The report and the findings in the report shall not, in whole or in part, be disseminated or conveyed to any other party, or used or relied upon by any other party, in whole or in part, except for the specific purpose and to the specific parties alluded to above, without the written consent of GZA. GZA would be pleased to discuss the conditions associated with any such additional dissemination, use, or reliance by other parties.

2. The conclusions and opinions submitted in this report are based in part upon the data obtained from a limited number of bedrock and groundwater samples from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until further investigation. If variations or other latent conditions then appear evident, it may be necessary to re-evaluate the findings of this report.

3. The generalized soil and bedrock profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual transitions are probably more gradual. For specific information, refer to the boring and rock core logs.

4. Water level readings were made in the borings at times and under conditions stated within the text of the report. These data were reviewed and interpretations made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, and other factors different from those prevailing at the time measurements were made.

5. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty, expressed or implied, should be understood.

APPENDIX B

Field Reports

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/16/08 (Wednesday) Sheet 1 of 1
Report No.:
Project: Deep Core Boring, Route 25 Repository Site Project No.: 152025.00
Client: Raimonde Drilling (for City of Aurora)
Location: Aurora, IL
Contractor:
Weather Conditions: Sun, 80-90°F
Attachments:

START OF DRILLING PROJECT

0730 - Arrive on site, Raimonde Drilling on site setting up, getting water. Crew: Terry Koch (driller/foreman), Mike + Noel (helpers)

0906 - Start drilling using 8-inch diameter tricone bit; cuttings logged on boring log w/ drill conditions (generally 12 ft. fill and glacial alluvium over bedrock).

1108 - Start advancing 5-inch ID casing to 19.5 ft.

1131 - Start advancing PQ core casing w/ rock bit to ~30 ft., no samples. Discussion en route to 30 ft. w/ Anne Leslie (Raimonde), Mark Krumenacher (GZA PM), and Marc Fischer (Deuchler Environmental - City's consultant) about when to start rock coring to retrieve samples. There is concern for infiltration at river elevation (Fox River located west of site; channel base at 629 ft. elevation according to Marc F. Site at approx. 670 ft. elv.) Anne L. requests to install PQ casing to 10 ft. below river base ≈ 620 ft. elevation, or ~50 ft. below site elevation. Marc F. approves strategy.

1215 - Resume PQ casing advance (to 48.0 feet depth); cuttings mostly beige, fine grit with no visible reaction to acid (dolomite).

1308 - Cuttings dark gray from ~41.5 to 42.5 (shale bed), back to beige dolomite.

1325 - PQ set to 48.0 feet, switch to HQ rock coring

1445 - Start HQ coring at 48.0 feet. Drillers core through dolomite, then into Maquoketa Group

1755 - Finished coring for day @ 118.0 feet. Leave site after logging and loading core boxes.

On-Job Time: 10 ½ hours
Travel Time: ½ hour
Office Time:
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/17/03 (Thursday) Sheet 1 of 1

Report No.:

Project: Deep Core Boring, Route 25 Repository Site Project No.: 152025.00

Client: Raimonde Drilling (for City of Aurora)

Location: Aurora, IL

Contractor:

Weather Conditions: Sun, 80-90°F

Attachments:

CONTINUE HQ CORING / START PACKER TESTING IN GALENA-PLATTEVILLE

0556 - Arrive on site, drillers not here yet.
0605 - Drillers arrive start set up, H+S meeting.
0640 - Measure groundwater @ 48 ft. bgs.
0657 - Start HQ coring @ 118 ft.
0930 - Cable snapped retrieving run 15 (168-178 ft.); respool w/new wire cable
1049 - Resume coring after repair + retrieving core w/broken wire.
~1200 - Encounter Galena Group below Scales Fm. @ 207 ft. bgs
1239 - Retrieve core f/212-228 ft.; set up packer test
 - Review core w/Don Mikulic (ISGS Silurian expert)
1405 - Packer test f/208-228 (Test #1)
1453 - Start coring @ 228 ft.
1553 - Packer test f/228-248 (Test #2)
1624 - Finish test #2, back to HQ coring
1652 - Start coring @ 248 ft.
1745 - Stop coring for day after retrieving core f/258-268 ft.
1748 - Measure groundwater @ 45.5 ft. bgs.
1750 - Drillers leave site; I stay to log core, boxes, + break down gear.
2007 - Leave site

AFTER SITE WORK:
1 hr - packer test analysis

On-Job Time: 14 hr
Travel Time: 1/2 hr
Office Time: 1 hr
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/18/08 (Friday)	Sheet 1 of 2
Report No.:	
Project: Deep Core Boring, Route 25 Repository Site	Project No.: 152025
Client: Raimonde Drilling (for City of Aurora)	
Location: Aurora, IL	
Contractor:	
Weather Conditions: Sun, 80-90 °F	
Attachments:	

CONTINUE HQ CORING / PACKER TESTING FROM THURS., 7/17/08

0535 - Drop off 18 boxes of core f/ Wed. + Thurs (7/16 + 7/17) @ Deuchler's warehouse; drive to site
0615 - Arrive @ site; drillers moving vehicles into position
0639 - Measure groundwater @ 48.1 ft. bgs.
0705 - Packer test f/248-268 ft. (Test #3)
0730 - Finish packer test #3; switch back to coring
0753 - Start coring @ 268 ft.
0825 - Retrieve core f/278-288 ft.; set up packer test
0848 - Packer test f/268-288 ft. (Test #4)
0916 - Finish packer test #4
0935 - Start coring @ 288 ft.
1018 - Retrieve core f/298-308 ft.; set up packer test
1031 - Packer test f/288-308 ft. (Test #5)
1054 - Finish packer test #5
1115 - Start coring @ 308 ft.
1126 - Retrieve core f/318-328 ft.; set up packer test
1159 - Packer test f/308-328 ft. (Test #6)
1228 - Finish packer test #6
1239 - Start coring @ 328 ft.
1322 - Retrieve core f/338-348 ft.; set up packer test
1347 - Packer test f/328-348 (Test #7)
1408 - Finish packer test #7
1422 - Start coring @ 348 ft.

On-Job Time: 11 1/2 hr
Travel Time: 1/2 hr
Office Time: 1 hr
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

e: 7/18/08 Sheet 2 of 2
Report No.:
Project: Deep Core Boring; Route 25 Repository Site Project No.: 152025
Client: Raimonde Drilling (for City of Aurora)
Location: Aurora, IL
Contractor:
Weather Conditions: Sun, 80-90°F
Attachments:

1509 - Packer test @/348-368 ft. (Test #8)
1528 - Finish packer test #8
1550 - Start coring @ 368 ft.
1609 - Pulley for wireline snapped off tower while retrieving core @/368-378 ft
1623 - Resume drilling after repair & retrieving core @/368-378 ft.
1629 - Swivel burst; break gear down for day
1650 - Measure groundwater @ 49.2 ft. bgs.
1710 - Leave site; take today's core boxes with to deliver Mon, 7/21/08

AFTER SITE WORK:
1 hr - packer test data analysis

On-Job Time: 11½ hr.
Travel Time: ½ hr.
Office Time: 1 hr.
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/21/08 (Monday) Sheet 1 of 2
Report No.:
Project: Deep Core Boring, Route 25 Repository Site Project No.: 152025.00
Client: Raimonde Drilling (for City of Aurora)
Location: Aurora, IL
Contractor:
Weather Conditions: Sun/Cloudy, 75-85°F (after A.M. rain)
Attachments:

CONTINUE HQ CORING/PACKER TESTING FROM FRI, 7/18/08:
0600 - Arrive on site, drillers waiting outside gate. Chain securing gate is locked only w/ City's padlock (not the one intended for Raimonde's use). Call Steve Leppard @ Deuchler; says Phillipe Moreau (president of Deuchler) will be in soon. Call Marc Fischer; left voicemail.
0625 - Called City of Aurora Public Works, leave message about locked gate. Received call back f/ Dom ? w/ Aurora PW; said gate could be unlocked ~0730. Discussed problems w/ using multiple locks.
~0700 - Drillers leave site for water.
712 - Marc Fischer arrives on site.
0715 - Phillipe M. arrives w/ key to City lock, opens gate.
0800 - Drillers return, start set up. Rain/lightning storm starts soon after. Wait for storm to pass.
0910 - Rain decreasing, no lightning; drillers prep for drilling
0915 - Measure groundwater at 47.3 feet bgs.
0925 - Start coring @ 378 ft.
0940 - Retrieve core f/378-388 ft; set up for packer test.
0958 - Packer test f/368-388 ft. (Test #9)
1020 - Finish packer test #9
1047 - Start coring @ 388 ft.
1053 - Swivel broke while coring @ ~391 ft.
1112 - Resume coring @ 391 ft. after repairs
1130 - Retrieve core f/398-408 ft.; set up for packer test.
1155 - Packer test f/388-408 ft. (Test #10)
1230 - Finish packer test #10

On-Job Time: 13 1/2 hr.
Travel Time: 1/2 hr.
Office Time: 1 hr.
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

:: 7/21/08 Sheet 2 of 2

Report No.:

Project: Deep Core Boring, Route 25 Repository Site **Project No.:** 152025.00

Client: Raimondo Drilling (for City of Aurora)

Location: Aurora, IL

Contractor:

Weather Conditions: Sun/Cloudy, 75-85°F (after A.M. rain)

Attachments:

1254 - Start coring @ 408 ft.
1330 - Retrieve core f/418-428 ft.; set up packer test
1345 - Packer test f/408-428 ft. (Test #11)
1420 - Finish packer test #11
1441 - Start coring @ 428 ft.
1515 - Retrieve core f/438-448 ft.; set up packer test
1534 - Packer test f/428-448 ft. (Test #12)
1558 - Finish packer test #12
1628 - Start coring @ 448 ft.
31 - Swivel broke.
1644 - Resume coring after repair
1725 - Retrieve core f/458-468 ft.; set up packer test
1742 - Packer test f/448-468 ft. (Test #13)
1811 - Finish packer test #13; break down site (photos of core, pack boxes, etc.)
1834 - Measure groundwater at 42.7 ft. bgs.
1855 - Leave site; lock gate w/ locks interconnected.

BEFORE SITE-WORK:
0530 - Drop off core boxes f/Friday (7/18) @ Deuchler's office/warehouse.

AFTER SITE-WORK:
1 hr - packer test data analysis

On-Job Time: 13 ½ hr.
Travel Time: ½ hr.
Office Time: 1 hr.
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/22/08 (Tuesday) Sheet 1 of 1

Report No.:

Project: Deep Core Boring, Route 25 Repository Site Project No.: 152025.00

Client: Raimonde Drilling (for City of Aurora)

Location: Aurora, IL

Contractor:

Weather Conditions: Sun, 70-80°F

Attachments:

0530 - Drop off core at Deuchler's warehouse from Monday, 7/21/08
0600 - Arrive on site; drillers setting up
0621 - Measure groundwater @ 47.2 ft. bgs.
0631 - Start coring @ 468 ft.; core to 488 ft.
0735 - Packer test w/ 468-488 ft. (Test #14)
0832 - Start coring @ 488 ft.; core to 508 ft.
0933 - Packer test w/ 488-508 ft. (Test #15)
1031 - Start coring @ 508 ft.; core to 518 ft.
1109 - Packer test w/ 508-518 ft. (Test #16)
1139 - Finish packer test #16; drillers start removing drill casing
1215 - Measure groundwater @ 50.1 ft. bgs (after drillers removed ~200 ft. of casing)
1230 - Leave site to drop off core boxes; drillers still removing casing.
1250 - Drop off core at Deuchler's office

AFTER SITE-WORK:
1/2 hour - packer test data analysis

On-Job Time: 7 1/2 hr.
Travel Time: 1/2 hr.
Office Time: 1/2 hr.
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 7/24/08 (Thursday) Sheet 1 of 1

Report No.:

Project: Deep Core Boring, Route 25 Repository Site Project No.: 152025.00

Client: Raimonde Drilling (for City of Aurora)

Location: Aurora, IL

Contractor:

Weather Conditions: Sun, 75-85°F

Attachments:

0735 - Arrive on site, Raimonde Drilling setting up pump for coring (Foreman: Terry Koch, Helper: Bill D.)

0810 - Start advancing HQ casing down existing borehole.

0914 - Finish setting HQ casing; drillers leave for water.

0942 - Drillers return, start advancing NQ core casing.

1032 - Mark Brummeler arrives on site.

1046 - Phillipe Moreno arrives on site. Discuss report needs w/ Deuchler + GZA.

1130 - Anne Leslie (Raimonde) arrives on site. Drilling starts at 518.0 feet (@ 1140) using NQ coring

1145 - Encounter sandstone (Glenwood Formation) at 539.6 feet. Lost 1.8 ft. of core, apparently as loose sand, possibly St. Peter Sandstone. (based on loose, light gray to white sand left in core barrel)

~1300 - Drillers remove NQ casing, then HQ casing. Log core, break down gear. Discuss filter/screen for well w/ Anne (via phone) + Marc F. at site.

1435 - Measure groundwater at 51 feet bgs after all NQ + HQ casing removed.

1440 - Leave site, deliver 2 core boxes to Deuchler's warehouse

1505 - Leave Deuchler's office.

On-Job Time: 7½ hr.

Travel Time: ½ hr.

Office Time:

Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 9/29/08 | Sheet 1 of 2

Report No.:

Project: City of Aurora - Deep Well Install | Project No.: 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Rain (light), 65°F

Attachments:

0935 - Arrive on site; Anne Leslie (Raimonde Drilling) on site, waiting for drillers. Rig is in place over hole, hole covered for security.

0945 - Drillers arrive, start setup. Trailer w/ PVC casing + screen, sand (filter pack), grout bags in place. Schedule 80 PVC w/ threaded couplings + gaskets (black) (Packaging: Campbell Monoflex 4" diam.)

1020 - Anne leaves site after reviewing install procedure/plan.

1025 - Albrecht Drilling starts assembling pipe. Crew: Pat - driller, Dave + Casey helpers.

1045 - Prior to placing PVC, measure groundwater @ 50.8 feet (52.8 - 2 casing stickup). Hole currently has 10" diameter steel casing to 18' (according to Pat).

1048 - Stop due to heavy rain. I measure PVC casing: 4.5" OD, ~3.8" ID

1112 - Resume preparing PVC/centralizer. Lowest section is screened + with end cap. First centralizer @ bottom, then @ 10' from bottom.

1130 - Hold health + safety meeting. Marc Fisher now on site

1140 - Start advancing screen into hole. Centralizers @ 0', 10', + 20' f/bottom.
{Centralizers @ 0', 10', 20', 50', 70', 100', 130', 160', 190', 220', 250', 280', 310', 340', 370', 400', 430', 460', [illegible] f/bottom

1148 - Start placing casing (no screen) @ 20' + f/bottom.

1210 - Stop for heavy rain. Measure sand bag dimensions (50 lb bag) ≈ 1.4' x 1.0' x 0.33' ≈ 0.46 ft³ ≈ 3.4 gallons; comparable to volume per lineal foot of borehole = 10" diam. hole - 4.5" diam. PVC ≈ 3.3 gallons

1245 - Resume install of PVC; Anne [illegible] [illegible] arrive, left [illegible]

1430 - Finish placing PVC casing; bottom end [illegible] @ ~602' (bottom of hole @ 605 to 606' acc. to Pat)

1445 - Marc Fisher on site. Discuss [illegible] vs. tremie annular materials.

On-Job Time: 6.3 hr
Travel Time: 1 hr
Office Time: 0.5 hr
Total Time: 8 hr

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 9/29/08 Sheet 2 of 2
Report No.:
Project: City of Aurora - Deep Well Install Project No.: 152025.00
Client: Raimonde Drilling
Location: Aurora, IL
Contractor: Albrecht Well Drilling
Weather Conditions: Overcast/Rain, 65°F
Attachments:

- CONTINUED -

Pat called his boss (Harold) to discuss methods for tremie pour of sand + pellets into hole. Pat said they will make hopper to load annular materials down their 1¼" diameter tremie pipe. Concerned about bridging in pipe. Need to stop for day to prepare hopper.

1600 - Albrecht leaves site.

1605 - Marc F. and I observed tremie pipe; pipe is used + has lubricant on threads. Marc concerned about affects of lube on groundwater. {I called Anne L. later to discuss thread lube}.

1610 - I leave site. Marc F. closes gate/site.

On-Job Time: 6.5 hr.
Travel Time: 1 hr.
Office Time: 0.5 hr.
Total Time: 8.0 hr.

Prepared By: [signature]

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FIELD SUMMARY

Date: 9/30/08 Sheet 1 of 2
Report No.:
Project: City of Aurora - Deep Well Install Project No.: 152025.00
Client: Raimonde Drilling
Location: Aurora, IL
Contractor: Albrecht Well Drilling
Weather Conditions: Sun, 60-65°F
Attachments:

1005 - Arrive on site. Albrecht preparing for work. They brought all new 1¼" diameter PVC pipe for tremie of annular fill in well.
1012 - Measure groundwater in 4" PVC well casing (installed to depth ~602' on 9/29/08) at 50.8' bgs (58.8' b/ top of casing - 8.0' stickup)
1025 - Albrecht starts advancing tremie pipe down annulus outside 4" casing
1100 - Marc Fisher arrives. (leaves later ~1200; returns ~1400)
1105 - Finish advancing tremie pipe; encountered soft material ~603' (measured at 602' yesterday w/ well casing; may indicate error in well/tremie lengths)
1115 - Attach hopper, start water flow from steel tank (water supply b/ City of Aurora hydrant according to Dat).
1118 - Measure 1 full bag of sand in 5-gallon bucket w/ estimated 1-gallon marks (using ruler measure of full height ÷ 5); 1 bag ≈ 3.4 gallons, in agreement w/ my estimate f/ measuring bag yesterday
1122 - Start adding sand (10-20 coarse sand) to hopper
1157 - Added 4 full bags of sand, which theoretically should put sand level @ ~599 (603-4 = 599). Sound sand @ 598' w/ tremie pipe; close to theoretical (+1 ft.)
1230 - Measure after 4 more bags (8 total); top of sand @ 593', +2 ft above theoretical (595').
1310 - Measure after 4 more bags (12 total); top of sand @ 588', +3 ft above theoretical (591'). Consistent w/ last measurement ≈ 5' per 4 bags.
1340 - Measure after 4 more bags (16 total); top of sand @ 584', +3 ft above theoretical (587').

On-Job Time: 6.5
Travel Time: 1.5
Office Time: 0.5
Total Time: 7.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

.e: 9/30/08 Sheet 2 of 2

Report No.:

Project: City of Aurora - Deep Well Install Project No.: 152025.00

Client: Raimondo Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Sun/Clouds, 60-65°F

Attachments:

1437 - Measure after 8 more bags (24 total); top of sand @ 575.5'
+3.5' above theoretical (579')
- Total filter sand thickness = 603 - 575.5 = 27.5 ft.

1442 - Start adding fine sand; add 2 x 50 lb. bags

1514 - Measure fine sand at ~574', but tremie probably penetrated into fine sand 6-12", finally stopped thereafter; theoretical is ~573.5'
- Fine sand layer ~1.5 to 2.5 feet depending on penetration

1520 - Start placing bentonite pellets (1 x 50 lb. bucket Cetco 3/8" coated bentonite tablets) (1 x 50 lb. bucket Cetco 3/8" bentonite tablets)
→ report recommended weights of product per foot of well volume (label on bucket f/manufacturer)
@ 8" diameter (0.35 ft³/ft) → use 27.80 lb.
@ 10" diameter (0.55 ft³/ft) → use 43.68 lb. } 79.4 lb./ft³
→ only placed coated pellets; uncoated pellets of concern because hydrate more rapidly

1545 - Discuss pellet issues + timing for hydration prior to grout placement. Plan to obtain 2nd bucket of pellets tomorrow morning + place in hole (Wed.), then grout Thursday.

1635 - Leave site. Marc Fisher locks gate.
(All: drillers, Marc, me)

On-Job Time: 6.5
Travel Time: 0.5
Office Time: 0.5
Total Time: 7.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/1/08 Sheet 1 of 1

Report No.:

Project: City of Aurora - Deep Well Install Project No.: 153025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Sun, 55°F

Attachments:

0940 - Arrive @ Lafarge Conco to pick up 5 gallon bucket of coated pellets for Albrecht (ordered by Raimonde % Lafarge).

0945 - Deliver pellets to Albrecht @ Deep Well site. Pat + Dave are preparing for pellet installation. Call Anne to update.

0955 - Measure groundwater inside casing @ 62.3' (70.3 - 8.0 stickup)
- in annulus outside casing @ 49.3' (51.3 - 2.0 stickup steel casing)

1000 - Place 5-gallon bucket of coated pellets in hopper, down tremie.

1040 - Finish adding pellets, sound top of pellets @ 570' w/ tremie pipe ≈ 4' of pellets counting 1st 5-gallon bucket w/ yesterday.

1050 - Albrecht cuts 8" PVC casing off @ ~2.5' above ground, places lid over pipe + can swing drill shroud to hide. Pat says they plan to clean-up/pack equipment for the rest of their day.

1100 - Discuss w/ Pat that grout is different than what was discussed earlier w/ team. Call Anne, Mark K. (GZA), Marc Fisher. GZA will be on site tomorrow to observe grout placement.

1145 - Leave site.

Note: Called Marc Fisher prior to pellet pour, left voicemail. He returned call + gave OK to proceed without him on site.

On-Job Time: 2.0

Travel Time: 0.5

Office Time: 0.5

Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
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FIELD SUMMARY

Date: 10/2/08 — Sheet 1 of 1

Report No.:

Project: City of Aurora - Deep Well Install — Project No.: 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Sun, 55°F

Attachments:

0930 - Arrive on site. Albrecht setting up for grouting hole. granular Grout material: "Volclay" by Cetco, a high-solids bentonite grout
- mix recommendations on bag: 1x50lb. bag per 24 gallons water
- Albrecht's mix tank is ~75 gallons (marked on inside of tank)
- They plan to mix 3 bags per tank, mixed through drill pump, + tremie down hole

1012 - Measure groundwater in casing @ 53.7' (56.2' - 2.5' stickup).

1014 - Begin pumping water into annulus via tremie. Groundwater rises in pipe slowly ~2'/minute. Water outside pipe up to ~10' bgs.

1023 - Pat calls Albrecht PM. Discuss possible causes (broken pipe, bad seal, flow through sandstone). Will check inside casing diameter for constrictions.

~1130 - Advance 3¼" diameter coupler attached to 1¼" used tremie pipe down inside 4" diameter well casing to check for constrictions. (Marc F approved use of used tremie pipe). No constrictions detected. Driller thought some resistant @ ~535-540', but could not find constriction after rechecking.

~1300 - Make several phone calls: Mark Krumenacher (GZA), Harold (Albrecht owner), Marc Fisher, Anne Leslie (Raimonde)

Decision: use televideo camera to inspect inside of well casing tomorrow

1400 - Leave site. Albrecht breaking down equipment for the day.

On-Job Time: 4.5
Travel Time: 0.5
Office Time: 1.5 (phones)
Total Time: 6.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/3/08 Sheet 1 of 2

Report No.:

Project: City of Aurora – Deep Well Install Project No.: 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Overcast, 55°F

Attachments:

0910 – Arrive on site. Measure groundwater:
→ in well casing @ 103.8' (106.3 – 2.5')
→ in annulus @ 49.0' (51.0 – 2.0')
Anne Leslie (Raimonde), Pat & Casey (Albrecht), & Andy (Municipal Well & Pump – video camera unit for well inspection) all on site.
0920 – Municipal sets up & starts viewing of casing. Clear water to ~470', slow increase in cloudiness (particulates) w/ depth to 559', then abruptly cloudy & no light visible in camera @ 560'.
~1045 – Place water in casing to top (~100'), cloudy water migrates down to screened interval @ ~585' in ~5 minutes (rate ~5 feet per minute). Once @ 585, cloudy water does not leave pipe (b/c w/in screened interval?)
~1115 – (Marc Fisher on site ~1000) – Discussion between Marc F., Anne L., & Pat re: grout vs. chips. Decide to grout above Pecatonica Dolomite (lowest member of Platteville Group), or ~500' bgs (≈70' of grout). Let cure over weekend, then test pressuring annulus again & see if water in well casing remains the same. Anne leaves site. Municipal retrieves camera. Set up for grouting.
1215 – Start mixing & placing grout. First 75-gallon tank (3 bags) set f/ ~570' to 550' (theoretical), but Pat said tremie tip at 540'. Suggested placing grout w/ tremie tip below grout level. Second 75-gallon tank placed f/ ~550' to 530' w/ tremie tip at 540', then third tank f/ 530–510' w/ tip at 540'. Raise & remove 20' of tremie, place 4th tank f/ 510–490' w/ tip @ 520'. Raise & remove 20' of tremie, place 5th tank f/ 490–470' w/ tip @ 500'.

On-Job Time: 7 hr.
Travel Time: 2.5 hr.
Office Time:
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
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FIELD SUMMARY

Date: 10/3/08 Sheet 2 of 2

Report No.:

Project: City of Aurora - Deep Well Install Project No.: 15202 5.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Sun, 60°F

Attachments:

1255 - Done placing grout, withdraw + rinse out tremie pipe. Set tremie pipe at 420' tip depth.

Summary: (using volume calculation below)

Tank	Approx. Depth	Tremie Tip	Above/Below Grout Line
1	550-570'	540	+10 to +30'
2	530-550'	540	-10 to +10'
3	510-530'	540	-30 to -10'
4	490-510'	520	↓
5	470-490'	500	↓

While tip of tremie at 420' & running water to clean tremie, clear water ran out of steel casing at ground surface. At same time, water inside well casing was ~static at ~18' (higher from having filled w/ water prior to placing grout).

1400 - Albrecht cleaning up for weekend. I leave site after calling Mark K.

Volume Calculation:

10" diam. hole - 4.5" diam. casing = $\left(\frac{5}{12}\right)^2\pi - \left(\frac{2.25}{12}\right)^2\pi$ = 0.5454 - 0.1104 = 0.4350 ft³/ft

∴ in gallons = 3.3 gallons/ft

~~75 gallon tank @ 3.3 gallons/ft.~~ = 23 feet/tank ≈ 20 feet/tank

(conservative estimate for errors in tank volume, boring diam., etc.)

On-Job Time: 7 hrs.
Travel Time: 1.5 hrs.
Office Time:
Total Time:

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/6/08 — Sheet 1 of 3

Report No.:

Project: City of Aurora - Deep Well Install — **Project No.:** 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Sun, 60°F

Attachments:

0955 - Arrive on site. Albrecht set up for grouting hole. Pat says pumped water into annulus through tremie @ ~0945 (~100 gallons). No water observed coming out of annulus or well casing.

1000 - Try to measure groundwater in casing; deeper than 203' below top of casing = maximum reach of tape.

1005 - Start mixing + placing grout. Tremie at ~460' bgs, grout @ ~470' based on theoretical calculations. Pat (Albrecht) says grout likely soft + could plug tremie if we sound bottom (i.e. top of grout). Will leave tremie deep for several tanks of grout. Still mixing 3 bags w/~75 gallons water per tank.

Tank	Approx. Depth	Tremie Tip	Above/Below Grout Line
6*	450-470'	460'	-10' to +10'
7	430-450'	460'	-30' to -10'
8	410-430'	460'	-50' to -30' (A)
9	390-410'	440'	-50' to -30' (B)
10	370-390'	420'	-50' to -30'
11	350-370'	400'	-50' to -30' (C)
12	330-350'	380'	-50' to -30'
13	310-330'	360'	-50' to -30'
14	290-310'	340'	-50' to -30'

* continued count from 5 tanks placed on 10/3/08

(A) observe water in annulus up within 10' of ground surface after 3 tanks

(B) Pat says pressure of tremie pump ~50-75 psi, ok for maintaining this grout head

(C) Water coming out of annulus at ground surface

On-Job Time: 4.5

Travel Time: 5

Office Time:

Total Time: 9.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/6/08 | Sheet 2 of 3

Report No.:

Project: City of Aurora - Deep Well Install | Project No.: 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Overcast, 65°F

Attachments:

Tank	Approx. Depth	Tremie Tip	Above/Below Grout Line
15	270'-290'	320'	-50' to -30' (at least)
16	250'-270'	(did not observe;	↓
17	230'-250'	discussions re:	
18	210'-230'	well development) ↓	
19	190'-210'	240' (counted removed pipes)	
20	170'-190'	220'	
21	150'-170'	200'	
22	130'-150'	180'	
23	110'-130'	160'	
24	90'-110'	140'	
25	70'-90'	120'	↓

END - grout coming out annulus after ~25 tanks of grout.
{The actual grout volume here is close to theoretical volume. See p. 3 of this field report for calculations.}

1140 - Stop to refill water tank - truck. Truck was full ≈ 1200 gallons according to gauge @ back. 1200 - 100 gallons for initial test = 1100 ÷ 75/tank = 14.67 tanks ≈ 15 tanks ✓
{pause after tank #20 = 15 tanks thus far}

1145 - Water in casing still below 203' from top of casing (exceeds tape reach).
1200 - Resume grout placement.

On-Job Time: 4.5
Travel Time: 5
Office Time:
Total Time: 9.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

.te: 10/6/08 Sheet 3 of 3
Report No.:
Project: City of Aurora - Deep Well Install Project No.: 152025.00
Client: Raimonde Drilling
Location: Aurora, IL
Contractor: Albrecht Well Drilling
Weather Conditions: Sun/Overcast, 65°F
Attachments:

1240 - Grout at ground surface out of annulus after pumping tank #25. This is in agreement with theoretical volume of grout.

{Note: 20-foot intervals used for convenience on preceding pages. Actual volume calculation below}

570' grouted interval x 3.3* gallons/foot = 1880 gallons
(*see calculation from 10/3/08 field report)
1880 gallons ÷ 75 gallons/tank = 25.1 ≈ 25 tanks

1245 - Albrecht starts cleaning up + withdrawing tremie pipe. Also ~~try~~ to measure groundwater level in well casing w/ string + weight. Did not hear splashing of weight in casing. String dry after retrieved from casing. Used all of string. Albrecht measured string length by laying out straight on ground + measuring increments w/ 100' tape. Final measurement = 385', indicates groundwater below 385'.

~1330 - After calls w/ Anne Leslie (Raimonde), Anne directed Albrecht to fill well casing w/ water because of concern w/ pipe collapse.

1400 - Discuss work plan w/ Albrecht. They plan to install pump tomorrow. Call Mark Krummenacher re: status. Call w/ Marc Fisher; Deuchler will provide "ESD" water level tomorrow. Discuss effect of water placed in casing on static groundwater level. Leave site at 1430.

On-Job Time: 4.5
Travel Time: 5
Office Time:
Total Time: 9.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/7/08	Sheet 1 of 2
Report No.:	
Project: City of Aurora - Deep Well Install	Project No.: 152025.00
Client: Raimonde Drilling	
Location: Aurora, IL	
Contractor: Albrecht Well Drilling	
Weather Conditions: Overcast, 65 °F	
Attachments:	

1000 - Arrive on site. Albrecht not on site, but gate "dummy-locked" + new gear on site.

1030 - Marc Fisher arrives, has spec sheet for pump that shows 4" diameter pump will be used. Calls to Raimonde re: pump + status.

1125 - Drillers arrive, start setting up for pump install. Pat (Albrecht) says pump is 3-inch diameter, not 4-inch. Will install 1-inch diameter, Schedule 80 PVC pipe w/ pump to near surface; pipe has threads. Pipes will be attached using threaded PVC couplers w/ teflon tape.

1135 - Measure groundwater in casing using Deuchler's 650-foot electric tape. (Solinst Water Level Meter Model 101) Water at 199.1' bgs (201.6 - 2.5 stickup).

[1?]10 - Measure bottom of casing/well at 604.5' bgs (607.0 - 2.5 stickup).

1215 - Albrecht starts lowering pump connected to 1" PVC pipe. Power cable attached to PVC in lower 3' using electric tape over full length (i.e. completely wound around lower 3' to bundle wires against pipe). Cable attached above at ~10' increments to PVC pipe using plastic zip ties, one above + below each coupler, and one ~½ way down each length of 20-foot-long PVC pipe.

1340 - Albrecht stops installation due to rain.

1400 - Hook up pump cable to trailer generator + start developing well. Once at steady rate, measure flow rate @ outlet using 5-gallon bucket. After several measurements, bucket filled in 50 to 55 seconds. (~5.5 to 6 gpm)

1419 - 5 gpm - filled bucket in ~1 minute

1427 - 3.5 gpm, then "sucked air", lost suction ∴ pumped down to pump level @ 440' bgs. Stop pumping + let water recharge into casing.

1437 - After 10 minutes, try to restart pump. No flow after several attempts.

1457 - Measure groundwater @ 439' bgs (441.5 - 2.5 stickup). Leave tape on @ 429' bgs.

On-Job Time: 6.5
Travel Time: 2.5
Office Time: 0.5
Total Time: 8.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

(Da)te: 10/7/08 **Sheet** 2 **of** 2

Report No.:

Project: City of Aurora - Deep Well Install **Project No.:** 152025.00

Client: Raimondo Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Rain, 60°F

Attachments:

1512 - Measure groundwater at 440' bgs (~442.5 - 2.5 stickup). Indicates lower groundwater level, or infiltration into St. Peter Sandstone @ ~1 ft. per 15 min (~4 ft/hr.). Static water must be deeper than ~440'.

1515 - Add 40 ft. more of 1" PVC pipe; pump @ 480'

1530 - Start pumping. Measure pump rate at ~2.5 to 3 gpm using 5 gallon bucket.

1540 - Lost suction - dry casing to pump @ ~480'. Discussions re: well collapse concerns w/ Albrecht, Anne L., Marc F., and John 3. (vendor for pipe-CME). Decide to leave well overnight and check water level first thing.

1630 - Leave site, lock gate (others already left or leaving).

On-Job Time: 6.5
Travel Time: 2.5
Office Time: 0.5
Total Time: 8.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

Date: 10/8/08 Sheet 1 of 2

Report No.:

Project: City of Aurora - Deep Well Install **Project No.:** 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: Overcast, 55°F

Attachments:

0930 - Arrive on site. Anne Leslie already here.
0938 - Albrecht arrives on site, Marc Fisher arrives shortly thereafter.
0942 - Measure groundwater using Deuchler's electric tape at 484.8' bgs (487.3'-2.5')
Albrecht starts splicing wires to prep for lowering pump (needs more cable).
1005 - Marc Fisher leaves site.
1048 - Pump set at 588' for development; groundwater @ ~475' after lowering pump to 588'
1107 - Start pumping. Water is clear.

1123 - Water turns cloudy after ~16 minutes pumping (roughly 30 gallons) which is what the pipe should have had in it from previous pumping. Turbid water = water from screened interval @ 588'. Pump rate has been steady @ 5 gallons per 2:45 minutes:sec for ~4 to 5 measurements; casing water level at 500.1 ft bgs.
Turbidity of first cloudy water = 356.5 ntu (wash water = 2.97 ntu)
1130 - Water was clearing, then became more cloudy. Casing water level @ 500.3' bgs.
1143 - Pump rate @ 1.7 gpm, water less cloudy. Turbidity at 79.42 ntu. Casing water level @ 500.6' bgs.
1157 - Turbidity measured at 44.07 ntu. (Rinse water @ 0.19 ntu). Casing water level at 500.7' bgs.
1220 - Turbidity 21.82 ntu, pump rate 5 gallons/3 min. (1.7 gpm), casing water level at 500.6' bgs.
1245 - Turbidity 10.74 ntu, pump rate 1.7 gpm, casing water level @ 500.6' bgs.
1310 - Turbidity 5.99 ntu, pump rate 1.7 gpm, casing water level @ 500.7' bgs.
1342 - Turbidity 9.16 ntu, pump rate 1.7 gpm. Albrecht placing bentonite chips in annulus

On-Job Time: 7
Travel Time: 2.5
Office Time:
Total Time: 9.5

Prepared By: [signature]

GZA GeoEnvironmental, Inc.
Engineers and Scientists

FIELD SUMMARY

te: 10/8/08 Sheet 2 of 2

Report No.:

Project: City of Aurora - Deep Well Install Project No.: 152025.00

Client: Raimonde Drilling

Location: Aurora, IL

Contractor: Albrecht Well Drilling

Weather Conditions: overcast, 58°F

Attachments:

1355 - Turbidity at 5.70 ntu, casing water level at 500.7' bgs.
1403 - Take another water sample: turbidity at 4.55 ntu. Wait 5 min., tap vial to dislodge air bubbles, retest same sample: 3.48 ntu. Repeat same process, same sample: 3.27 ntu. Discuss sampling for turbidity w/ Anne L., who plans to test turbidity tomorrow.
1425 - Leave site. Albrecht & Anne L. still on site.

On-Job Time: 7

Travel Time: 2.5

Office Time:

Total Time: 9.5

Prepared By: [signature]

APPENDIX C

Boring Log

GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No	DH-01
Page No.	1 of 15
File No.	20 0152025.00
Checked By.	M Krumenacher

Drilling Co.	Raimonde Drilling Corporation		
Foreman	Terry Koch	Rig Type	CME-75 (truck mounted)
GZA Rep.	Erick Staley	Method	
Date Start	7/16/08 End 7/24/08	Hole Dia.	
Loc. Coord.		Other	
GS. Elev.	670'		

Groundwater Readings

Date	Time	Depth (ft)	Casing Depth	Stab. Time

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
	Over-Burden							0-2.5' **TOPSOIL and FILL**	0' TOPSOIL and FILL	1
								2.5-5 5' Crushed rock (FILL)	2 5' FILL	
								5.5-7' Fine to medium SAND and SILT, brown	5 5' SAND and SILT	
								7-8' Boulders and cobbles	7' BOULDERS and COBBLES	
								8-12' Silty SAND	8' SAND and SILT	
								12-41.5' Abrupt change to strong drill resistance at 12'; cuttings consist of very fine grit, light gray/beige **(DOLOMITE)**	12' DOLOMITE	
								41.5-42.5' Cuttings change to dark gray at 41.5' for approx. 1' **(SHALE)** then back to light gray/beige **(DOLOMITE)**		2 3
48										4
49		1	48 - 48.6	100	100	0		48-48.6' **DOLOMITE**, strong to very strong, light gray to greenish-gray, microcrystalline w/ rare fossils (brachiopods), fresh, minor pitting/competent, rare vugs associated w/ fossil shelters (<1/4" diameter), core only 7" broken up during retrieval, uppermost sample has 1" pod of white chert	48' SILURIAN ELWOOD FORMATION DOLOMITE	
		2	48.6 - 58	100	92	85		48.6 53.1' **DOLOMITE**, as above, white deleterious chert pods at approx. 49 5', orange oxidation at 49 6', 50 5' associated w/ increased pitting and vugs up to 1/4" x 1/2" in size, wavy bedding throughout (stylolites)		
50, 1, 52, 53										
54, 55, 56, 57								53 1-57.7' **DOLOMITE**, strong, medium to light gray, vuggy w/ abundant small interconnected vugs lined w/ secondary crystals, orange oxide stained at 53.5' and from 55.5 to 57', intensely fractured, green clay beds <1/4" thick at 54', 55.4', 55.6', 55 8 and 57 5-57.8', pyrite at approx. 54' in broken zone, mechanical breaks at 48 9', 49.2', 50.1', 51.1', 51 6', 52 1', 52.7', 53-53 2', 54' (pyrite zone), 54.2-54.5', 55 1', 55.3', 56.6', 57' and 57.3', horizontal partings/fractures at 53 5', 53.7 54', 55 4', 55 6, 55 8' and 57 5-57 8', vertical fracture at 56.6-57'	53' ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON FORMATION DOLOMITE	
58, 59		3	58 - 64	100	92	82		57 7-58 2 **DOLOMITE**, as above, interbedded w/ light green/gray, microcrystalline dolomite w/ few pits and green clay-filled irregular seams	57.7' ORDOVICIAN MAQUOKETA GROUP BRAINARD FORMATION DOLOMITE	
60, 61, 62, 63								58.2-63 5 **DOLOMITE**, argillaceous, strong, light green/gray, fresh to slightly decomposed, competent, medium to thinly bedded w/ green clay-filled wavy bedding and partings <1/4" thick, rare siliceous pods <1" thick from 62-64' (deleterious chert), no reaction to HCl, horizontal partings and fractures at 58.2', 58 9-59.3', 59.7', 59.9', 60.5', 60.7', 61.1' and 61 5'		
64, 65		4	64 - 68	100	100	83		63 5-68' **SHALE**, dolomitic, strong, light green/gray to medium green, fresh, competent, massive to vaguely laminated, green/gray zones more calcareous (more of an argillaceous dolomite), including some solution pitting, chert pods rare throughout up to 2" thick irregular orientation, mechanical breaks along irregular bed partings	63 5' SHALE	
66, 67										

1 Start drilling at 9 06 am on July 16, 2008, using 8-inch diameter tricone bit, no casing Drill to 19 5 feet
2 Switch to 6-inch OD casing, advance casing to 19 5 feet
3 Switch to PQ core casing with rock bit set within 6-inch OD casing; drill from 19 5 feet to 48 feet without sampling
4 Switch to HQ coring at 48 feet through PQ casing; start core log of boring

GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01
Page No. 2 of 15
File No. 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
69		5	68 - 78	100	100	82		68-72.5' **SHALE**, dolomitic, strong, light green/gray to medium green, massive, vaguely laminated, fresh, competent, green/gray zones more calcareous (more of an argillaceous dolomite), including some solution pitting, chert pods common throughout up to 2" thick, irregular orientation, mechanical breaks along irregular bed partings, one clay/chert zone brecciated by drilling at 70.7-71.1'	68' SHALE	
70										
71										
72										
73								72.5-75.5' **DOLOMITE**, argillaceous, strong, light green/gray, fresh, pitted, rare light gray chert pods, moderately to slightly fractured, stained red and more intensely pitted along fracture at 75.2', fractures inclined 10 to 30° at 72.3-73.2', 74.1', 75.4', 75.8' and 77.5' (especially along chert boundaries)	72.5' DOLOMITE	
74										
75										
76								75.5-81' **SHALE**, as above, subhorizontal partings around chert pods (moderately fractured)	75.5' SHALE	
77										
78										
79		6	78 - 88	100	100	96				
80										
81										
82								81-82' **SHALE**, as above, less fractures, vugs and pits in calcareous zones, horizontal fractures at 79.5' and 79.8' along edges of calcareous zones, no staining 82-98' **SHALE**, strong, green, aphanitic, laminated, fresh, competent, unfractured, has thin dark gray laminations within green fracture at 96-98', chert absent w/ depth		
83										
84										
85										
86										
87										
88										
89		7	88 - 98	100	100	100				
90										
91										
92										
93										
94										5
95										
96										
97										
98										
99		8	98 - 108	100	100	100		**SHALE**, as above, green grades out at 100' to alternately dark and medium gray, laminated		
100										
101										
102										
103										

Notes:
5. Driller comment: losing water slowly at 93 feet (continue to lose water through remainder of drilling).

GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01
Page No. 3 of 15
File No. 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
104								SHALE, strong, dark and medium gray, aphanitic, laminated, fresh, competent, unfractured, chert absent w/ depth 104' 2" thick calcareous bed w/ 1-1/2" x 1/2" vug		
105										
106										
107										
108										
109		9	108 - 118	100	100	100		SHALE, as above, similar calcareous/coarser-grained beds at 109.5', 112.2' and 114.4'		
110										
111										
113										
114										
115										
116										
117									SHALE	
118										6 7
119		10	118 - 128	100	100	100		Interstratified, gray SHALE and light gray calcareous SHALE, strong, laminated within each shale type, fresh, competent, fractures (mechanical) along laminations		
120										
121										
122										
123										
124										
125										
126										
127										
128										
129		11	128 - 138	100	100	100	1	128-136.1' SHALE, as above, w/ calcareous, lenticular nodules up to 2" long w/ vugs at center at 134', increasing calcareous material below 135'		
130										
131										
132										
133										
134										
135										
136										
137								136.2-138' SHALE, strong, dark gray, laminated, fresh, competent, unfractured, occasional lenses and stringers of black, fossiliferous zones w/ some white recrystallization		
138										
39		12	138 - 148	100	100	100		138-138.7' SHALE, as above 138.7-139.8' LIMESTONE, argillaceous, strong, thin bedding, slightly decomposed to fresh, slightly disintegrated w/ some pits and pyrite mineralization, unfractured, consists of fossil debris, recrystallized carbonate material, clasts of shale mixed w/ carbonate up to 1/2" diameter	138' ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON FORMATION	

Notes:
6. Stop drilling at 118 feet at 5:50 pm on July 16, 2008
7. Measure groundwater prior to drilling at 48 feet at 6:40 am on July 17, 2008, resume drilling at 6:57 am on July 17, 2008.

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ROCK CORE LOG
Aurora, Illinois

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
140								139.8-155' Interstratified, strong, dark gray **SHALE** and fossiliferous/calcareous, strong, gray and white SHALE, beds thin to laminated, fresh, competent, calcareous beds only weak to no reaction w/ HCl, some pyrite mineralization in calcareous beds, uppermost zone (139.8-140.2') has calcite-filled burrows	139.8' **ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON - SCALES FORMATION (Transitional Zone)**	
141										
142										
143										
144										
145										
146										
147									SHALE	
148										
149		13	148 - 158	100	100	100				
150										
151										
152										
153										
154										
155										
156								155-158' **SHALE**, strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3°	155' **ORDOVICIAN MAQUOKETA GROUP SCALES SHALE**	
157										
158										
159		14	158 - 168	100	100	97	1	158-161.4' **SHALE**, as above, 1/2" diameter pyrite crystal in matrix at 159'		
160										
161										
162								161.4-164.1' **SHALE**, as above, medium gray w/ black stringers and zones, calcareous shale beds <1" thick each at 161.4' and 164.1'		
163										
164									SHALE	
165								164.1-167.2' **SHALE** strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3°, horizontal fractures		
166										
167										
168								167.2-167.6' **SHALE**, medium gray, laminated, several calcareous zones and calcite mineralization		
169		15	168 - 178	100	100	100		167.6-168' **SHALE**, strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3°, possible natural fracture (bed parting) at 167.7', ground down by drilling		
170								168-178' **SHALE**, as above		
171										
172										
173										
74										

Notes:

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
175								SHALE, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3°, horizontal fractures, ground down by drilling		
176										
177										
178										
179		16	178 - 188	100	100	93	4	178-182.8' SHALE, as above		
180										
181										
182										
183								182.8-183.2' SHALE, moderate to weak, green/gray, brecciated along horizontal and vertical cracks (very intensely fractured), decomposed to green clay along fractures, slightly decomposed away from fractures, sticky clay-healed fractures 183.2-183.5' SHALE, strong to moderate, dark gray, laminated, vertical fractures, fresh, no infilling, abruptly terminates at bed plane 183.5-188' SHALE, as above, w/out natural fractures		
184										
185										
186										
187										
188										
189		17	188 - 198	100	100	100		SHALE, strong to moderate, dark gray, laminated, fresh, competent, unfractured, rare pyrite mineralization/nodules throughout up to approx. 1/2" diameter	SHALE	
190										
191										
192										
193										
194										
195										
196										
197										
198										
199		18	198 - 208	89	78	78		198-207' SHALE, as above, some brecciated zones at 202.8', 204.5' and 205.5'		8
200										
201										
202										
203										
204										
205										
206										
207								207-208' DOLOMITE, argillaceous, strong, light gray and white banded, microcrystalline, laminated, slightly decomposed but abundant recrystallization as pyrite and calcite, vertical fracture at 207.5' w/ pyrite and calcite cement		
208									207' ORDOVICIAN GALENA GROUP WISE LAKE FORMATION	
209		19	208 - 218	100	100	100		See Page 6		

Notes:
8. Recovered approximately 5 feet in first pull, went back down and retrieved remaining core with some rotation (probably brecciated core and accounts for last 1.1 feet of core length.

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
								208-218' **LIMESTONE**, strong to very strong, light brownish-gray, microcrystalline w/ abundant white recrystallized laminations of calcite, thickly to thinly bedded along stylolitic bed contacts, slightly decomposed, pitted and w/ vugs <1", lined w/ calcite pyrite and black mineralization (sulfides?), only mechanically fractured along stylolitic partings (weak reaction to HCl except for white seams and bodies), partings mostly coated w/ black mud and mineralization <1 mm thick		
210										
211										
212										
213										
214										
215										
216										
217										
218										
219		20	218 - 228	100	100	100		218-219.7' **LIMESTONE**, as above		
220								219.7-219.8' Moderately disintegrated zone w/ iron staining and abundant stylolites, horizontal fracture coated w/ mineralization		
221								219.8-228' **LIMESTONE**, strong to very strong, light brownish-gray, microcrystalline w/ abundant white recrystallized laminations of calcite, some white recrystallized zones, thickly to thinly bedded along stylolitic bed contacts, slightly decomposed, pitted and w/ vugs <1", only mechanically fractured along stylolitic partings		
222										
223									LIMESTONE	
224										
225										
226										
227										
228										
229		21	228 - 238	100	100	100		228-233' **LIMESTONE**, as above		
230										
231										
232										
233										
234								233-238' **LIMESTONE**, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl		
235										
236										
237										
238										
239		33	238 - 248	100	100	100		**LIMESTONE**, as above		
240										
241										
242										
243										
14										

Notes:

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Depth (feet)	Graphic Log	Sample Information		Mechanical Core Log				Sample Description and Classification	Generalized Stratum Description	NOTES
		Core Run No.	Core Run Interval Depth (feet)	TCR (%)	SCR (%)	RQD	IF			
245								LIMESTONE, brown/gray, strong to very strong, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl		
246										
247										
248										
249		23	248 - 258	100	100	100	1	LIMESTONE, as above, occasional dolomitic zones (lesser reaction to HCl), natural, horizontal fracture at intensely stylolitized zone at 257.6'		
250										
251										
252										
253										
254										
255										
256										
257										
258									LIMESTONE	
259		24	258 - 268	100	100	100		LIMESTONE, as above		
260										
261										
262										
263										
264										
265										
266										
267										
268										9
269		25	268 - 278	100	100	100		LIMESTONE, as above, mechanical breaks at 280.5', 281.8', 282.5' and 285.5' at stylolitic partings		10
270										
271										
272										
273										
274										
275										
276										
277										
278										
279		26	278 - 288	100	100	100		LIMESTONE, as above, mechanical breaks at 278.3', 280.3', 280.6', 282.3', 284.9', and 287.8'		

Notes:

9. Stop drilling at 268 feet at 5:45 pm on July 17, 2008; measure groundwater at 45.5 feet at 5:48 pm on July 17, 2008.

10. Measure groundwater prior to drilling at 48.1 feet at 6:39 am on July 18, 2008; resume drilling at 7:53 am on July 18, 2008.

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
280								LIMESTONE, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl w/ occasional dolomitic zone (lesser reaction to HCl)	280' ORDOVICIAN GALENA GROUP WISE LAKE - DUNLEITH FORMATION (Transitional Zone)	
281										
282										
283										
284										
285									LIMESTONE	
286										
287										
288										
289		27	288 - 298	100	100	100	1	LIMESTONE, as above, mechanical breaks at 289.8', 292.2', 294.5', 296.9' and 297.7', horizontal fracture in heavily stylolitized zone (w/ 1" thick zone) at 293.4', approx. 2" irregular void at 297.6' filled in w/ sparry calcite		
290									290' ORDOVICIAN GALENA GROUP DUNLEITH FORMATION	
291										
292										
293										
294										
295										
296										
297										
298										
299		28	298 - 308	100	100	100	1	LIMESTONE, as above, some gray, recrystallized zones (slightly coarser-grained, dolomitic crystals visible), mechanical break at 299.4', 302.1' and 303.1', horizontal fracture in approx. 1/2" thick stylolitized zone at 301.4', mechanical break at 302.1' ground-up to tapered ends		
300										
301									LIMESTONE	
302										
303										
304										
305										
306										
307										
308										
309		29	308 - 318	100	100	100		LIMESTONE, as above, dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter, mechanical break at 309.3', 310.7', 311.8', 312.5' (ground-up), 314.8' and 317.5'		
310										
311										
312										
313										
14										

Notes:

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Depth (feet)	Graphic Log	Core Run No.	Core Run Interval Depth (feet)	TCR (%)	SCR (%)	RQD	IF	Sample Description and Classification	Generalized Stratum Description	NOTES
315								LIMESTONE, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter		
316										
317										
318										
319		30	318 - 328	100	100	100		LIMESTONE, as above, stylolitic partings have less clayey debris, mechanical breaks at 320.6', 322.3' (ground-up), 325.1' and 326.8'		
320										
321										
322										
323										
324										
325										
326										
327										
328									LIMESTONE	
329		31	328 - 338	100	100	100		LIMESTONE, as above, mechanical breaks at 330.4', 332.3', 334.4' and 337.1'		
330										
331										
332										
333										
334										
335										
336										
337										
338										
339		32	338 - 348	100	100	100		LIMESTONE, as above, mechanical breaks at 341.2', 346' and 347.5', 3" x 4" irregular body filled w/ harder microcrystalline siliceous material which is offset by fine fractures and filled w/ sparry calcite at 347.1', bodies have many fossils (replacement by silica)		
340										
341										
342										
343										
344										
345										
346										
347										
348										
49		33	348 - 358	100	100	100		LIMESTONE, as above, more fossiliferous, similar siliceous bodies at 348.4' and 352.8', both >2" diameter, mechanical breaks at 352.1', 352.6', 355.8' and 357.2'		

Notes:

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350								**LIMESTONE**, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, more fossiliferous, dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter		
351										
352										
353										
354										
355										
356										
357										
358										
359		34	358 - 368	100	100	100		**LIMESTONE**, as above, w/out siliceous bodies, mechanical breaks at 360.8', 362.4' and 365.7'		
360										
361										
362									LIMESTONE	
363										
364										
365										
366										
367										
368										
369		35	368 - 378	100	100	100		**LIMESTONE**, as above, mechanical breaks at 368.9', 372.5', 375.1' and 377.3', increasing dolomitization below 377.2'		
370										
371										
372										
373										
374										
375										
376										
377										
378										11
379		36	378 - 388	100	100	100		378-387' **DOLOMITIC LIMESTONE**, brown-gray bands (Dolomite) surrounding light brown/gray Limestone zones 2-4" thick, increasing stylolites, gray recrystallized zones from 384.5-387', mechanical breaks at 379.2', 380', 382.4', 383.2', 384.6', 386.2' and 387.2'	378'	12
380										
381									DOLOMITIC LIMESTONE	
382										
383										
84										

Notes:
11 Stop drilling at 378 feet at 4:29 pm on July 18, 2008; measure groundwater at 49.2 feet at 4:50 pm on July 18, 2008.
12. Measure groundwater prior to drilling at 47.3 feet at 9:15 am on July 21, 2008; resume drilling at 9:25 am on July 21, 2008

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
385								**DOLOMITIC LIMESTONE**, brown-gray bands (Dolomite) surrounding light brown/gray Limestone zones 2-4" thick, increasing stylolites	DOLOMITIC LIMESTONE	
386										
387										
388								387-388.6' **DOLOMITE**, strong to very strong, gray to brown/gray, microcrystalline, thinly bedded w/ stylolitic partings, slightly decomposed, pitted, vugs at 387.5' approx. 1" x 1/2", lined w/ dolomite and pyrite crystals, smaller vugs spread throughout below 387.5' w/ similar mineralization, vugs truncated at 387.5' along apparently uniform surface which is also marked by dark/light color contrast (possible contact) 388.6-389.9' **DOLOMITE**, very strong, gray w/ light brown/gray mottles, microcrystalline, medium bedded along stylolites, some pitting, no vugs 389.9-393.6' **DOLOMITE**, strong, gray, microcrystalline, medium to thinly bedded, slightly decomposed and pitted, but w/ 1/2" to 2" beds and lenses of tan, heavily pitted Dolomite or large vugs up to 2" diameter, moderately fractured at pitted dolomite/vug zones, 2" thick white chert pod (flinty) at 392.4', mechanical break at 393', 395.8' and 396.5', horizontal weakness/fracture at 390.8' (along large vug >2" diameter), 391.6', 391.9', 392.4' (above chert pod), 390.3' (several vugs) and 393.4'	387' DOLOMITE	
389		37	388 - 398	100	100	97	7			
390										
391										
392										
393										
394								393.6-394.3' **DOLOMITE**, strong, red/brown, microcrystalline, thinly bedded along abundant stylolites, slightly decomposed, slightly disintegrated, abrupt contact w/ gray dolomite at 394.3' 394.3-398' **DOLOMITE**, very strong, tan w/ some light gray mottling, microcrystalline, massive to thickly bedded, fresh, competent, moderately fractured along vertical planes, but healed (no cement evident, no staining), scattered vugs mostly <1/4" and some pitting	393.6' ORDOVICIAN GALENA GROUP GUTTENBERG FORMATION	
395										
396										
397									394.3' ORDOVICIAN PLATTEVILLE GROUP QUIMBYS MILL FORMATION	
398										
399		38	398 - 408	100	100	100	1	398-403.4' **DOLOMITE**, as above, white chert pods (deleterious) <1" thick at 399.1' and 399.4', mechanical breaks at 399.3', 400.1', 402.4' and 403', horizontal fracture at chert/dolomite contact at 399.4'		
400										
401									DOLOMITE	
402										
403										
404								403.4-405.5' **DOLOMITE**, very strong, mottled gray and tan, microcrystalline, massive to thickly bedded, fresh, competent to slightly disintegrated w/ 1" to 2" zones of more strongly pitted rock, mechanical breaks at 403.8' and 405'	403.4' ORDOVICIAN PLATTEVILLE GROUP NACHUSA FORMATION	
405										
406								405.5-408' **DOLOMITE**, as above, mottling grades out to more uniform brown/gray color, less pitting, mechanical breaks at 405.9' and 406.3'		
407										
408										
409		39	408 - 418	98	98	97	5	**DOLOMITE**, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, bound by stylolites, fresh, competent to pitted, vugs throughout up to 1" diameter, slightly to moderately fractured, clustered stylolites lead to horizontal fractures at 408.6', 409.3', 413.2' and 417.9', parting w/ beige chert pod (deleterious) at 416.3', mechanical breaks at 409.7', 410.4', 412', 412.5', 413.7', 414.7' and 415.6'		
410										
411									DOLOMITE	
412										
413										
414										
415										
416										
417										
418										
19		40	418 - 428	100	100	100	3	**DOLOMITE**, as above, stylolite clusters create horizontal fractures at 421.5', 424.6' and 425.6', mechanical breaks at 419.7', 420.9', 424.5' and 427'		

Notes:

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Depth (feet)	Graphic Log	Core Run No.	Core Run Interval Depth (feet)	TCR (%)	SCR (%)	RQD	IF	Sample Description and Classification	Generalized Stratum Description	NOTES
420								DOLOMITE, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, bound by stylolites, fresh, pitted, vugs throughout up to 1" diameter	DOLOMITE	
421										
422										
423										
424										
425										
426										
427										
428										
429		41	428 - 438	100	99	97	2	DOLOMITE, as above, zones colored/mottled gray to dark gray w/ more stylolites from 429.3' to 430.5' and 435.5' to 438', stylolite clusters create horizontal fractures at 428.9' and 430.3', other horizontal fracture at boundary w/ light gray chert pod (flinty) at 434.3', vug-rich zone at 432.5', mechanical breaks at 430.9', 431.7', 433.4', 435.2', 436.1' and 436.8'		
430										
431										
432										
433										
434										
435										
436										
437										
438										
439		42	438 - 448	100	99	99	2	438-444.4' DOLOMITE, as above, brown, vugs and white chert pods (flinty), horizontal fracture at chert pod at 439.4', mechanical breaks at 440.2', 440.6' and 442.5'	438' ORDOVICIAN PLATTEVILLE GROUP NACHUSA - GRAND DETOUR FORMATION (Transitional Zone) DOLOMITE	
440										
441										
442										
443										
444										
445								444.4-448' DOLOMITE, as above, gray and light brown mottled, fine clay partings <1 mm thick, wavy (may be clustered stylolites or fine clay laminations), horizontal fracture at 444.6', mechanical breaks at 445.8' and 447.3'	444.4' ORODIVICIAN PLATTEVILLE GROUP GRAND DETOUR FORMATION	
446										
447										
448										
449		43	448 - 458	100	100	100		DOLOMITE, as above, competent, no vugs or pits, breaks after several hammer strikes w/ conchoidal fracture, mechanical breaks at 452.3', 453.2', 454.5', 456.7' and 457.6'	DOLOMITE	
450										
451										
452										
453										
454										

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
455								**DOLOMITE**, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, fresh, no vugs or pits, competent, break after several hammer strikes w/ conchoidal fracture		
456										
457										
458										
459		44	458 - 468	100	100	100	5	458-466' **DOLOMITE**, as above, decreasing mottling w/ depth, horizontal/irregular fractures along shale partings at 459.2', 461.4', 463.6', 464.4' and 464.9', mechanical breaks at 460.2', 460.6', 462.3', 463.2', 464.2' and 465.5'		
460										
461										
462										
463										
464										
465										
466										
467								466-468' **DOLOMITE**, very strong, brown, microcrystalline, medium bedded, fresh, competent, mechanical breaks at 466.2', 466.4', 466.7' and 467.3'		
468										13
469		45	468 - 478	100	100	93	9	**DOLOMITE**, as above, thin shale partings leading to horizontal fractures in core, planar to wavy, 0-4° orientation, smooth to rough, wide to moderately narrow spaced, have <1 mm of shale, upper surfaces typically have fossil debris, lower surfaces have burrows and trails, horizontal fractures along flat or wavy shale partings at 468.8', 470.6', 471.3', 471.6', 472.9', 474.5', 476.8', 477.1' and 477.4', mechanical breaks at 469.8' and 473.5'		14
470										
471										
472									DOLOMITE	
473										
474										
475										
476										
477										
478										
479		46	478 - 488	98	98	98	4	478-481.1' **DOLOMITE**, as above		
480										
481										
482								481.1-488' **DOLOMITE**, very strong, gray, microcrystalline, thinly bedded to laminated w/ wavy shale partings (most <1 mm thick), fresh, competent, some pits and vugs, horizontal fractures along wavy/irregular partings, rare macrofossils up to 1", horizontal (bed partings) at 479.4', 481.3', 474.5' and 476.9'	481.1' **ORODIVICIAN PLATTEVILLE GROUP MIFFLIN FORMATION**	
483										
484										
485										
486									DOLOMITE	
487										
488										
89		47	488 - 498	102	102	97	4	**DOLOMITE**, as above, clusters of shale laminations around bodies of Dolomite, horizontal (bed partings) at 488', 491', 494.1', 497.7' and 498'		15

Notes:

13. Stop drilling at 468 feet at 6:11 pm on July 21, 2008, measure groundwater at 42.7 feet at 6:34 pm on July 21, 2008.
14. Measure groundwater prior to drilling at 47.2 feet at 6:21 am on July 22, 2008, resume drilling at 6:31 am on July 22, 2008
15. Rods have been tight/not easily advancing down hole after past three packer tests.

GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01

File No. 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
490								**DOLOMITE**, very strong, gray, microcrystalline, thinly bedded to laminated w/ wavy shale partings (most <1 mm thick), fresh, competent, some pits and vugs		
491										
492										
493										
494										
495									DOLOMITE	
496										
497										
498										
499		48	498 - 508	100	100	100		498-503.1' **DOLOMITE**, as above, bed parting at 501.3'		
500										
501										
502										
503										
504								503.1-508' **DOLOMITE**, very strong, light brown/gray, microcrystalline, massive, fresh, competent w/ some lenticular vugs up to 1" diameter, no shale partings, stylolites below 506', rare chert pods and lenticular siliceous zones, horizontal fracture at 506.7', mechanical breaks at 504.4', 505.9' and 507.6'	503.1' ORODIVICIAN PLATTEVILLE GROUP PECATONICA FORMATION	16
505										
506										
507										
508										
509		49	508 - 518	100	100	98	4	**DOLOMITE**, as above, pitted, increasing vugs up to 2" across, increasing chert (deleterious) and siliceous bodies up to width of core and 2" thick, slightly to moderately spaced horizontal fractures (bed parting/stylolite) at 514.6', 515.6', 517.3' and 517.5', mechanical breaks at 511.3', 513.9' and 516.5'		
510										
511										
512										
513										
514									DOLOMITE	
515										
516										
517										
518										17
519		50	518 - 525.7	100	100	100	3	518-522' **DOLOMITE**, as above, increasing pitted zones/recrystallized zones, mechanical breaks at 518.7', 519.4' and 521.7'		18
520										
521										
522										
523								522-525.7' **DOLOMITE**, as above, gray to gray/brown, thin (<1 mm) black shale partings, medium to thinly bedded, wavy bed partings, some vugs, horizontal fractures at 522.4', 523.9' and 524.7', mechanical breaks at 525.1' and 525.5'		
24										

Notes:
16. Abrupt contact, flat at 503.1 feet.
17. Stop drilling at 518 feet at 11:09 am on July 22, 2008; measure groundwater at 50.1 feet at 12:15 pm on July 22, 2008
18. Switch to NQ coring at 518 feet through HQ casing; start drilling at 11:40 am on July 24, 2008.

GZA GeoEnvironmental, Inc.
Engineers/Scientists
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01

File No. 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
525										
526		51	525.7 - 535.7	100	94	91	12	**DOLOMITE**, very strong, gray to gray/brown, microcrystalline, medium to thinly bedded, fresh, competent to vuggy w/ pitted/recyrstallized zones, increasing shale partings and clustered stylolites leading to horizontal fractures/partings, moderately fractured along vug-rich zones, two fractures oblique to core at 531' (65° from horizontal, very narrow, not healed, stained, rough) and 533.5' (60° from horizontal, extremely narrow, not healed, stained, mineralized, undulating), horizontal fractures at 527.1', 528.5', 529.1', 530.7', 531.2', 531.6', 532.3', 533.9', 534.4' and 534.9', mechanical breaks at 529.6', 532.9', 533.2', 534.6', 535.4' and 535.6'		
527										
528										
529										
530										
531										
532									DOLOMITE	
533										
534										
535										
536		52	535.7 - 545.7	82	80	39	3	535.7-538.8' **DOLOMITE**, as above, horizontal fractures at 536.8' and 538', mechanical breaks at 535.8', 536.1' and 536.5'		
537										
538										
539								538.8-539.6' **DOLOMITE**, as above, w/ some rounded, gray, fine Sand (quartz), sand content dramatically increases at 539.4'		
540								539.6-543.9' **SANDSTONE**, moderately strong, gray, fine-grained, massive, fresh, competent to slightly disintegrated, many mechanical breaks (horizontal) generally 1 to 3" apart, well cemented	539.6' **ORDOVICIAN ANCELL GROUP GLENWOOD FORMATION**	
541										
542										
543									SANDSTONE	
544										19
545										
546								**END OF ROCK CORE AT 545.7'**		
547										
548										
549										
550										
551										
552										
553										
554										
555										
556										
557										
558										
559										

Notes:

19 Did not recover 1.8' of core; collected approx. 100 g of light gray to white, loose Sand that came from core barrel. St. Peter Sandstone may have washed out of core barrel from 543.9-545.7'.

APPENDIX D

Packer Testing Data and Summary

Date Printe[...] [...]/2008 [...] 1 of 2

PACKER TESTING SUMMARY

Route 25 Repository Site — Aurora, Illinois — (SE Corner of Route 25 and Mettel Road) — HOLE NO: DH-01

Test Number	Date	Limits of Test Interval: Depth from Ground Surface (ft) to (ft)	Limits of Test Interval: Elevation (ft) to (ft)	Length of Test Interval (ft)	Borehole Radius (inches)	Borehole Diameter (feet)	Flow Rate (gpm)	Pressure at Meter (psi)	Estimated pressure loss due to pipe friction (psi)	Pressure Head above Meter (ft)	Depth to Groundwater (ft)	Total Head (ft)	Horizontal Permeability "k" (cm/sec)	Geologic Unit	Depth below Ground Surface (feet)	Rock Core Recovery (%)	Rock Quality Designation (RQD) (%)
1	7/17/08	208 to 228	462.0 to 442.0	20	1.9	0.32	2.4	20	0	46.5	50.0	96.5	6.6E-05	Ordovician Galena Group; Wise Lake Formation	208	100	100
							2.6	30		69.8		119.8	5.8E-05				
							3.0	40		93.0		143.0	5.4E-05		218	100	100
												Average	5.92E-05				
2	7/17/08	228 to 248	442.0 to 422.0	20	1.9	0.32	0.4	20	0	46.5	52.0	98.5	9.3E-06		228	100	100
							0.3	30		69.8		121.8	5.5E-06				
							0.5	40		93.0		145.0	9.0E-06		238	100	100
												Average	7.95E-06				
3	7/18/08	248 to 268	422.0 to 402.0	20	1.9	0.32	0.0	20	0	46.5	48.0	94.5	4.0E-07		248	100	100
							0.0	29		67.4		115.4	0.0E+00				
							0.0	41		95.3		143.3	0.0E+00				
							0.0	50		116.3		164.3	0.0E+00		258	100	100
												Average	9.89E-08				
4	7/18/08	268 to 288	402.0 to 382.0	20	1.9	0.32	0.0	20	0	46.5	48.0	94.5	1.4E-06		268	100	100
							0.0	31		72.1		120.1	8.7E-07				
							0.1	40		93.0		141.0	1.5E-06				
							0.1	49		114.0		162.0	1.3E-06		278	100	100
												Average	1.26E-06				
5	7/18/08	288 to 308	382.0 to 362.0	20	1.9	0.32	0.1	31	0	72.1	48.0	120.1	1.3E-06	Trans. Zone	288	100	100
							0.0	40		93.0		141.0	0.0E+00				
							0.1	49		114.0		162.0	2.2E-06	Dunleith Formation	298	100	100
												Average	1.18E-06				
6	7/18/08	308 to 328	362.0 to 342.0	20	1.9	0.32	-	-	0		48.0				308	100	100
							0.0	40		93.0		141.0	9.3E-07				
							0.1	50		116.3		164.3	1.6E-06		318	100	100
												Average	1.26E-06				
7	7/18/08	328 to 348	342.0 to 322.0	20	1.9	0.32	0.1	31	0	72.1	48.0	120.1	2.6E-06		328	100	100
							0.1	42		97.7		145.7	2.6E-06				
							0.1	50		116.3		164.3	9.6E-07		338	100	100
												Average	2.05E-06				
8	7/18/08	348 to 368	322.0 to 302.0	20	1.9	0.32	0.0	32	0	74.4	48.0	122.4	4.3E-07		348	100	100
							0.0	40		93.0		141.0	7.4E-07				
							0.0	55		127.9		175.9	3.0E-07		358	100	100
												Average	4.89E-07				

Aurora_PackerTests_REPORT.xls.xls\K Calcs

Date Printe[d] [.]0/2008 [Page] 2 of 2

PACKER TESTING SUMMARY

Route 25 Repository Site | **Aurora, Illinois** | **(SE Corner of Route 25 and Mettel Road)** | **HOLE NO: DH-01**

Test Number	Date	Limits of Test Interval: Depth from Ground Surface (ft) to (ft)	Limits of Test Interval: Elevation (ft) to (ft)	Length of Test Interval (ft)	Borehole Radius (inches)	Borehole Diameter (feet)	Flow Rate (gpm)	Pressure at Meter (psi)	Estimated pressure loss due to pipe friction (psi)	Pressure Head above Meter (ft)	Depth to Groundwater (ft)	Total Head (ft)	Horizontal Permeability "k" (cm/sec)	Geologic Unit (Group)	Geologic Unit (Formation)	Depth below Ground Surface (feet)	Rock Core Recovery (%)	Rock Quality Designation (RQD) (%)
9	7/21/08	368 to 388	302.0 to 282.0	20	1.9	0.32	0.0	32	0	74.4	47.0	121.4	4.3E-07	Ordovician Galena Group	Dunleith Formation	368	100	100
							0.1	40		93.0		140.0	1.1E-06					
							0.1	52		120.9		167.9	1.6E-06			378	100	100
												Average	1.02E-06					
10	7/21/08	388 to 408	282.0 to 262.0	20	1.9	0.32	1.1	32	0	74.4	47.0	121.4	2.3E-05		Dunleith Formation	388	100	97
							1.2	42		97.7		144.7	2.2E-05		G			
							0.9	51		118.6		165.6	1.4E-05	Ordovician Platteville Group	Q	398	100	100
												Average	1.98E-05					
11	7/21/08	408 to 428	262.0 to 242.0	20	1.9	0.32	0.7	32	0	74.4	47.0	121.4	1.5E-05		Nachusa Formation	408	98	97
							0.7	42		97.7		144.7	1.2E-05					
							0.6	52		120.9		167.9	9.6E-06			418	100	100
												Average	1.23E-05					
12	7/21/08	428 to 448	242.0 to 222.0	20	1.9	0.32	0.5	34	0	79.1	47.0	126.1	1.0E-05		Nachusa Formation	428	100	97
							0.6	44		102.3		149.3	1.0E-05					
							0.4	52		120.9		167.9	5.6E-06			438	100	99
												Average	8.57E-06					
13	7/21/08	448 to 468	222.0 to 202.0	20	1.9	0.32	0.4	34	0	79.1	47.0	126.1	8.6E-06		Grand Detour Formation	448	100	100
							0.5	47		109.3		156.3	7.5E-06					
							0.3	56		130.2		177.2	4.7E-06			458	100	100
												Average	6.95E-06					
14	7/21/08	468 to 488	202.0 to 182.0	20	1.9	0.32	0.6	30	0	69.8	47.0	116.8	1.3E-05		Grand Detour Formation	468	100	93
							0.2	47		109.3		156.3	3.0E-06					
							0.2	57		132.6		179.6	2.9E-06			478	98	98
												Average	6.46E-06					
15	7/21/08	488 to 508	182.0 to 162.0	20	1.9	0.32	0.0	40	0	93.0	47.0	140.0	7.5E-07		Mifflin Formation	488	102	97
							0.1	49		114.0		161.0	9.8E-07					
							0.1	59		137.2		184.2	9.5E-07			498	100	100
												Average	8.90E-07					
16	7/21/08	508 to 518	162.0 to 152.0	10	1.9	0.32	0.8	40	0	93.0	47.0	140.0	2.6E-05		Pecatonica Fm.	508	100	98
							0.8	50		116.3		163.3	2.1E-05					
							0.4	61		141.9		188.9	9.0E-06			518	100	100
												Average	1.87E-05					

G = Guttenberg Formation
Q = Quimbys Mill Formation

Aurora_PackerTests_REPORT.xls.xls\K Calcs

PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)

DATE: 17-Jul-08	SHEET 1 OF 16		
BORING NO: DH-01		DRILLING COMPANY: Raimonde	
PROJECT NO: 20.0152025.00		INSPECTOR: EJS	
GROUND SURFACE EL: 670.0	BORING DIAMETER: 3.8 inches	TEST INTERVAL: 208 feet to 228 feet	
STATIC WATER LEVEL DEPTH: 50 feet	ELEVATION: 620.0	WATER PIPE I.D.: inch	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658.0	STATION:	OFFSET:
TOTAL BORING DEPTH: 228 feet	ELEVATION: 442.0	NORTHING:	EASTING:
SWL PSI:	TZ Baseline PSI:		

Test 1

TEST ZONE PRESSURE: 20
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60106.9	
1	60109.3	2.4
2	60111.6	2.3
3	60113.9	2.3
4	60116.5	2.6
5	60119.0	2.5

AVERAGE FLOW: 2.4
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2

TEST ZONE PRESSURE: 30
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60135.0	
1	60137.5	2.5
2	60139.8	2.3
3	60142.4	2.6
4	60145.2	2.8
5	60148.1	2.9
6	60150.8	2.7
7	60153.5	2.7

AVERAGE FLOW: 2.6
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time:

Test 3

TEST ZONE PRESSURE: 40
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60161.0	
1	60164.1	3.1
2	60166.9	2.8
3	60169.8	2.9
4	60172.6	2.8
5	60175.7	3.1
6	60178.7	3.0
7	60181.7	3.0

AVERAGE FLOW: 3.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

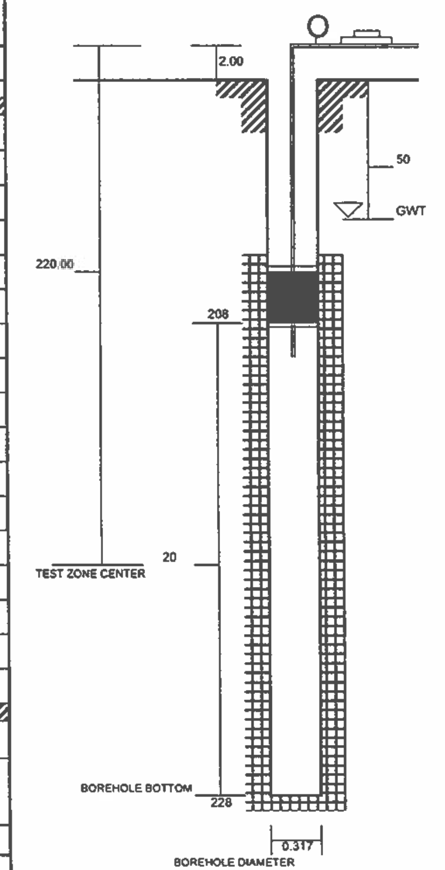
Test 5

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)

BORING NO: DH-01				DATE: 17-Jul-08	SHEET 2 OF 16
PROJECT NO: 20.0152025.00				DRILLING COMPANY: Raimonde	
GROUND SURFACE EL: 670	BORING DIAMETER: 3.8 inches			INSPECTOR: EJS	
STATIC WATER LEVEL DEPTH: 52 feet	ELEVATION: 618			TEST INTERVAL: 228 feet to 248 feet	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658			WATER PIPE I.D.: 0 inch	
TOTAL BORING DEPTH: 248 feet	ELEVATION: 422			STATION:	OFFSET:
SWL PSI: 0	TZ Baseline PSI: 0			NORTHING:	EASTING:

Test 1 — TEST ZONE PRESSURE: 20; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60192.2	
1	60192.4	0.2
2	60192.8	0.4
3	60193.1	0.3
4	60193.5	0.4
5	60193.9	0.4
6	60194.3	0.4

AVERAGE FLOW: 0.4
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 30; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60199.0	
1	60199.2	0.2
2	60199.4	0.2
3	60199.6	0.2
4	60199.9	0.3
5	60200.2	0.3
6	60200.5	0.3
7	60200.8	0.3

AVERAGE FLOW: 0.3
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3 — TEST ZONE PRESSURE: 40; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60207.1	
1	60207.4	0.3
2	60208.0	0.6
3	60208.5	0.5
4	60209.0	0.5
5	60209.5	0.5
6	60210.1	0.6

AVERAGE FLOW: 0.5
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		

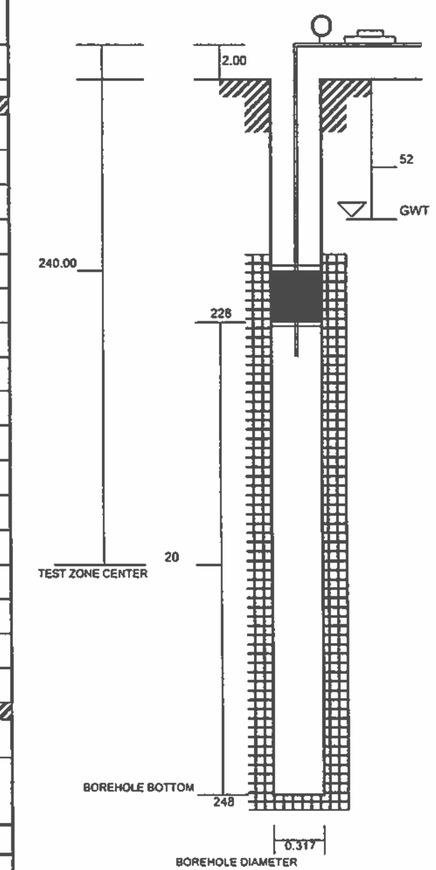
AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

DATE	18-Jul-08	SHEET	3 OF 16
BORING NO:	DH-01	DRILLING COMPANY:	Raimonde
PROJECT NO:	20.0152025.00	INSPECTOR:	EJS
GROUND SURFACE EL:	670	BORING DIAMETER:	3.8 inches
TEST INTERVAL:	248 feet to 268 feet		
STATIC WATER LEVEL DEPTH:	48 feet	ELEVATION:	622
WATER PIPE I.D.:	0 inch		
TOP OF ROCK DEPTH:	12 feet	ELEVATION:	658
STATION:		OFFSET:	
TOTAL BORING DEPTH:	268 feet	ELEVATION:	402
NORTHING:		EASTING:	
SWL PSI:		TZ Baseline PSI:	

Test 1
TEST ZONE PRESSURE: 20
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60219.6	
1	60219.6	0.0
2	60219.6	0.0
3	60219.7	0.1
4	60219.7	0.0
5	60219.7	0.0
6	60219.7	0.0
7	60219.7	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2
TEST ZONE PRESSURE: 29
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60224.0	
1	60224.0	0.0
2	60224.0	0.0
3	60224.0	0.0
4	60224.0	0.0
5	60224.0	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3
TEST ZONE PRESSURE: 41
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60226.2	
1	60226.2	0.0
2	60226.2	0.0
3	60226.2	0.0
4	60228.2	0.0
5	60226.2	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4
TEST ZONE PRESSURE: 50
PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60227.2	
1	60227.2	0.0
2	60227.2	0.0
3	60227.2	0.0
4	60227.2	0.0
5	60227.2	0.0

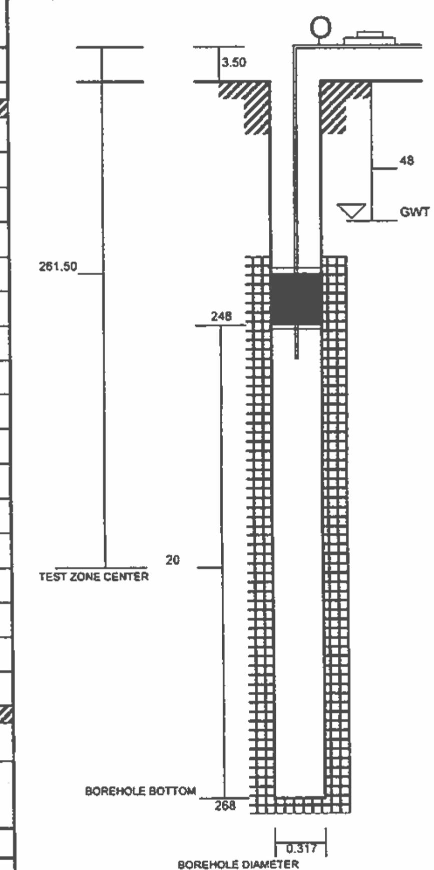
AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5
TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		
6		
7		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI:	
TZ Baseline PSI:	
BORING NO:	DH-01
PROJECT NO:	20.0152025.00
GROUND SURFACE EL:	670
BORING DIAMETER:	3.8 inches
STATIC WATER LEVEL DEPTH:	48 feet
ELEVATION:	622
TOP OF ROCK DEPTH:	12 feet
ELEVATION:	658
TOTAL BORING DEPTH:	288 feet
ELEVATION:	382
DATE	18-Jul-08
SHEET	4 OF 16
DRILLING COMPANY:	Raimonde
INSPECTOR:	EJS
TEST INTERVAL:	268 feet to 288 feet
WATER PIPE I.D.:	0 inch
STATION:	
OFFSET:	
NORTHING:	
EASTING:	

Test 1 — TEST ZONE PRESSURE: 20; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60226.9	
1	60226.9	0.0
2	60227.0	0.1
3	60227.0	0.0
4	60227.1	0.1
5	60227.2	0.1
6	60227.2	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 31; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60230.4	
1	60230.4	0.0
2	60230.4	0.0
3	60230.5	0.1
4	60230.5	0.0
5	60230.6	0.1

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3 — TEST ZONE PRESSURE: 40; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60232.5	
1	60232.5	0.0
2	60232.6	0.1
3	60232.7	0.1
4	60232.8	0.1
5	60232.9	0.1

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: 49; PACKER INFLATION PRESSURE: 300

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60234.0	
1	60234.1	0.1
2	60234.2	0.1
3	60234.3	0.1
4	60234.3	0.0
5	60234.4	0.1

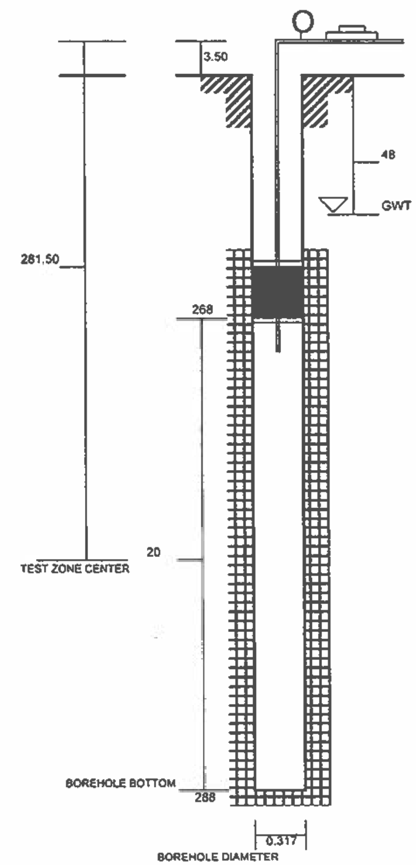
AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE:; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI:		TZ Baseline PSI:	
BORING NO:	DH-01	DATE	18-Jul-08
PROJECT NO:	20.0152025.00	SHEET	5 OF 16
GROUND SURFACE EL:	670	BORING DIAMETER:	3.8 inches
STATIC WATER LEVEL DEPTH:	48 feet	ELEVATION:	622
TOP OF ROCK DEPTH:	12 feet	ELEVATION:	658
TOTAL BORING DEPTH:	308 feet	ELEVATION:	362
DRILLING COMPANY:	Raimonde	INSPECTOR:	EJS
TEST INTERVAL:	288 feet to 308 feet	WATER PIPE I.D.:	0 inch
STATION:		OFFSET:	
NORTHING:		EASTING:	

Test 1 — TEST ZONE PRESSURE: 31; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60248.9	
1	60249.0	0.1
2	60249.0	0.0
3	60249.1	0.1
4	60249.2	0.1
5	60249.2	0.0

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 40; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60249.3	
1	60249.3	0.0
2	60249.3	0.0
3	60249.3	0.0
4	60249.3	0.0
5	60249.3	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3 — TEST ZONE PRESSURE: 49; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60249.4	
1	60249.5	0.1
2	60249.6	0.1
3	60249.7	0.1
4	60249.9	0.2
5	60250.0	0.1
6	60250.2	0.2
7	60250.3	0.1
8	60250.5	0.2

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

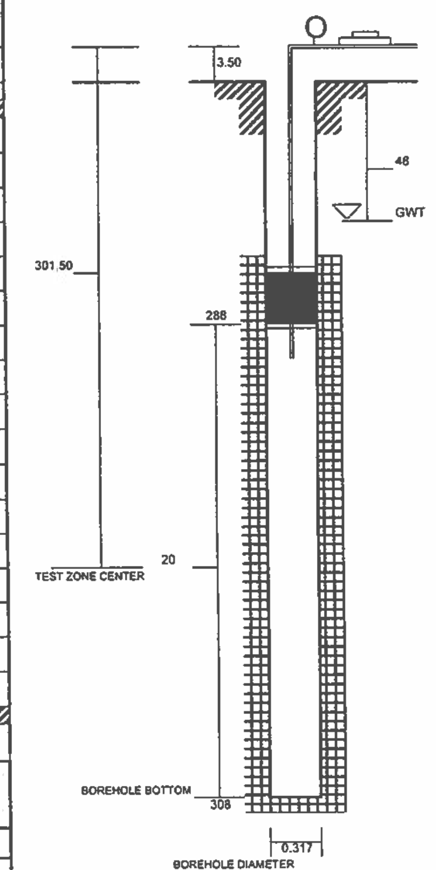
AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)

0			
0			
SWL PSI:		TZ Baseline PSI:	

BORING NO: DH-01			
PROJECT NO: 20.0152025.00			
GROUND SURFACE EL: 670		BORING DIAMETER: 3.8 inches	
STATIC WATER LEVEL DEPTH: 48 feet		ELEVATION: 622	
TOP OF ROCK DEPTH: 12 feet		ELEVATION: 658	
TOTAL BORING DEPTH: 328 feet		ELEVATION: 342	

DATE	18-Jul-08	SHEET	6 OF 16
DRILLING COMPANY:	Raimonde		
INSPECTOR:	EJS		
TEST INTERVAL:	308 feet	to	328 feet
WATER PIPE I.D.:	0 inch		
STATION:		OFFSET:	
NORTHING:		EASTING:	

Test 1 — TEST ZONE PRESSURE: 30; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60262.7	
1	60264.0	1.3
2	60265.3	1.3
3	60266.5	1.2
4	60267.7	1.2
5	60268.9	1.2
6	60270.0	1.1

AVERAGE FLOW: 1.2

REMARKS: decreasing trend in infiltration rate and "no take" at higher pressures suggest the pressure test at 30 psi does not represent aquifer, result omitted from summary sheet

Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 40; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60270.8	
1	60270.8	0.0
2	60270.8	0.0
3	60270.8	0.0
4	60270.9	0.1
5	60270.9	0.0
6	60271.0	0.1
7	60271.1	0.1
8	60271.2	0.1

AVERAGE FLOW: 0.0

REMARKS:

Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3 — TEST ZONE PRESSURE: 50; PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60271.5	
1	60271.6	0.1
2	60271.7	0.1
3	60271.8	0.1
4	60271.9	0.1
5	60272.0	0.1

AVERAGE FLOW: 0.1

REMARKS:

Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

REMARKS:

Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

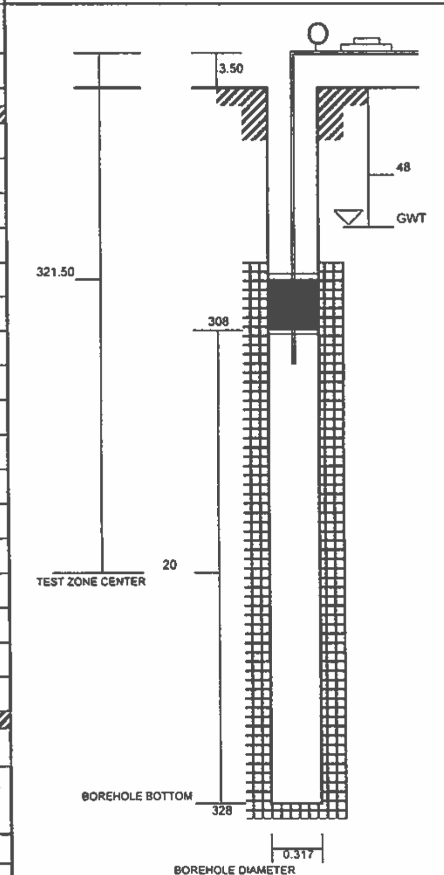
ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

REMARKS:

Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)

DATE	18-Jul-08	SHEET	7 OF 16		
BORING NO:	DH-01	DRILLING COMPANY:	Raimonde		
PROJECT NO:	20.0152025.00	INSPECTOR:	EJS		
GROUND SURFACE EL:	670	BORING DIAMETER: 3.8 inches	TEST INTERVAL:	328 feet to 348 feet	
STATIC WATER LEVEL DEPTH:	48 feet	ELEVATION: 622	WATER PIPE I.D.:	0 inch	
TOP OF ROCK DEPTH:	12 feet	ELEVATION: 658	STATION:		OFFSET:
TOTAL BORING DEPTH:	348 feet	ELEVATION: 322	NORTHING:		EASTING:
SWL PSI: 0	TZ Baseline PSI: 0				

Test 1 — TEST ZONE PRESSURE: 31 — PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60287.2	
1	60287.5	0.3
2	60287.6	0.1
3	60287.6	0.0
4	60287.7	0.1
5	60287.8	0.1

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 42 — PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60289.8	
1	60289.9	0.1
2	60290.0	0.1
3	60290.2	0.2
4	60290.4	0.2
5	60290.5	0.1
6	60290.7	0.2
7	60290.8	0.1

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time:

Test 3 — TEST ZONE PRESSURE: 50 — PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60291.4	
1	60291.5	0.1
2	60291.6	0.1
3	60291.7	0.1
4	60291.7	0.0
5	60291.7	0.0

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: — PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

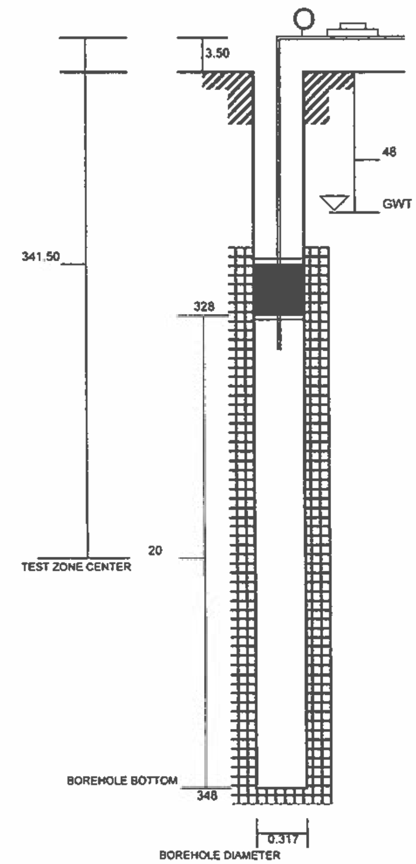
AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: — PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI: | TZ Baseline PSI:

BORING NO:	DH-01		
PROJECT NO:	20.0152025.00		
GROUND SURFACE EL:	670	BORING DIAMETER:	3.8 inches
STATIC WATER LEVEL DEPTH:	48 feet	ELEVATION:	622
TOP OF ROCK DEPTH:	12 feet	ELEVATION:	658
TOTAL BORING DEPTH:	368 feet	ELEVATION:	302

DATE	18-Jul-08	SHEET	8 OF 16
DRILLING COMPANY:	Raimonde		
INSPECTOR:	EJS		
TEST INTERVAL:	348 feet	to	368 feet
WATER PIPE I.D.:	0 inch		
STATION:		OFFSET:	
NORTHING:		EASTING:	

Test 1
TEST ZONE PRESSURE: 32
PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60299.0	
1	60299.0	0.0
2	60299.0	0.0
3	60299.1	0.1
4	60299.1	0.0
5	60299.1	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2
TEST ZONE PRESSURE: 40
PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60300.1	
1	60300.2	0.1
2	60300.2	0.0
3	60300.3	0.1
4	60300.3	0.0
5	60300.3	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3
TEST ZONE PRESSURE: 55
PACKER INFLATION PRESSURE: 340

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60302.0	
1	60302.1	0.1
2	60302.1	0.0
3	60302.1	0.0
4	60302.1	0.0
5	60302.1	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4
TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

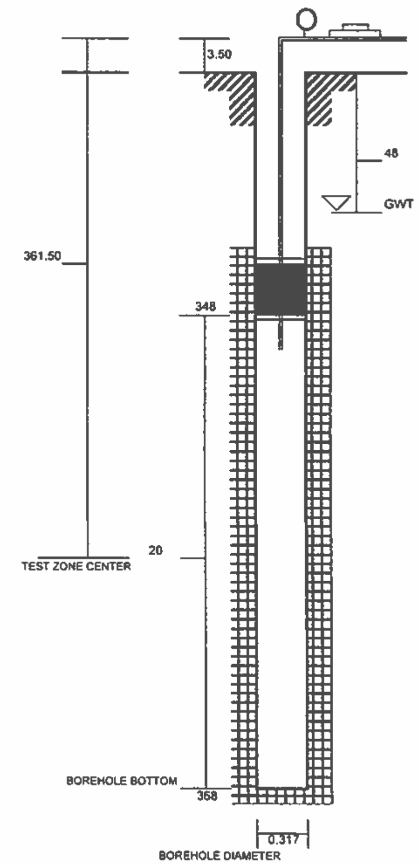
AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 5
TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)

DATE	21-Jul-08	SHEET	9 OF 16
BORING NO:	DH-01	DRILLING COMPANY:	Raimonde
PROJECT NO:	20.0152025.00	INSPECTOR:	EJS
GROUND SURFACE EL:	670	BORING DIAMETER:	3.8 inches
TEST INTERVAL:	368 feet to 388 feet		
STATIC WATER LEVEL DEPTH:	47 feet	ELEVATION:	623
WATER PIPE I.D.:	0 inch		
TOP OF ROCK DEPTH:	12 feet	ELEVATION:	658
STATION:		OFFSET:	
TOTAL BORING DEPTH:	388 feet	ELEVATION:	282
NORTHING:		EASTING:	
SWL PSI:	0	TZ Baseline PSI:	0

Test 1

TEST ZONE PRESSURE: 32
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60309.3	
1	60309.4	0.1
2	60309.4	0.0
3	60309.4	0.0
4	60309.4	0.0
5	60309.4	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2

TEST ZONE PRESSURE: 40
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60310.7	
1	60310.9	0.2
2	60311.0	0.1
3	60311.1	0.1
4	60311.1	0.0
5	60311.1	0.0
6	60311.1	0.0
7	60311.1	0.0

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3

TEST ZONE PRESSURE: 52
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60312.5	
1	60312.7	0.2
2	60312.9	0.2
3	60313.0	0.1
4	60313.1	0.1
5	60313.1	0.0
6	60313.1	0.0
7	60313.2	0.1

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

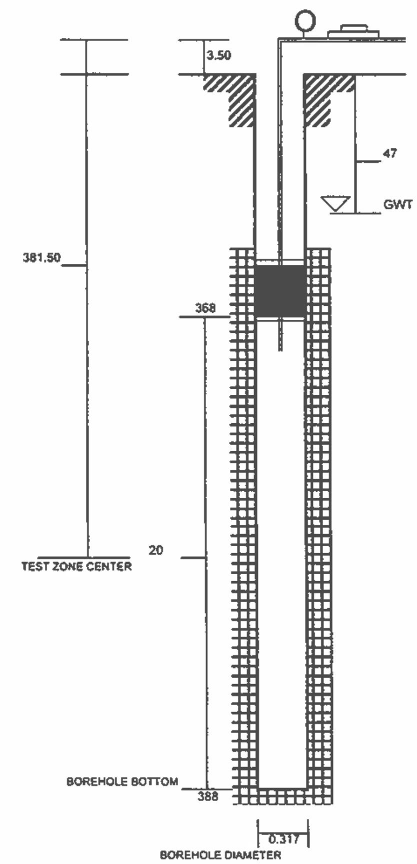
Test 5

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

DATE: 21-Jul-08	SHEET: 10 OF 16		
BORING NO: DH-01		DRILLING COMPANY: Raimonde	
PROJECT NO: 20.0152025.00		INSPECTOR: EJS	
GROUND SURFACE EL: 670	BORING DIAMETER: 3.8 inches	TEST INTERVAL: 388 feet to 408 feet	
STATIC WATER LEVEL DEPTH: 47 feet	ELEVATION: 623	WATER PIPE I.D.: 0 inch	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658	STATION:	OFFSET:
TOTAL BORING DEPTH: 408 feet	ELEVATION: 262	NORTHING:	EASTING:
SWL PSI:	TZ Baseline PSI:		

Test 1

TEST ZONE PRESSURE: 32
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60318.6	
1	60319.6	1.0
2	60320.5	0.9
3	60321.6	1.1
4	60322.7	1.1
5	60323.8	1.1
6	60325.0	1.2
7	60326.1	1.1
8	60327.3	1.2

AVERAGE FLOW: 1.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2

TEST ZONE PRESSURE: 42
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60328.8	
1	60329.9	1.1
2	60331.1	1.2
3	60332.3	1.2
4	60333.6	1.3
5	60334.8	1.2
6		

AVERAGE FLOW: 1.2
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3

TEST ZONE PRESSURE: 51
PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60338.0	
1	60339.2	1.2
2	60340.5	1.3
3	60341.5	1.0
4	60342.3	0.8
5	60343.2	0.9
6	60344.1	0.9
7	60345.0	0.9
8	60346.0	1.0
9	60346.8	0.8
10	60347.6	0.8
11	60348.4	0.8
12	60349.1	0.7
13	60349.9	0.8
14	60350.7	0.8
15	60351.6	0.9
16	60352.4	0.8

AVERAGE FLOW: 0.9
REMARKS: "jerky" flow on dial gauge
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

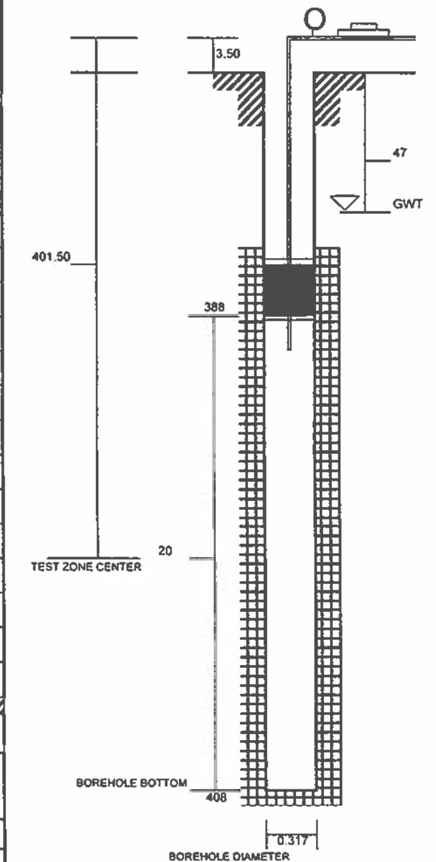
Test 5

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 26 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI: | TZ Baseline PSI:

BORING NO: DH-01		DATE 21-Jul-08	SHEET 11 OF 16
PROJECT NO: 20.0152025.00		DRILLING COMPANY: Raimonde	
GROUND SURFACE EL: 670	BORING DIAMETER: 3.8 inches	INSPECTOR: EJS	
STATIC WATER LEVEL DEPTH: 47 feet	ELEVATION: 623	TEST INTERVAL: 408 feet to 428 feet	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658	WATER PIPE I.D.: 0 inch	
TOTAL BORING DEPTH: 428 feet	ELEVATION: 242	STATION:	OFFSET:
		NORTHING:	EASTING:

Test 1 — TEST ZONE PRESSURE: 32; PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60366.8	0.8
1	60367.6	0.7
2	60368.3	0.8
3	60369.1	0.5
4	60369.6	0.6
5	60370.2	0.7
6	60370.9	0.7
7	60371.6	0.7
8	60372.3	

AVERAGE FLOW: 0.7

REMARKS:

Pressure Gauge:
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2 — TEST ZONE PRESSURE: 42; PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60375.6	0.7
1	60376.3	0.7
2	60377.0	0.6
3	60377.6	0.7
4	60378.3	0.7
5	60379.0	0.7
6	60379.7	

AVERAGE FLOW: 0.7

REMARKS: "jerky" flow, build up pressure, then infiltrate (?)

Pressure Gauge:
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3 — TEST ZONE PRESSURE: 52; PACKER INFLATION PRESSURE: 370

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60382.4	0.8
1	60383.2	0.7
2	60383.9	0.8
3	60384.7	0.6
4	60385.3	0.6
5	60385.9	0.6
6	60386.5	0.5
7	60387.0	0.5
8	60387.5	0.6
9	60388.1	0.5
10	60388.6	0.6
11	60389.2	

AVERAGE FLOW: 0.6

REMARKS: steady flow

Pressure Gauge:
SWL PSI:
TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

REMARKS:

Pressure Gauge:
SWL PSI:
TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

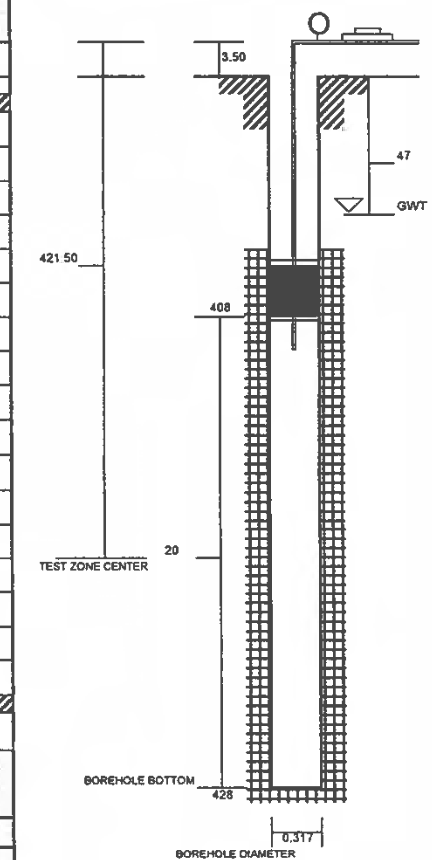
ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

REMARKS:

Pressure Gauge:
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI:		TZ Baseline PSI:	
BORING NO:	DH-01	DATE	21-Jul-08
PROJECT NO:	20.0152025.00	SHEET	12 OF 16
GROUND SURFACE EL:	670	DRILLING COMPANY:	Raimonde
BORING DIAMETER:	3.8 inches	INSPECTOR:	EJS
STATIC WATER LEVEL DEPTH:	47 feet	ELEVATION:	623
TOP OF ROCK DEPTH:	12 feet	ELEVATION:	658
TOTAL BORING DEPTH:	448 feet	ELEVATION:	222
TEST INTERVAL:	428 feet to 448 feet	WATER PIPE I.D.:	0 inch
STATION:		OFFSET:	
NORTHING:		EASTING:	

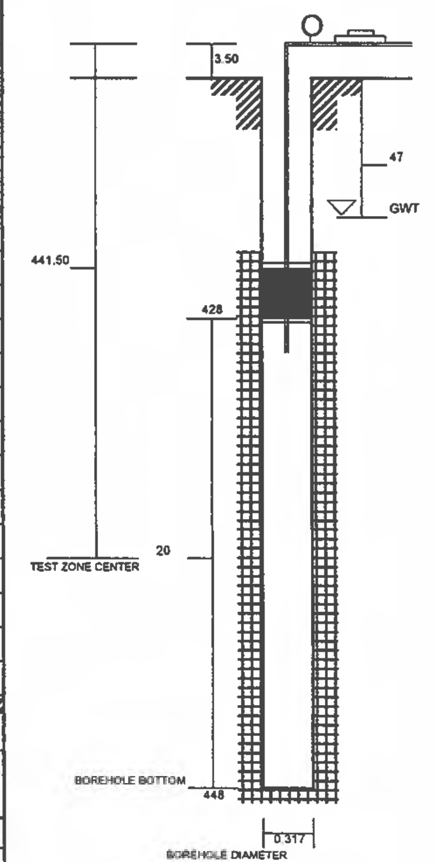
	Test 1	Test 2	Test 3	Test 4	Test 5
TEST ZONE PRESSURE:	34	44	52		
PACKER INFLATION PRESSURE:	370	370	370		

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60398.5		0	60403.9		0	60408.6		0			0		
1	60399.0	0.5	1	60404.5	0.6	1	60409.0	0.4	1			1		
2	60399.5	0.5	2	60405.0	0.5	2	60409.3	0.3	2			2		
3	60399.9	0.4	3	60405.6	0.6	3	60409.6	0.3	3			3		
4	60400.4	0.5	4	60406.2	0.6	4	60409.9	0.3	4			4		
5	60400.9	0.5	5	60406.8	0.6	5	60410.3	0.4	5			5		
						6	60410.7	0.4						
						7	60411.1	0.4						

	Test 1	Test 2	Test 3	Test 4	Test 5
AVERAGE FLOW:	0.5	0.6	0.4		
REMARKS:			had to increase pressure supplied from drill rig to achieve 50+ psi		
Pressure Gauge					
SWL PSI:					
TZ Transducer Reading PSI:					

Start Time:
End Time

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0
SWL PSI: | TZ Baseline PSI:

BORING NO: DH-01		DATE 21-Jul-08	SHEET 13 OF 16
PROJECT NO: 20.0152025.00		DRILLING COMPANY: Raimonde	
GROUND SURFACE EL: 670	BORING DIAMETER: 3.8 inches	INSPECTOR: EJS	
STATIC WATER LEVEL DEPTH: 47 feet	ELEVATION: 623	TEST INTERVAL: 448 feet to 468 feet	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658	WATER PIPE I.D.: 0 inch	
TOTAL BORING DEPTH: 468 feet	ELEVATION: 202	STATION:	OFFSET:
		NORTHING:	EASTING:

Test 1 — TEST ZONE PRESSURE: 34; PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60426.0	
1	60426.5	0.5
2	60426.8	0.3
3	60427.2	0.4
4	60427.5	0.3
5	60427.9	0.4
6	60428.4	0.5
7	60428.9	0.5

AVERAGE FLOW: 0.4

REMARKS:

Pressure Gauge:

SWL PSI:

TZ Transducer Reading PSI:

Start Time:

Test 2 — TEST ZONE PRESSURE: 47; PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60432.2	
1	60432.5	0.3
2	60432.8	0.3
3	60432.9	0.1
4	60433.6	0.7
5	60435.5	1.9
6	60435.8	0.3
7	60436.0	0.2
8	60436.3	0.3
9	60436.4	0.1
10	60436.7	0.3

AVERAGE FLOW: 0.5

REMARKS: Sudden increase in flow between minutes 3 and 5, accompanied by 5 psi drop in water pressure. Regained pressure afterward with lower flow.

Pressure Gauge:

SWL PSI:

TZ Transducer Reading PSI:

End Time:

Test 3 — TEST ZONE PRESSURE: 56; PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60437.8	
1	60438.1	0.3
2	60438.4	0.3
3	60438.8	0.4
4	60439.1	0.3
5	60439.4	0.3

AVERAGE FLOW: 0.3

REMARKS:

Pressure Gauge:

SWL PSI:

TZ Transducer Reading PSI:

Test 4 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

REMARKS:

Pressure Gauge:

SWL PSI:

TZ Transducer Reading PSI:

Test 5 — TEST ZONE PRESSURE: ; PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:

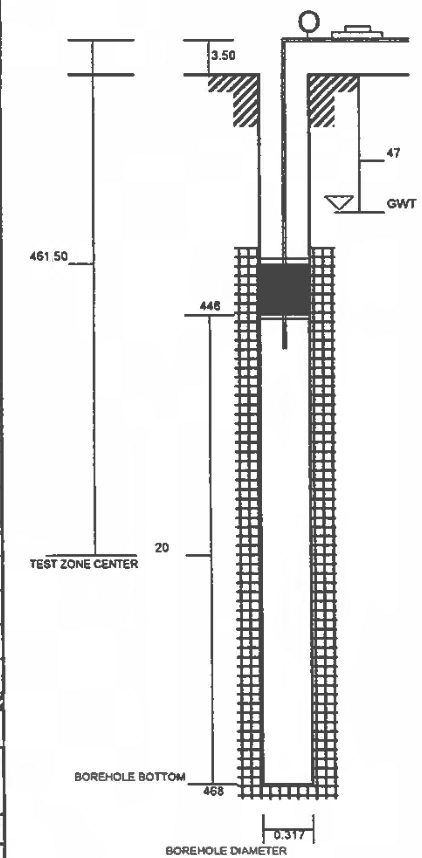
REMARKS:

Pressure Gauge:

SWL PSI:

TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 26 Repository Site
Aurora, Illinois
(SE Corner of Route 26 and Mettel Road)

DATE	21-Jul-08
SHEET	14 OF 16
BORING NO:	DH-01
PROJECT NO:	20.0152025.00
GROUND SURFACE EL:	670
BORING DIAMETER:	3.8 inches
STATIC WATER LEVEL DEPTH:	47 feet
ELEVATION:	623
TOP OF ROCK DEPTH:	12 feet
ELEVATION:	658
TOTAL BORING DEPTH:	488 feet
ELEVATION:	182
DRILLING COMPANY:	Raimonde
INSPECTOR:	EJS
TEST INTERVAL:	468 feet to 488 feet
WATER PIPE I.D.:	0 inch
STATION:	
OFFSET:	
NORTHING:	
EASTING:	
	0
	0
SWL PSI:	
TZ Baseline PSI:	

Test 1

TEST ZONE PRESSURE: 30
PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60449.1	
		0.7
1	60449.8	
		0.6
2	60450.4	
		0.7
3	60451.1	
		0.6
4	60451.7	
		0.5
5	60452.2	
		0.5
6	60452.7	
		0.6
7	60453.3	

AVERAGE FLOW: 0.6
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2

TEST ZONE PRESSURE: 47
PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60465.0	
		0.1
1	60465.1	
		0.2
2	60465.3	
		0.2
3	60465.5	
		0.2
4	60465.7	
		0.2
5	60465.9	

AVERAGE FLOW: 0.2
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time

Test 3

TEST ZONE PRESSURE: 57
PACKER INFLATION PRESSURE: 380

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60467.4	
		0.2
1	60467.6	
		0.2
2	60467.8	
		0.2
3	60468.0	
		0.2
4	60468.2	
		0.2
5	60468.4	

AVERAGE FLOW: 0.2
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

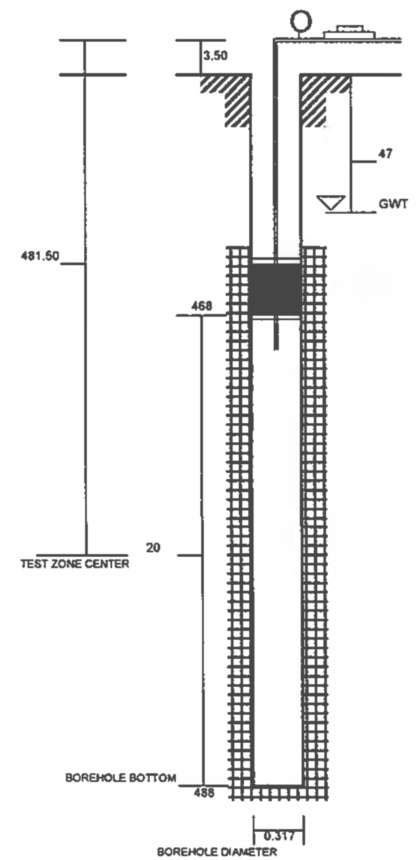
Test 5

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

SWL PSI: | TZ Baseline PSI:

DATE	21-Jul-08		SHEET	15 OF 16	
BORING NO:	DH-01		DRILLING COMPANY:	Raimonde	
PROJECT NO:	20.0152025.00		INSPECTOR:	EJS	
GROUND SURFACE EL:	670	BORING DIAMETER: 3.8 inches	TEST INTERVAL:	488 feet to 508 feet	
STATIC WATER LEVEL DEPTH:	47 feet	ELEVATION: 623	WATER PIPE I.D.:	0 inch	
TOP OF ROCK DEPTH:	12 feet	ELEVATION: 658	STATION:		OFFSET:
TOTAL BORING DEPTH:	508 feet	ELEVATION: 162	NORTHING:		EASTING:

Test 1

TEST ZONE PRESSURE: 40
PACKER INFLATION PRESSURE: 400

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60483.6	
1	60483.7	0.1
2	60483.7	0.0
3	60483.8	0.1
4	60483.8	0.0
5	60483.8	0.0

AVERAGE FLOW: 0.0
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
Start Time:

Test 2

TEST ZONE PRESSURE: 49
PACKER INFLATION PRESSURE: 400

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60485.0	
1	60485.1	0.1
2	60485.2	0.1
3	60485.2	0.0
4	60485.3	0.1
5	60485.3	0.0

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:
End Time:

Test 3

TEST ZONE PRESSURE: 59
PACKER INFLATION PRESSURE: 400

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60486.2	
1	60486.3	0.1
2	60486.3	0.0
3	60486.4	0.1
4	60486.5	0.1
5	60486.5	0.0
6	60486.6	0.1

AVERAGE FLOW: 0.1
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

Test 4

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

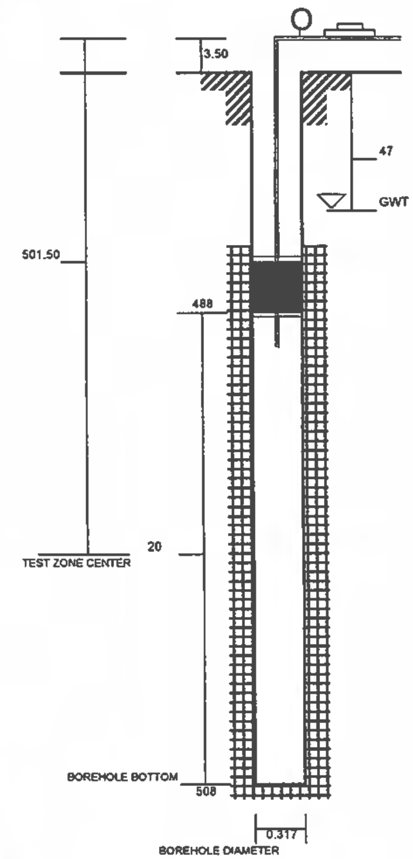
Test 5

TEST ZONE PRESSURE:
PACKER INFLATION PRESSURE:

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0		
1		
2		
3		
4		
5		

AVERAGE FLOW:
REMARKS:
Pressure Gauge
SWL PSI:
TZ Transducer Reading PSI:

MEASUREMENT DATA



PACKER TESTING DATA SHEET

GZA GEOENVIRONMENTAL, INC.

Route 25 Repository Site
Aurora, Illinois
(SE Corner of Route 25 and Mettel Road)
0
0

DATE: 22-Jul-08	SHEET 16 OF 16		
BORING NO: DH-01		DRILLING COMPANY: Raimonde	
PROJECT NO: 20.0152025.00		INSPECTOR: EJS	
GROUND SURFACE EL: 670	BORING DIAMETER: 3.8 inches	TEST INTERVAL: 508 feet to 518 feet	
STATIC WATER LEVEL DEPTH: 47 feet	ELEVATION: 623	WATER PIPE I.D.: 0 inch	
TOP OF ROCK DEPTH: 12 feet	ELEVATION: 658	STATION:	OFFSET:
TOTAL BORING DEPTH: 518 feet	ELEVATION: 152	NORTHING:	EASTING:

SWL PSI: | TZ Baseline PSI:

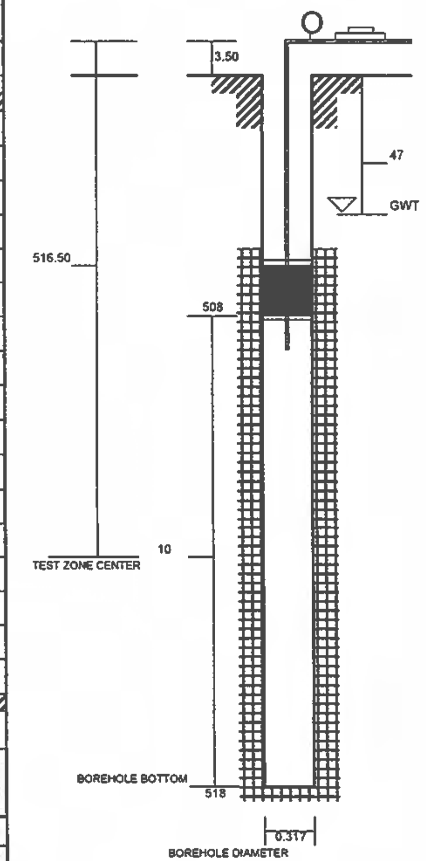
	Test 1	Test 2	Test 3	Test 4	Test 5
TEST ZONE PRESSURE:	40	50	61		
PACKER INFLATION PRESSURE:	420	420	420		

ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)	ELAPSED TIME (MIN.)	FLOW READING (GAL.)	FLOW (GAL.)
0	60501.0		0	60508.4		0	60513.4		0			0		
1	60501.8	0.8	1	60509.1	0.7	1	60513.8	0.4	1			1		
2	60502.6	0.8	2	60509.9	0.8	2	60514.3	0.5	2			2		
3	60503.4	0.8	3	60510.7	0.8	3	60514.6	0.3	3			3		
4	60504.2	0.8	4	60511.5	0.8	4	60514.9	0.3	4			4		
5	60505.0	0.8	5	60512.3	0.8	5	60515.3	0.4	5			5		

	Test 1	Test 2	Test 3	Test 4	Test 5
AVERAGE FLOW:	0.8	0.8	0.4		
REMARKS:		sometimes "jerky" flow, 0.05 to 0.1 gallon jumps			
Pressure Gauge					
SWL PSI:					
TZ Transducer Reading PSI:					

Start Time: | End Time:

MEASUREMENT DATA



APPENDIX E

Borehole Geophysical Log and Report
(Hager-Richter Geoscience, Inc.)

Please see Appendix C of Permit Application Narrative for Copy of Hager-Richter Geophysics Report Dated November 13, 2008

APPENDIX F

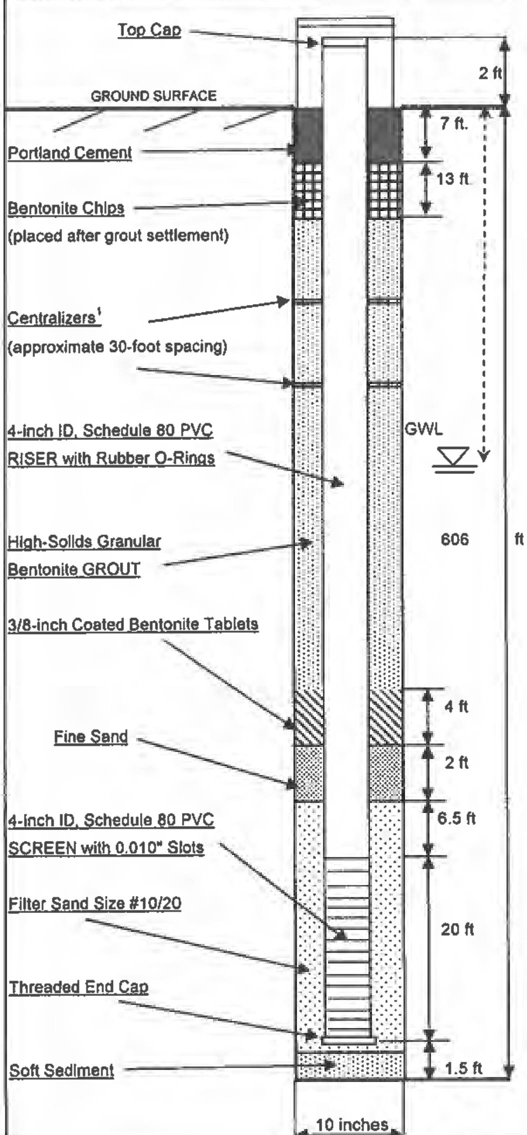
Groundwater Monitoring Well Installation Log

GROUNDWATER MONITORING WELL INSTALLATION LOG

GZA GEOENVIRONMENTAL	DEEP CORE BORING AND	REPORT OF BORING NO.	MW-1
20900 Swenson Drive	MONITORING WELL INSTALLATION	SHEET	1 of 1
Waukesha, Wisconsin 53186	ROUTE 25 REPOSITORY SITE	FILE NO.	20.0152025.00
	AURORA, ILLINOIS	CHKD BY	

BORING CO.	Albrecht Well Drilling, Inc.	WELL LOCATION	Sotheast corner of IL Route 25 and Mettel Road		
FOREMAN	Pat	GROUND SURFACE ELEV.	670 feet	DATUM	mean sea level (msl)
GZA GEOLOGIST	Erick Staley	DATE START	Sept. 29, 2008	DATE END	Oct. 10, 2008

AS-BUILT



SUBSURFACE PROFILE (feet below ground surface)

Geologic Unit	Depth	Description
Soil Overburden	0 - 12 ft.	fill; glacial silt, sand and gravel
Silurian dolomite	12 - 53 ft.	dolomite with chert
Maquoketa Group	53 - 207 ft.	shale, some dolomite/limestone
Galena Group	207 - 394 ft.	limestone, some dolomite
Platteville Group	394 - 540 ft.	dolomite
Ancell Group	540 - 606 ft.	sandstone

GROUNDWATER LEVEL (feet below ground surface)

Date	Time	Water Depth	Notes
9/29/08	1045	50.8	in borehole prior to well installation
9/30/08	1012	50.8	inside well, no annular backfill
10/1/08	955	62.3	inside well, partial bentonite seal
10/1/08	955	49.3	outside of well in annulus, no grout
10/3/08	910	103.8	inside well, full bentonite seal
10/3/08	910	49.0	outside of well in annulus, no grout
10/6/08	1245	> 385	inside well, below reach of instrument
10/7/08	1135	199.1	drillers filled well to top previous day;
			overnight infiltration
10/8/08	942	484.8	driller pumped water in well down to 480
			previous day; overnight infiltration
10/8/08	1320	500.7	approx. steady-state during development

WELL DEVELOPMENT DATA (Water pumped, field measurements, etc.)

Date	Time	Pump Rate	Notes
10/7/08	1400	2.5 to 5 gpm	pumping water previously placed in casing;
			pumped water down to 480 feet bgs
10/8/08	1123	1.8 gpm	water level 500.1 ft. bgs, turbidity 356.5 ntu
10/8/08	1143	1.7 gpm	water level 500.6 ft. bgs, turbidity 74.42 ntu
10/8/08	1157	1.7 gpm	water level 500.7 ft. bgs, turbidity 44.07 ntu
10/8/08	1220	1.7 gpm	water level 500.6 ft. bgs, turbidity 21.82 ntu
10/8/08	1245	1.7 gpm	water level 500.6 ft. bgs, turbidity 10.74 ntu
10/8/08	1320	1.7 gpm	water level 500.7 ft. bgs, turbidity 5.99 ntu
10/8/08	1342	1.7 gpm	water level 500.7 ft. bgs, turbidity 9.16 ntu
10/8/08	1355	1.7 gpm	water level 500.7 ft. bgs, turbidity 5.70 ntu
10/8/08	1403	1.7 gpm	water level 500.7 ft. bgs, turbidity 4.55 ntu;
			turbidity after bubbles released = 3.27 ntu

Pumped Volume = 2 hours 40 minutes @ 1.7 gpm = 272 gallons (> 3 well volumes[2])

**Schematic drawing only. NOT DRAWN TO SCALE

ANNULAR MATERIALS

Material	Thickness in Annulus		Theoretical Amount		Actual Amount		% Difference	Possible Resaons for Difference
Filter Sand	27.5	feet	89	gallons	82	gallons	9%	Error in initial depth measurement; variation
Fine Sand	2	feet	6.5	gallons	6.6	gallons	1%	in boring diameter
Bentonite Tablets	4	feet	138	pounds[3]	100	pounds[3]	28%	Installed in 2 phases, 1st layer hydrated
Grout	570	feet	1855	gallons	1875	gallons	1%	overnight and swelled prior to 2nd layer

NOTES

1. Centralizers placed at depths: 604, 594, 584, 554, 534, 504, and in 30-foot increments up to 24 feet bgs.
2. Well volume calculation based on assumed static water level of 485 feet. Well volume = 78 gallons; 3 well volumes = 234 gallons.
3. Manufacturer recommends 79.4 pounds of tablets per cubic foot, or 34.6 pounds per lineal foot of annulus.

GZA GeoEnvironmental, Inc.
Engineers & Scientists

Appendix C

APPENDIX C:

Hager-Richter Report

HAGER-RICHTER
GEOSCIENCE, INC.

BOREHOLE GEOPHYSICAL LOGGING
DEEP CORE BORING PROJECT
ROUTE 25 REPOSITORY SITE
AURORA, ILLINOIS

Prepared for:

Raimonde Drilling Corporation
770 Factory Road
Addison, Illinois 60101

Prepared by:

Hager-Richter Geoscience, Inc.
846 Main Street
Fords, New Jersey 08863

File 08RG46
November 2008

HAGER-RICHTER
GEOSCIENCE, INC.

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November 13, 2008
File 08RG26

Anne Leslie
President
Raimonde Drilling Corporation
770 Factory Road
Addison, Illinois 60101

Tel: 630.458.0590
Fax: 630.458.0914
Cell: 773.617.2442

RE: Borehole Geophysical Logging
Deep Core Boring Project
Route 25 Repository Site
Aurora, Illinois

Dear Ms. Leslie:

In this report, we summarize the results of borehole geophysical logging conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) in one borehole for the Deep Core Boring Project at a site identified as the Route 25 Repository Site located in Aurora, Illinois for Raimonde Drilling Corporation (RDC). The scope of work was specified by RDC.

Introduction

RDC requested borehole geophysical logging as part of the Deep Core Boring Project, a sludge injection investigation for the Route 25 Repository Site in Aurora, Illinois. The general location of the site is shown in Figure 1, and Figure 2 is a site plan showing the approximate location of the logged borehole. RDC was interested in characterizing the bedrock, including the depth and orientation of bedrock fractures, intersected by the borehole.

The logged borehole was identified as DH-01. The bedrock penetrated by the borehole consists of shale, dolomite, and limestone. The datum for depths in this report is the ground surface at the location of the borehole. DH-01 was cased through the overburden to a depth of approximately 48 feet and was open-hole in the HQ cored (4-inch diameter) bedrock portion of the borehole to a depth of approximately 517 feet. The logging program was specified by RDC and consisted of acoustic televiewer (ATV), caliper, natural gamma ray, normal resistivity, spontaneous potential (SP), and single point resistance (SPR).

Objectives

The objectives of the borehole geophysical logging program were to characterize the bedrock, including the depth and orientation of bedrock fractures, intersected by the borehole.

The Field Operations

Robert Garfield and Alexis Martinez of Hager-Richter conducted the field operations on July 23, 2008. The project was coordinated with Ms. Anne Leslie of RDC. Ms. Leslie, Mr. Marc Fisher of Deuchler Environmental, and Mr. Erick Staley of GZA GeoEnvironmental, Inc. (GZA) were present during field operations. Data analysis and interpretation were completed at the Hager-Richter offices. Original data and field notes reside in the Hager-Richter files and will be retained at least three years. Preliminary borehole geophysical logging data were provided to RDC electronically on July 29, 2008. Final borehole geophysical logging data were provided to RDC electronically on October 23, 2008.

Equipment

Mount Sopris Matrix and MGXII portable digital logging systems were used with a 4MXA-1000 winch for the borehole geophysical logging. Data were recorded along with depth in digital format using a PC. Data were displayed in real time in the field and were processed in the office using WellCAD v. 4.2, commercially licensed software.

Acoustic Televiewer. An ALT ABI-40 acoustic televiewer (ATV) probe was used for this project. The ATV acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall using the reflected signal of sound waves in the ultrasonic frequency range. Both amplitude and travel time of the reflected signal are displayed and can be used to detect bedrock structures such as fractures, foliation, and bedding planes. The probe includes a 3-axis magnetometer and three accelerometers to orient the image and to provide borehole deviation data that are used to correct structure orientations from apparent to true orientations.

ATV travel time data can also be used to calculate an acoustic caliper log. The acoustic caliper log measures the average borehole diameter as a function of depth. The acoustic caliper log is derived from the travel time data and the velocity of the acoustic signal in water. The acoustic caliper log is used to locate possible fractures and to aid in the interpretation of other borehole geophysical logs.

Natural Gamma Ray. A Mount Sopris 2PGA-1000 poly-gamma probe was used for the natural gamma ray logging. The probe uses a sodium iodide crystal that produces a pulse of light when struck by a gamma ray. The variation of radioactivity naturally occurring in rocks and sediments makes the natural gamma ray log an excellent indicator of changes in lithology.

Radioactive minerals tend to accumulate in clays with the practical result that layers with higher clay content are commonly expressed in the natural gamma ray log as relatively higher counts per second (cps). Clean sands, which are normally low in radioactivity, produce low count rates.

Normal Resistivity, SP, and SPR. A Mount Sopris 2PEA-1000 poly-electric probe attached to a 2PGA-1000 poly-gamma probe was used for the normal resistivity (16" and 32" electrode spacing), SP, and SPR logging. The normal resistivity, SP, and SPR logs are all types of electric logs. The electric logs are calculated from combinations of voltage and current measurements made with various combinations of a fixed electrode at the surface and one or more electrodes mounted on a downhole probe.

Resistivity is the physical property that relates electric current density to potential gradient and is defined as:

$$\rho = (A / L) * (V / I) \qquad \text{Eq 1}$$

Resistivity, as defined by Equation 1, applies to normal resistivity. The normal resistivity data are measured by applying an electric current and measuring the voltage between a pair of current and voltage downhole electrode arrays. The electrode spacing determines the effective distance of the measurement from the borehole wall. The effective sample interval for each pair of electrode spacings (16" and 32") is usually considered to be a sphere with a diameter about two times the electrode spacing. Normal resistivity logs provide information about lithology, bed thickness, and water quality in the surrounding material.

SP measures the voltage that occurs between the borehole fluid and the surrounding materials. Spontaneous potentials occur in the earth due to chemical and physical differences between rock types and saturating fluids. The SP data are the difference in potential (or voltage) between a fixed electrode at the surface and a single moving electrode in the borehole. It is commonly used to identify changes in lithology, bed thickness, and salinity of formation fluid under some conditions.

SPR measures the electric resistance of the material surrounding the borehole and saturating fluid with depth. The SPR measurement is made by passing an alternating current between a surface electrode and the electrode on the probe. The resistance is calculated using the voltage between the two electrodes and Ohms Law, which is defined as:

$$R = E / I \qquad \text{Eq 2}$$

where: R is resistance
E is potential
I is current

SPR data are useful in the determination of qualitative lithologic information, water quality, and location of fractures/fracture zones. The SPR increase with increasing grain size and decrease with increasing borehole diameter, fracture density, and with higher concentrations of dissolved solids in the borehole fluid.

Limitations of the Method

With the 4MXA-1000 winch, the logging cable passes over a calibrated wheel, and an encoder counts the revolutions, which are converted to depth. Slippage of the logging cable may occur, resulting in errors in recorded depth. At the beginning and end of a logging run, fiducial depths (commonly ground surface or top of casing) are measured and are compared to determine if slippage occurred.

Acoustic Televiewer. ATV logging requires that liquid be present in the portion of the borehole to be logged. However, the liquid does not need to be optically clear. The ATV probe must be centralized in the borehole to acquire optimal images of the borehole wall. If the borehole wall is rough and/or irregular or the diameter of the open borehole is larger than the diameter of the casing, the probe may not be adequately centralized and the quality of the acoustic images may be compromised.

The ATV logs are used to determine the depth and orientation of fractures and other planar features intersected by a borehole. In some cases, natural planar features in the bedrock, such as mineral veins, bedding, and foliation may appear to be fractures in the ATV logs, but are not actual discontinuities in the bedrock.

The accuracy of the orientation measured by the ABI-40, as stated by the manufacturer, is ±0.5° for the inclination data and ±1° for the azimuth data. The ABI-40 relies on the earth's magnetic field to determine azimuth. Therefore, in areas where the magnetic field may be significantly affected by local magnetic objects, the accuracy of dip azimuths reported in the logs may be reduced. Specifically, the dip azimuth data of bedrock structures and the borehole deviation data within approximately five feet of steel casing are not accurate. However, the depth and dip angle of bedrock structures within approximately five feet of steel casing are accurate.

The acoustic caliper data is unlikely to indicate the presence of high angle fractures and fractures with small apertures. High angle fractures with large apertures may show small enlargements in the caliper log at both the top and bottom of the intersection of the fracture with the borehole. It also may be difficult to identify fractures in the caliper log located near the bottom of casing where a significant enlargement commonly occurs and may be due to causes other than natural fractures.

Natural Gamma Ray. Natural gamma ray data can be acquired with or without liquid in the borehole and in an un-cased, PVC-cased, or steel-cased borehole. However, if a liquid or casing is present, the liquid or the casing attenuates the natural gamma rays, and, therefore, lower values are measured than if the borehole was air-filled and/or un-cased. According to the manufacturer's specifications, the measurement range is 0 CPS to 100,000 CPS, the accuracy is ±1% of full scale, and the resolution is 0.02% of full scale. Natural gamma ray data do not have a quantitative value in terms of geologic properties.

Normal Resistivity, SP, and SPR. All electric logs require that liquid be present in the portion of the borehole to be logged. The borehole must be un-cased, and if steel casing is present, data cannot be acquired within approximately 10 to 20 feet below the bottom of steel casing for normal resistivity and data cannot be acquired within approximately 2 to 5 feet below the bottom of steel casing for SP and SPR.

According to the manufacturer's specifications, the normal resistivity measurement range is 0 ohm-m to 2,500 ohm-m, the accuracy is 1% of full scale, and the resolution is 0.02% of full scale. Normal resistivity logs can be affected by the resistivity of the drilling fluid. In addition, in extremely resistive formations, such as observed for this project, the data might exhibit artificially negative normal resistivity values as a result of the probe's inability to measure extremely high resistivities.

According to the manufacturer's specifications, the SP measurement range is -1,500 mV to 1,500 mV, the accuracy is 1% of full scale, and the resolution is 0.02% of full scale. According to the manufacturer's specifications, the SPR measurement range is 1 ohm to 5,000 ohms, the accuracy is 1% of full scale, and the resolution is 0.02% of full scale. Borehole diameter changes have a significant affect on the data. The depth resolution of the SPR data is approximately equal to the diameter of the borehole. SPR data do not have a quantitative value in terms of geologic properties.

Field Procedures & Data Acquisition

Adequate tension was maintained with the logging cable during the borehole geophysical logging and the depth encoder was cleaned after each logging run in order to maintain accurate depth measurements. Repeat sections were acquired to verify depth consistency. In addition, at the beginning and end of a logging run, a fiducial depth (top of casing or ground surface) was measured and checked for consistency. The data acquisition parameters are listed in Table 1.

Table 1 – Data Acquisition Parameters

Log	Sampling Interval	Logging Speed	Logging Direction
ATV & Acoustic Caliper	0.01 feet	8 - 10 feet / minute	down and up
Natural Gamma Ray	0.1 feet	8 - 11 feet / minute	down and up
Normal Resistivity, SP, & SPR	0.1 feet	8 - 11 feet / minute	down and up

Data Processing

The processing consists mainly of selecting scales, filters, and the layout of the tracks. In addition, the OTV and ATV data require determining the depth, orientation, and category of the bedrock structures detected. To increase the quality of the images, the brightness and contrast of the OTV images were adjusted and the ATV travel time images were digitally centralized. The ATV amplitude images can be normalized, although normalization was not applied to the ATV amplitude data for this project.

Data Interpretation & Presentation

The lithology logs provided in the first two tracks of the borehole geophysical logs in Appendix 1 are based on an integrated interpretation of data in the core logs for DH-01 provided by GZA (reproduced in Appendix 2) and the borehole geophysical logging data. The core logs report the depths of specific rock types and formations. We note that it is not possible to determine the rock type or formation based on the borehole geophysical logging data. The borehole geophysical logging data were used to better define the depths of lithologic variation reported in the core logs.

Two sets of borehole geophysical logs are provided in Appendix 1 for borehole DH-01. The first set of logs (image logs) consist of lithology logs, ATV amplitude and travel time image logs, structure projection plot, acoustic caliper log, tadpole plot, and the ATV virtual core. The image logs are provided at a scale of 1 inch to 2 feet. The second set of logs (summary logs) consist of lithology logs, natural gamma ray log, SPR log, SP log, normal resistivity logs, and borehole deviation logs. The summary logs are provided at a scale of 1 inch to 10 feet. The scales are not equal for the image logs and summary logs in order to provide a more detailed view of the ATV image log data while providing a more compressed scale for the summary logs, which allows better interpretation of the linear data where anomalies may be subtle and take place over a broad depth range.

Fractures can be identified on the basis of the ATV amplitude images and/or the ATV travel time images. Some, if not most, of the criteria for the identifying fractures require a judgment call, and different log analysts will not necessarily make the same call. Hence, some of the bedrock structures identified as fractures may not be fractures. Bedding, foliation, veins, and other planar geologic features in the rock may appear similar to fractures in the borehole geophysical data. The WellCAD software program reports the orientation of bedrock structures (fractures, bedding, foliation, veins, and other planar geologic features) as the dip azimuth (dip direction) and dip angle of each structure. The dip azimuth is perpendicular to the strike as used commonly by geologists. The dip azimuth data are referenced to magnetic north and the dip angle data are reported as the bedrock structure's angle from horizontal. The datum for depths in this report is the ground surface at the location of the borehole. The WellCAD software program reports the depth of a bedrock structure as the average of the depth of the top and bottom intersections of the bedrock structure and the borehole wall.

Bedrock structures detected in the televiewer logs are grouped into four categories: Fracture Rank 1, Fracture Rank 2, Fracture Rank 3, and Bedding. The categories are shown as color-coded lines and symbols on the structure projection plots, tadpole plots, and on the structure statistics plots. Figure 3 explains the bedrock structure categories, and Figure 4 explains how to read the tadpole plots.

Fracture Rank 1 describes minor fractures that are not distinct and may not be continuous around the borehole. Fracture Rank 2 describes intermediate fractures that are distinct and continuous around the borehole with little or no apparent aperture. Fracture Rank 3 describes major fractures that are distinct and continuous around the borehole with apparent aperture. The Bedding category describes planar geologic structures in the rock interpreted as bedding.

The structure projection plots display the structural interpretation of the televiewer data and displays the bedrock structures as they appear in the televiewer images. The depth, orientation, and category of the bedrock structures can be read from the structure projection plots. The data in the structure projection plots are apparent data and are not corrected from apparent to true dip azimuth and dip angle.

The tadpole plots are created from the structure projection plots after the data are corrected from apparent to true dip azimuth and dip angle. The tadpole plots graphically display the depth, orientation, and category of the bedrock structures interpreted from the televiewer images. The orientation of bedrock structures are graphically displayed on the tadpole plots by a tadpole made up of a circle, the head, and a line, the tail. The position of the head, left to right on the tadpole plot, gives the dip angle of the bedrock structure. The left side of the track indicates a dip angle of 0° and the right side of the track indicates a dip angle of 90° from horizontal. The position of the tail gives the dip azimuth of the fracture and can be read like a compass. The tail pointing directly up is 0°, magnetic north. We note explicitly that the dip azimuth is perpendicular to the strike as the term is used by geologists.

Borehole deviation data are reported as Northing and Easting logs. The Northing and Easting data are the distance in feet the borehole has horizontally deviated from where the borehole would be if it was vertical. Zero Northing and zero Easting is located at the start of the data acquisition, typically the bottom of casing. The depth track in the logs and tables is the depth along the borehole (i.e. the length of the borehole), which, if the borehole is vertical will be equal to the vertical depth. The deviation log can not be acquired in the steel casing due to the magnetic interference of the casing.

Results

The general location of the site is shown in Figure 1, and Figure 2 is a site plan showing the approximate location of the logged borehole. The borehole geophysical logs are given in Appendix 1, the core logs (provided by GZA) are given in Appendix 2, the table of bedrock structures is given in Appendix 3, and the bedrock structure statistics plots are given in Appendix 4. The dip azimuth data are referenced to magnetic north, and the dip angle data are reported as the bedrock structure's angle from horizontal. The datum for depths in this report is the ground surface at the location of the borehole.

DH-01 was cased through the overburden to a depth of approximately 48 feet and was open-hole in the HQ cored (4-inch diameter) bedrock portion of the borehole to a depth of approximately 517 feet. The logging program was specified by RDC and consisted of ATV, caliper, natural gamma ray, normal resistivity, SP, and SPR. ATV, normal resistivity, SP, and SPR data can only be acquired in the water filled portion of the borehole. Therefore, the data in the borehole geophysical logs are provided from the water level at approximately 48.5 feet to the bottom of the borehole at approximately 517 feet. The ATV probe would not advance below approximately 510 feet. Therefore, ATV data are only provided to approximately 510 feet.

The depths of lithologic variation, rock type, and formation are reported in the lithology logs provided in the first two tracks of the borehole geophysical logs in Appendix 1. The lithology data are based on an integrated interpretation of data in the core logs for DH-01 provided by GZA (reproduced in Appendix 2) and the borehole geophysical logging data. The core logs report the depths of specific rock types and formations. We note that it is not possible to determine the rock type or formation based on the borehole geophysical logging data. The borehole geophysical logging data were used to better define the depths of lithologic variation reported in the core logs.

Based on the borehole geophysical logging data, the most prominent orientation of bedrock fractures detected in borehole DH-01 is approximately parallel to the orientation of bedding. The number of bedrock structures interpreted as fractures and bedding in borehole DH-01 and the most prominent orientations of the fractures and bedding detected in borehole DH-01 are reported in Table 2 and are evident in the bedrock structure statistics plots in Appendix 4.

Table 2 - DH-01 Bedrock Structure Statistics

Structure Category	Total Number of Structures	Most Prominent Dip Azimuth(s)	Most Prominent Dip Angle
Fractures	141	west-southwest	0° - 10° (near horizontal)
Bedding	67	approximately west and approximately north	0° - 5° (near horizontal)

The bedrock in DH-01 is moderately fractured between the depths of 48 feet and 85 feet. Of the 141 fractures detected in DH-01, 79 fractures were detected between the depths of 48 feet and 85 feet. The portion of the borehole between the depths of 48 feet and 85 feet makes up approximately 8% of the logged portion of DH-01, but 56% of the fractures detected in borehole DH-01 are in this portion of the borehole.

The bedrock in DH-01 has low fracture density between 85 feet and the bottom of the borehole at approximately 517 feet. Of the 141 fractures detected in DH-01, 62 fractures were detected between 85 feet and the bottom of the borehole. The portion of the borehole between 85 feet and the bottom of the borehole makes up approximately 92% of the logged portion of DH-01, but only 42% of the fractures detected in borehole DH-01 are in this portion of the borehole. A summary of the bedrock fracture density is reported in Table 3.

Table 3 - DH-01 Bedrock Fracture Density Statistics

Depth Range (feet bgs)	Percent of Logged Portion of DH-01	Number of Fractures	Percent of Fractures Detected in DH-01
48 feet - 85 feet	8%	79	56%
85 feet - 517 feet	92%	62	44%

bgs = below ground surface

The average angle of borehole DH-01 is less than 0.5° from vertical. The borehole deviated less than three feet south and less than one foot east over the length of the borehole.

Limitations

This letter report was prepared for the exclusive use of Raimonde Drilling Corporation (Client). No other party shall be entitled to rely on this Report or any information, documents, records, data, interpretations, advice or opinions given to Client by Hager-Richter Geoscience, Inc. in the performance of its work. The Report relates solely to the specific project for which Hager-Richter has been retained and shall not be used or relied upon by Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of Hager-Richter. Any unpermitted use by Client or any third party shall be at Client's or such third party's own risk and without any liability to Hager-Richter.

Hager-Richter has used reasonable care, skill, competence and judgment in the performance of its services for this project consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by Hager-Richter should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

Except as expressly provided in this limitations section, Hager-Richter makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

If you have any questions or comments on this report, please contact us at your convenience. It has been a pleasure to work with RDC on this project. We look forward to working with you again in the future.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Robert L. Garfield

Robert Garfield
Senior Borehole Geophysicist

Dorothy Richter, P.G.
President

Enclosures:

FIGURES

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LOCATION

NOT TO SCALE

Figure 1 General Site Location Deep Core Boring Project Route 25 Repository Site Aurora, Illinois	
File 08RG26	November, 2008
HAGER–RICHTER GEOSCIENCE, INC. Fords, New Jersey	

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LEGEND

BOREHOLE LOGGED BY HAGER–RICHTER

NOT TO SCALE

Figure 2
Site Plan
Deep Core Boring Project
Route 25 Repository Site
Aurora, Illinois

File 08RG26 | November, 2008

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey

Tadpole	Structure Category (Symbol Color)	Description
	Bedding (Brown)	Planar structure interpreted to be a bedding plane
	Fracture Rank 1 (Light Blue)	Minor Fracture - not distinct and may not be continuous around the borehole
	Fracture Rank 2 (Blue)	Intermediate Fracture - distinct and continuous around the borehole with little or no apparent aperture
	Fracture Rank 3 (Red)	Major Fracture - distinct and continuous around the borehole with apparent aperture

Figure 3. Key to bedrock structure categories.

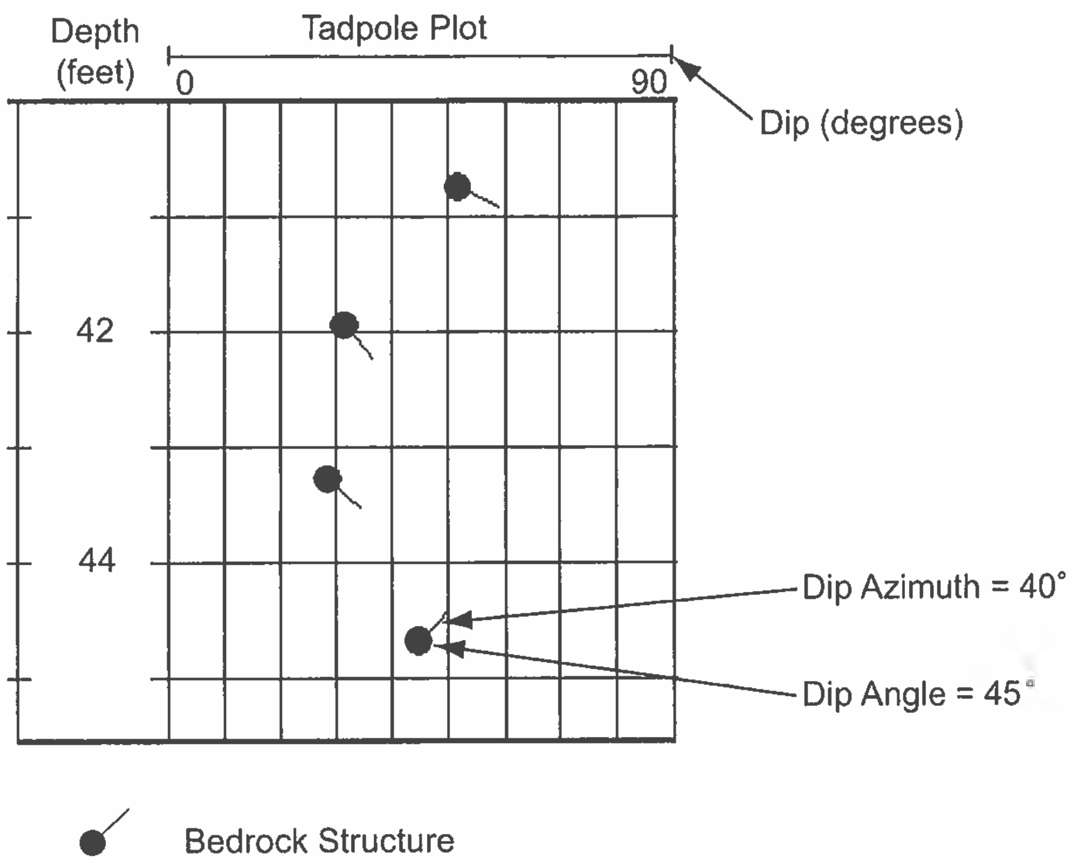


Figure 4. Key to tadpoles. The orientation of the bedrock structures is graphically displayed by a tadpole made up of a circle, the head, and a line, the tail. The position of the head, left to right on the tadpole plot, gives the dip angle of the structure. The left side of the track indicates a dip angle of 0°, and the right side of the track indicates a dip angle of 90°from horizontal. The position of the tail gives the dip azimuth of the structure and can be read like a compass. The tail pointing directly up is 0°, magnetic north.

APPENDIX 1

BOREHOLE GEOPHYSICAL LOGS

HAGER-RICHTER GEOSCIENCE, INC.
846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

BOREHOLE ID: DH-01
DATE LOGGED: July 23, 2008

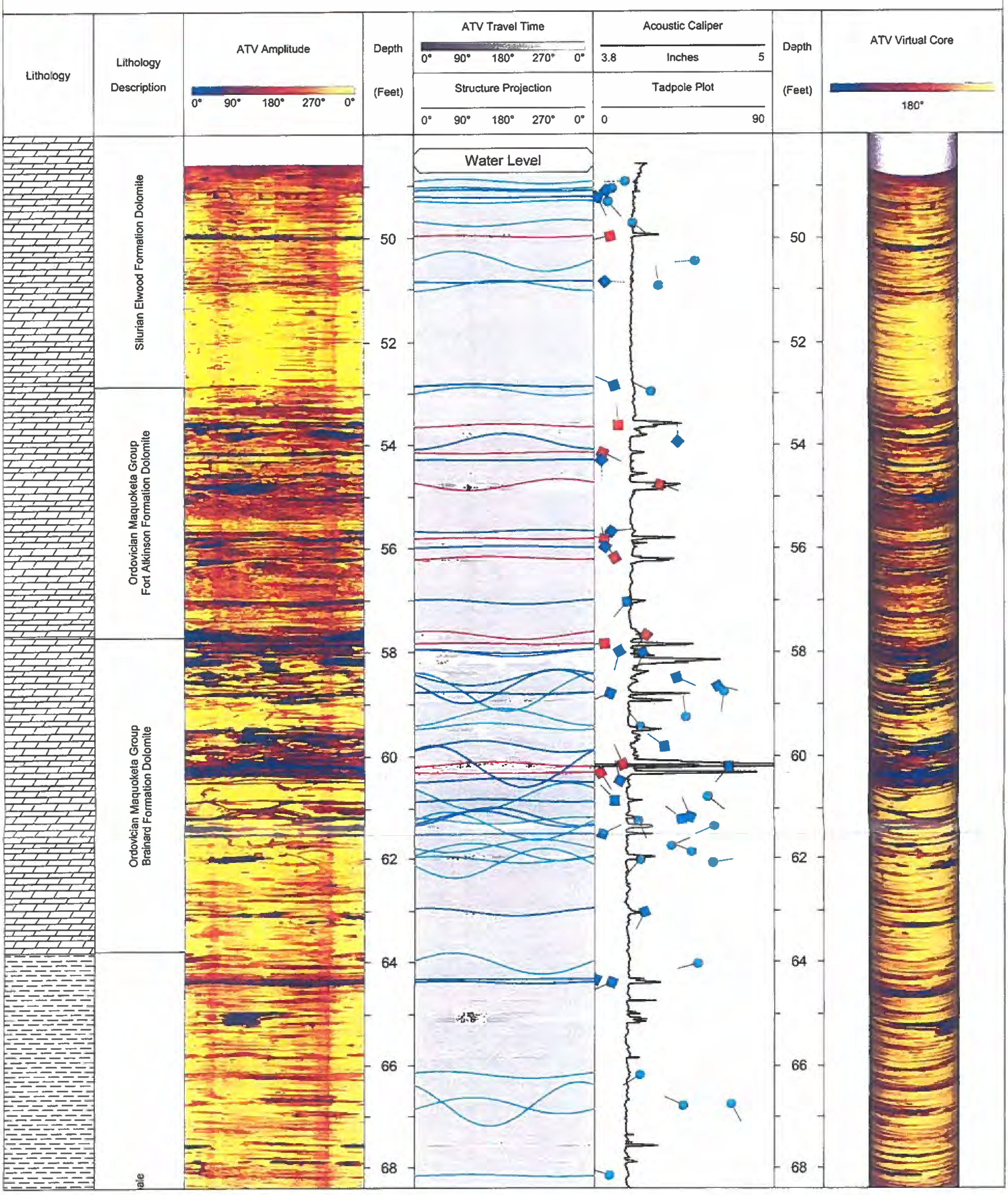
CLIENT: Raimonde Drilling Corporation
PROJECT: Deep Core Boring Project
LOCATION: Route 25 Repository Site
CITY, STATE: Aurora, Illinois
LOGGING GEOPHYSICIST(S): Robert Garfield & Alexis Martinez
PROJECT REPRESENTATIVE(S): A. Leslie (RDC) & M. Fisher (DEI)

H-R FILE: 08RG26
LOG DATUM: Ground Surface
LOG DATUM ELEVATION: 670 Feet
ORIENTATION REFERENCE: Magnetic North
BOREHOLE DIAMETER: HQ (4 Inches)
WATER LEVEL DEPTH: 48.5 Feet

LITHOLOGY LEGEND
Shale   Dolomite   Limestone   Dolomitic Limestone

NOTE: The lithology logs are based on data provided by GZA and the borehole geophysical logging data.

STRUCTURE LEGEND
Fracture Rank 1   Fracture Rank 2   Fracture Rank 3   Bedding



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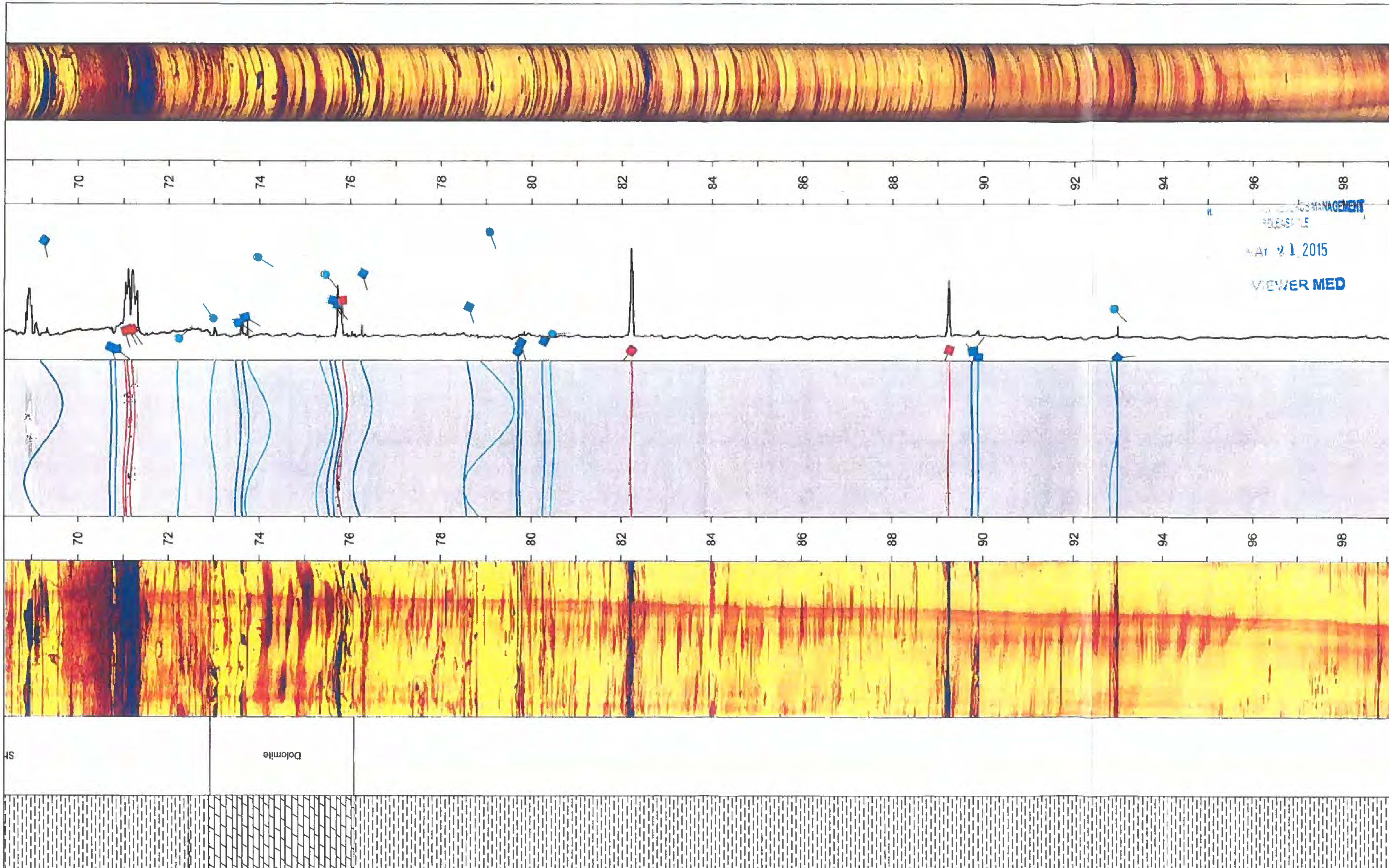
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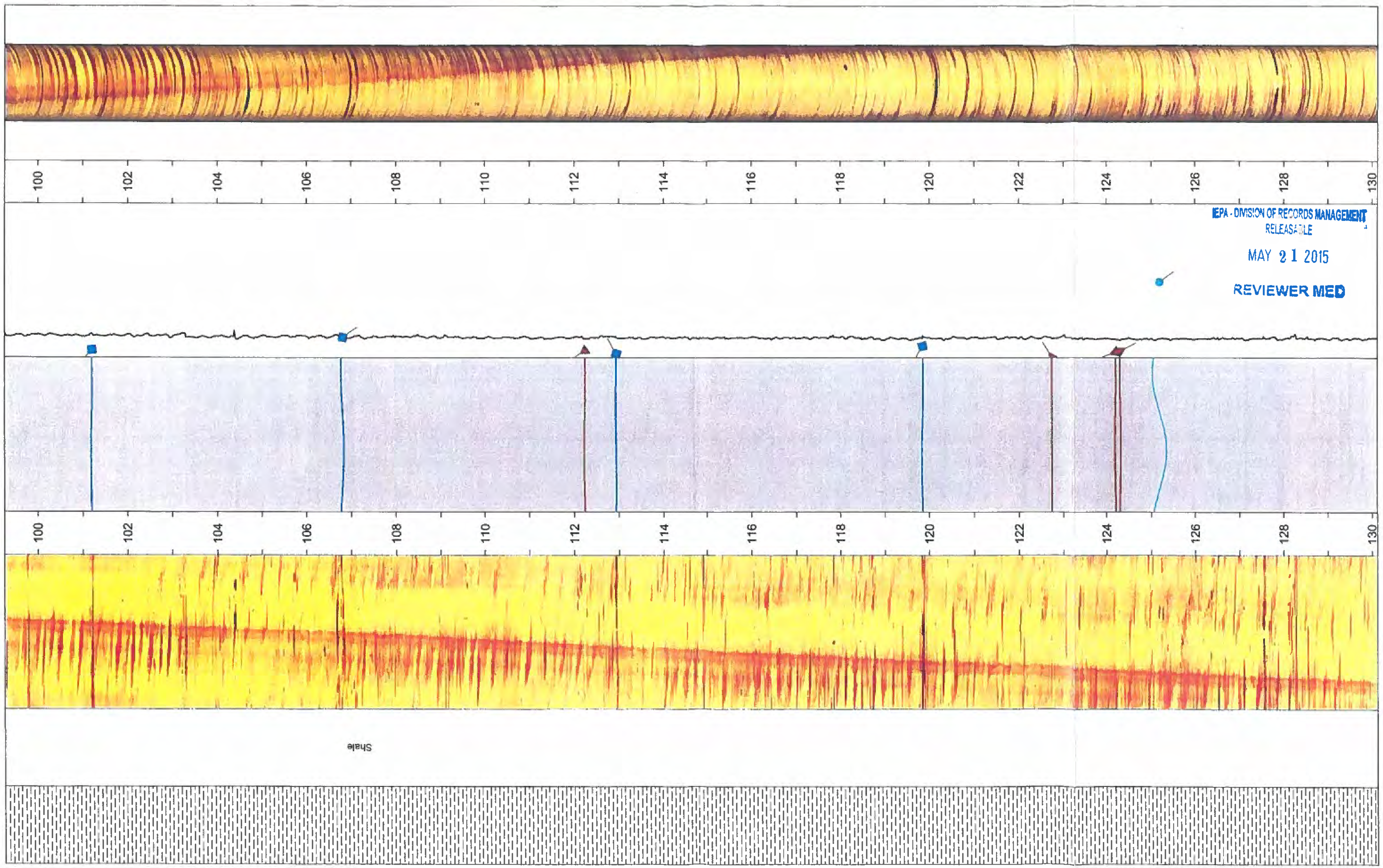
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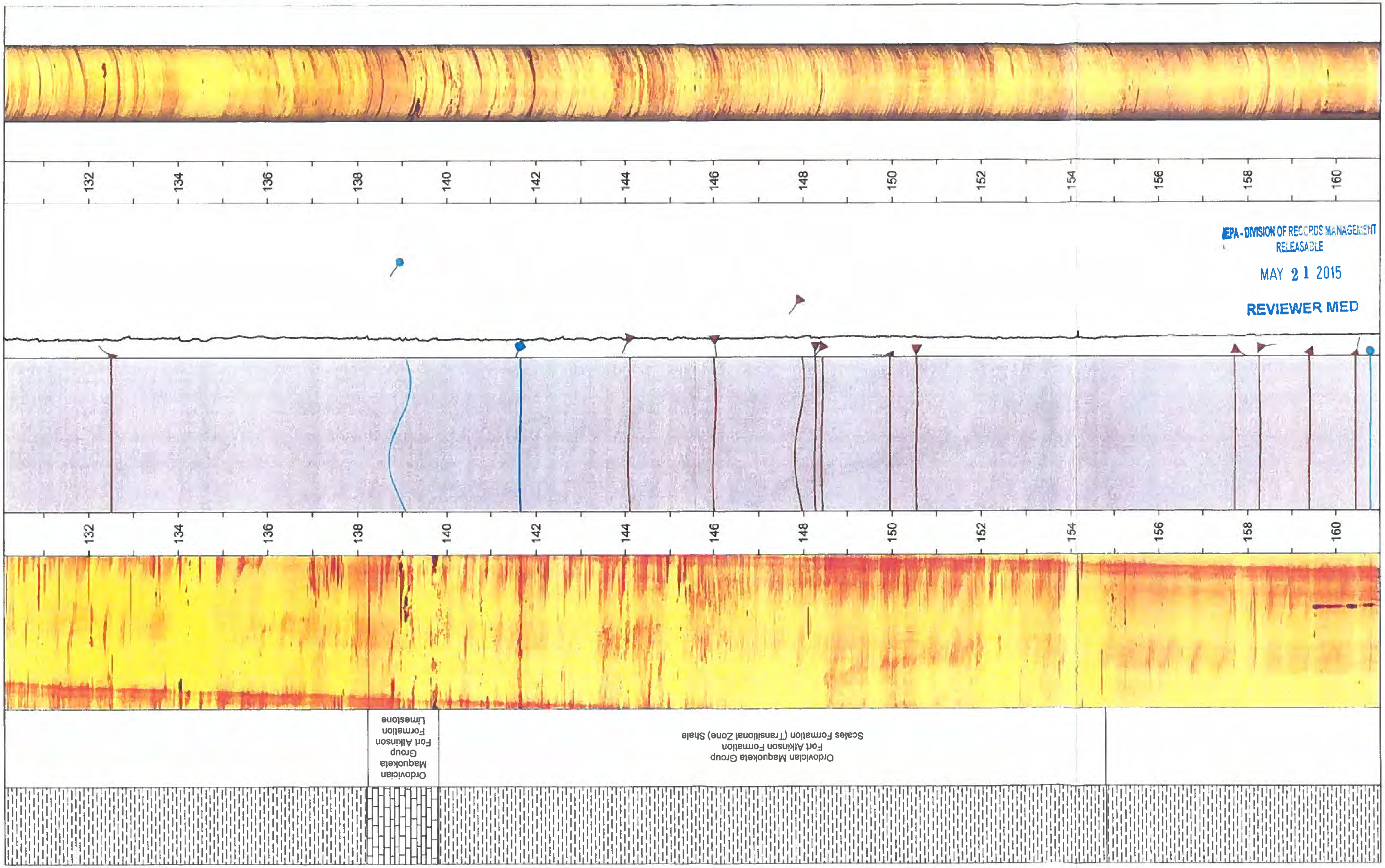
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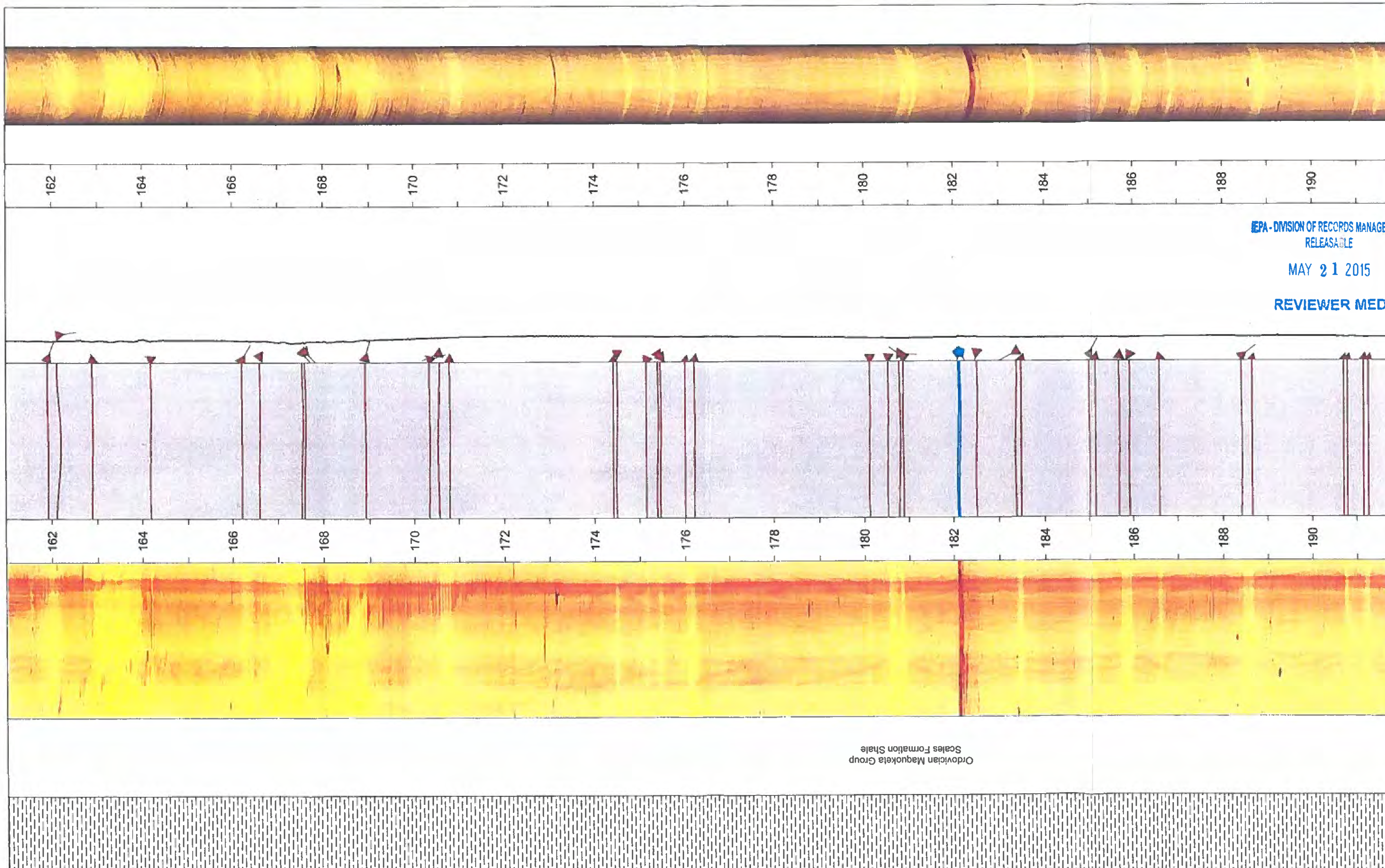
Ordovician Maquoketa Group
Fort Atkinson Formation
Scales Formation (Transitional Zone) Shale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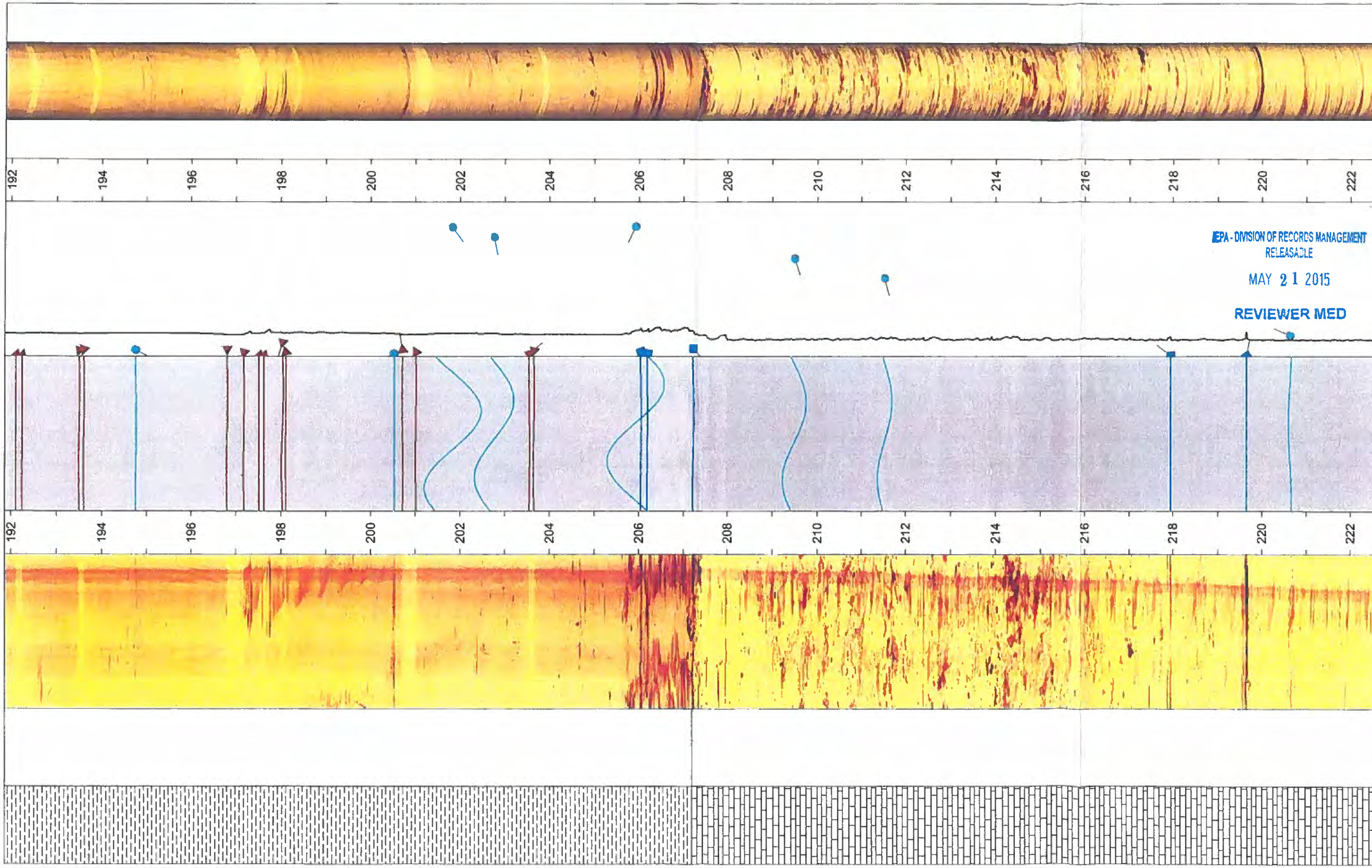
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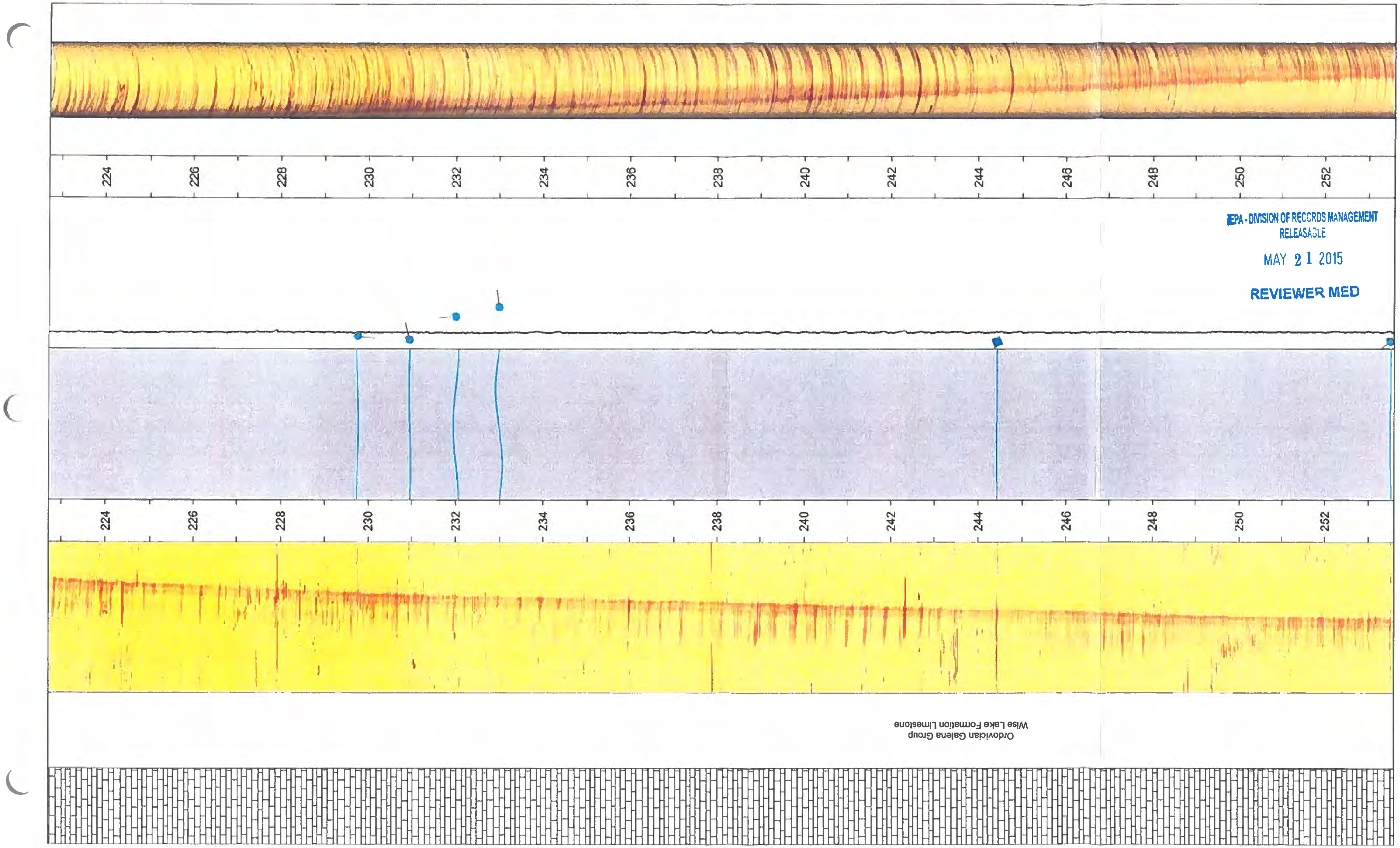
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Wise Lake Formation Limestone
Ordovician Galena Group

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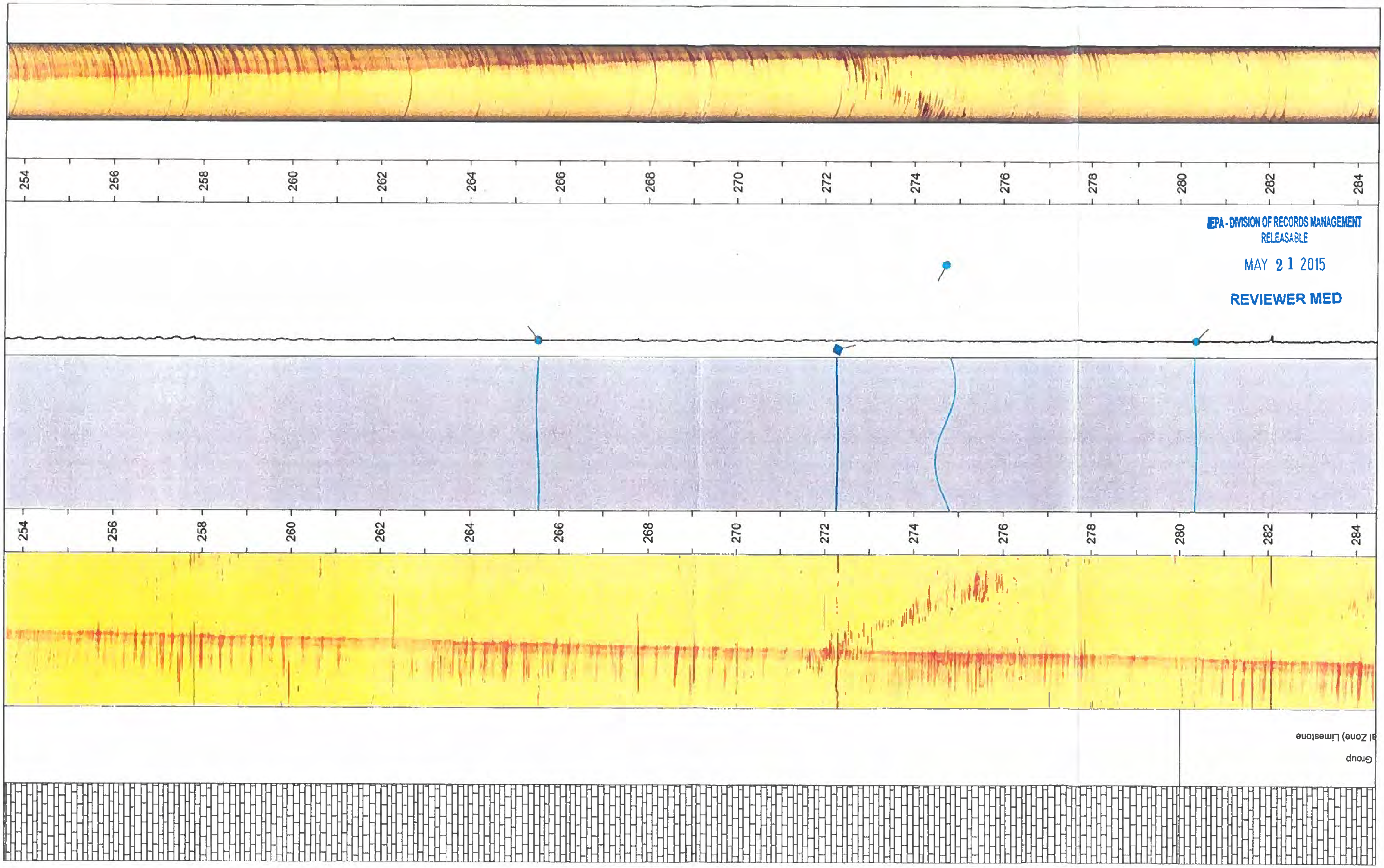
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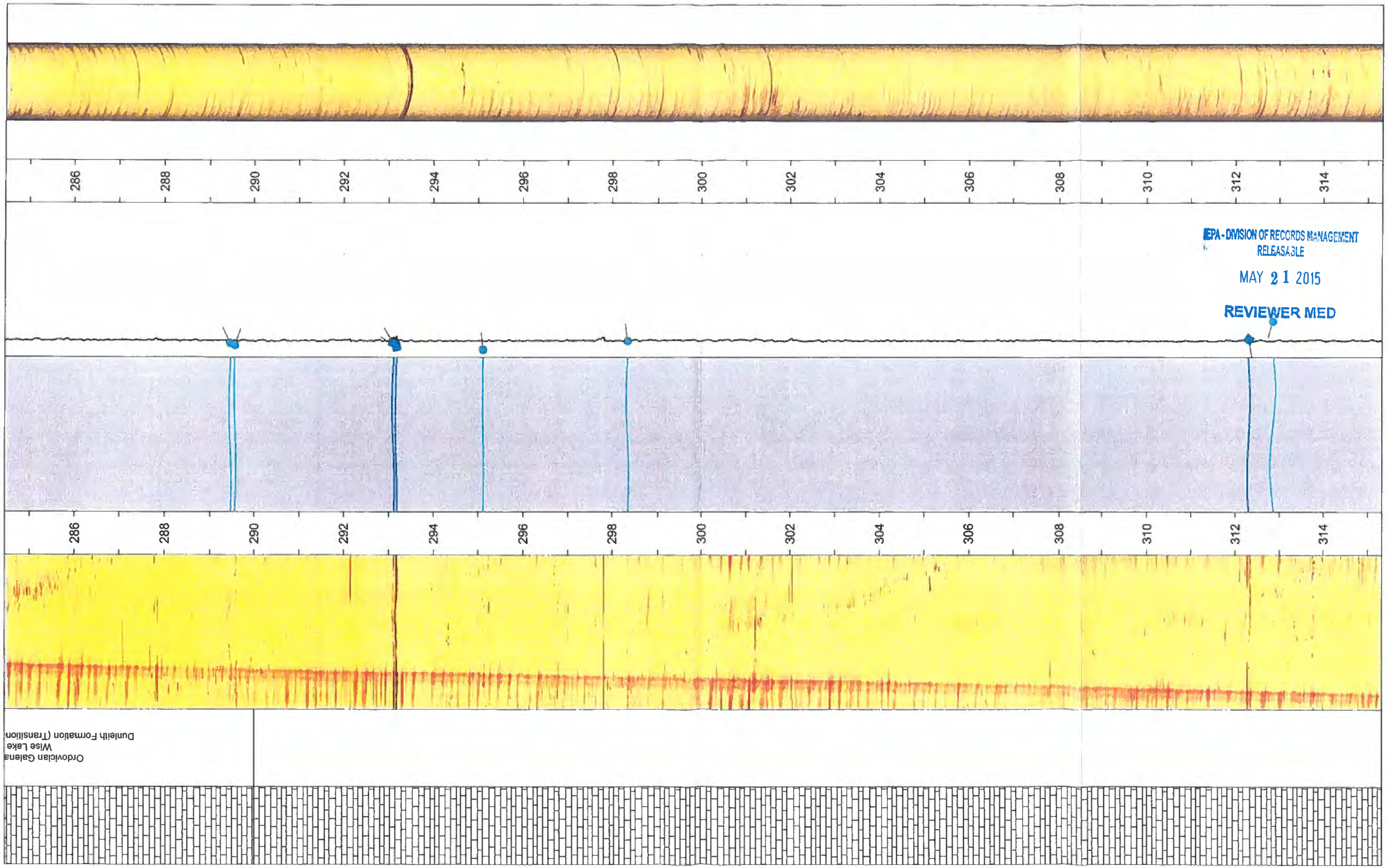
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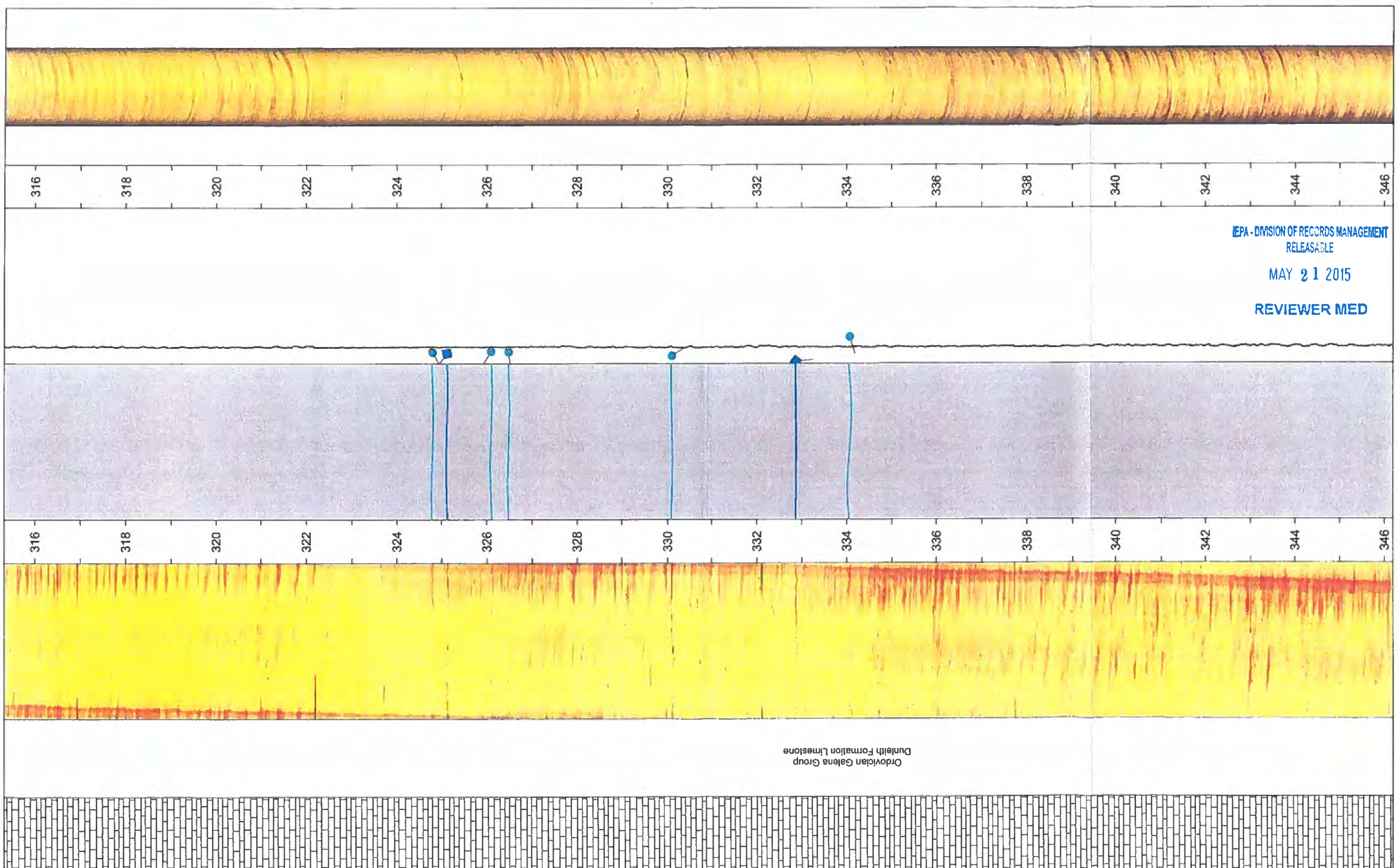
Dunleith Formation (Transition)
Wise Lake
Ordovician Galena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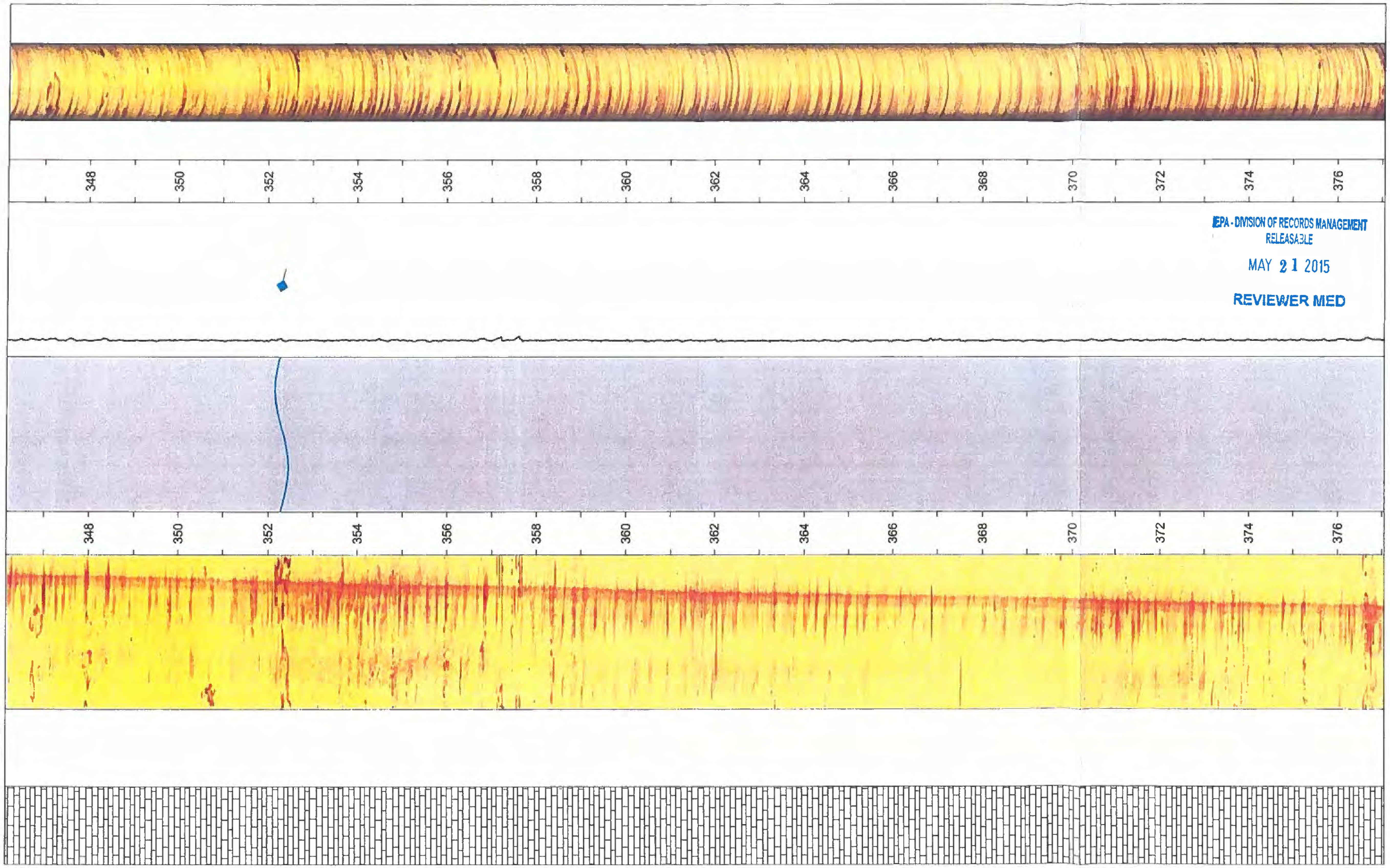
IEPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
MAY 21 2015
REVIEWER MED
Ordovician Galena Group
Dunleith Formation Limestone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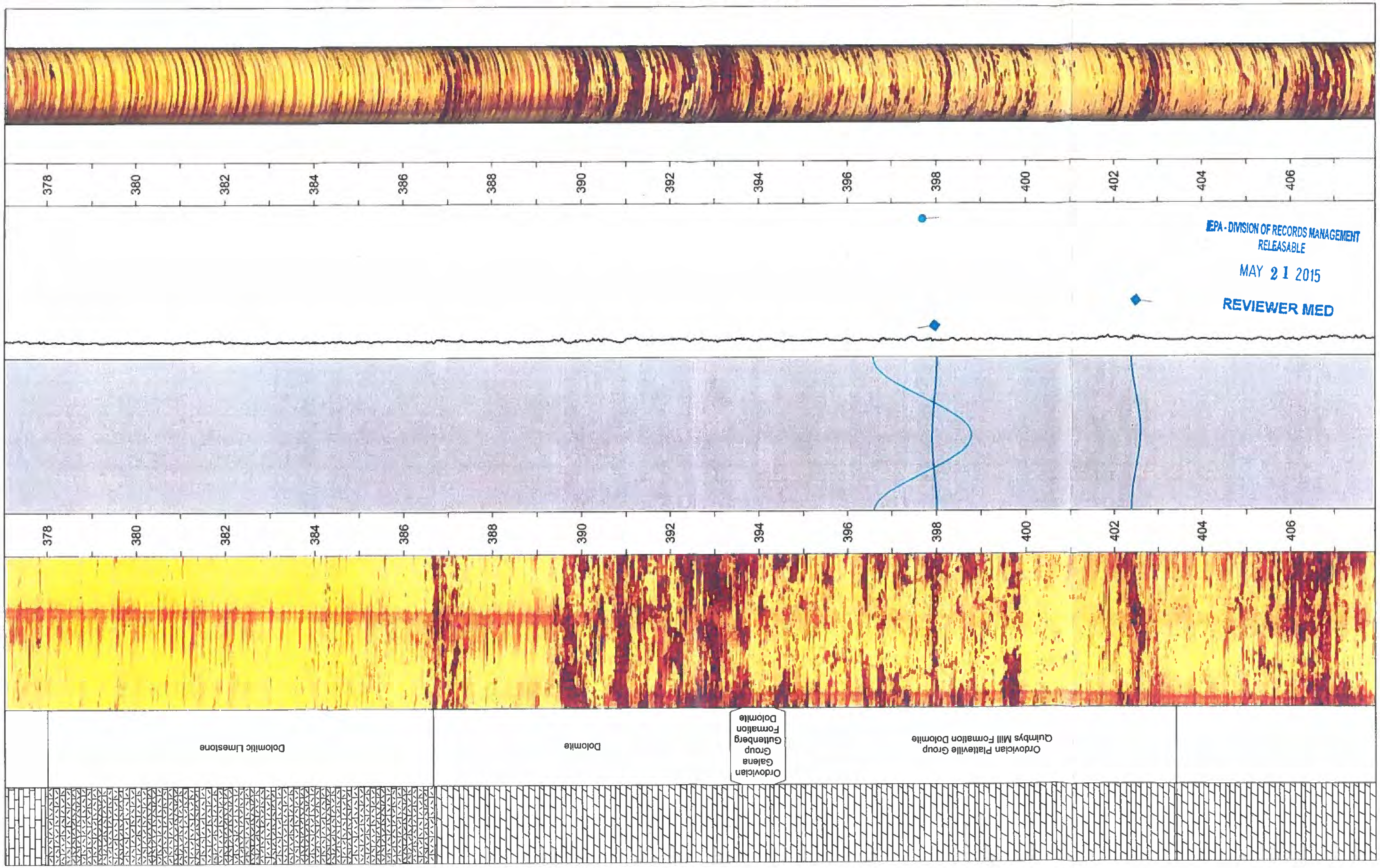
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EPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
MAY 21 2015
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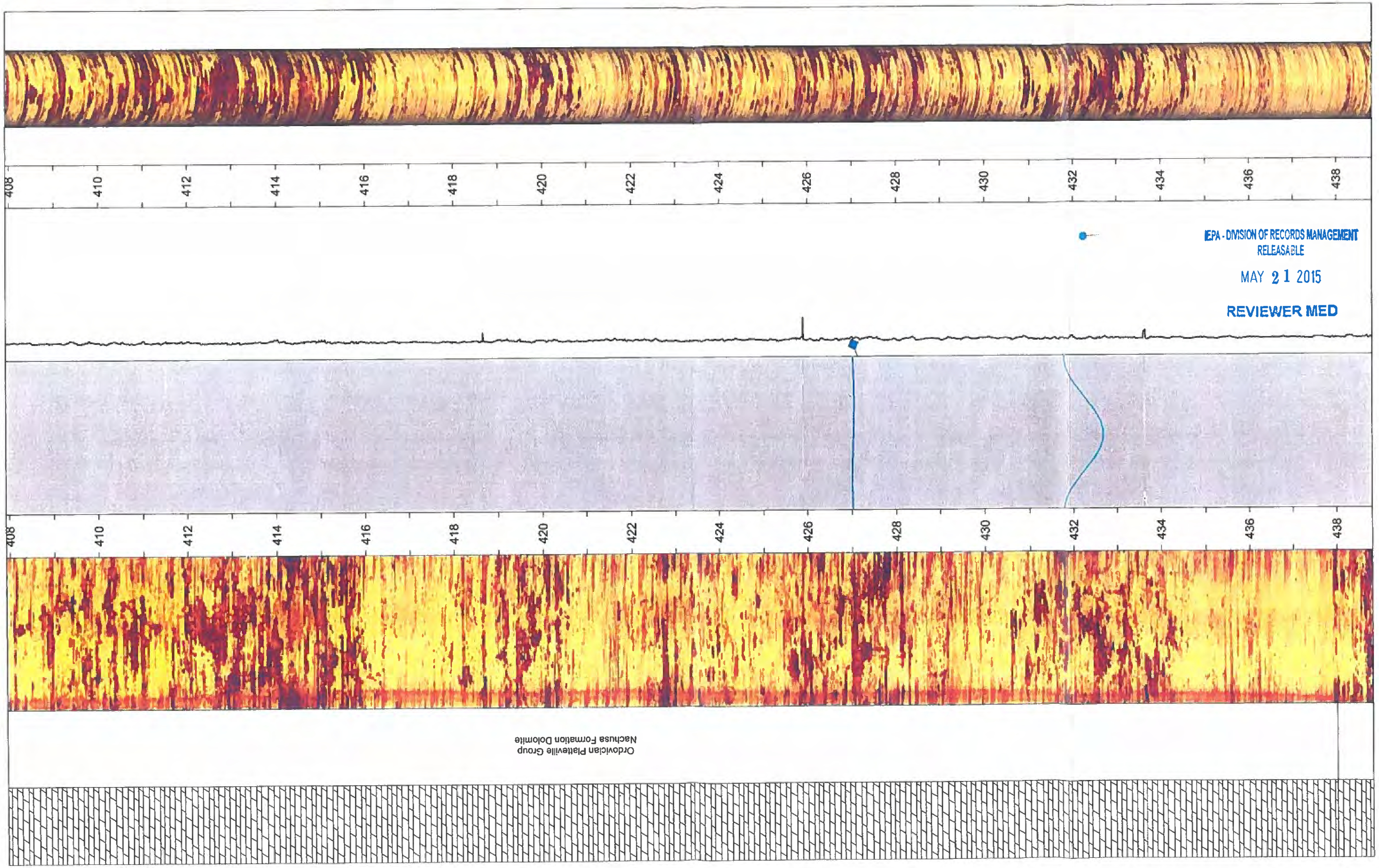
Dolomitic Limestone
Dolomite
Ordovician Galena Group Guttenberg Formation Dolomite
Ordovician Platteville Group Quimbys Mill Formation Dolomite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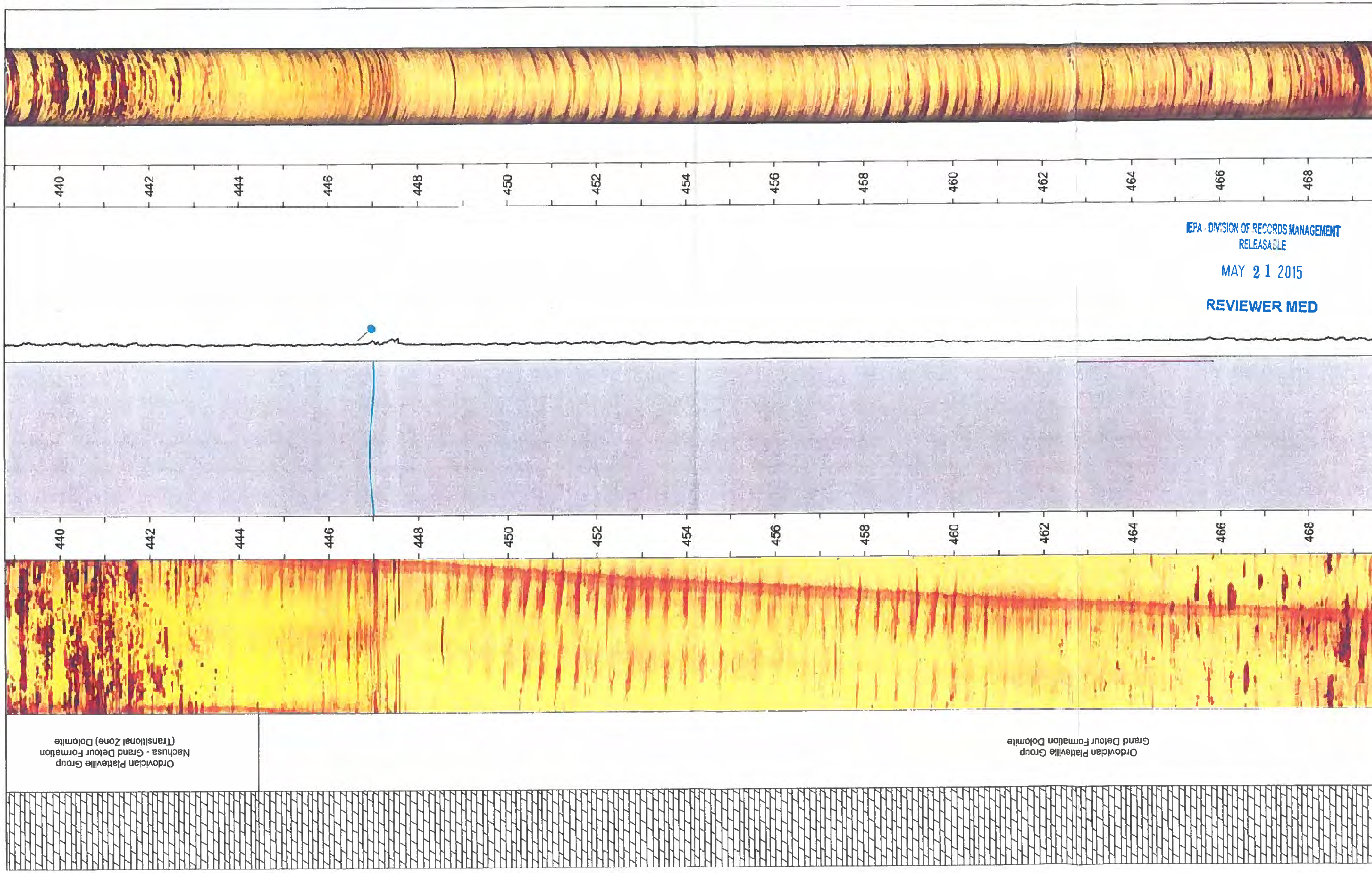
MAY 21 2015
REVIEWER MED
Ordovician Platteville Group
Nachusa Formation Dolomite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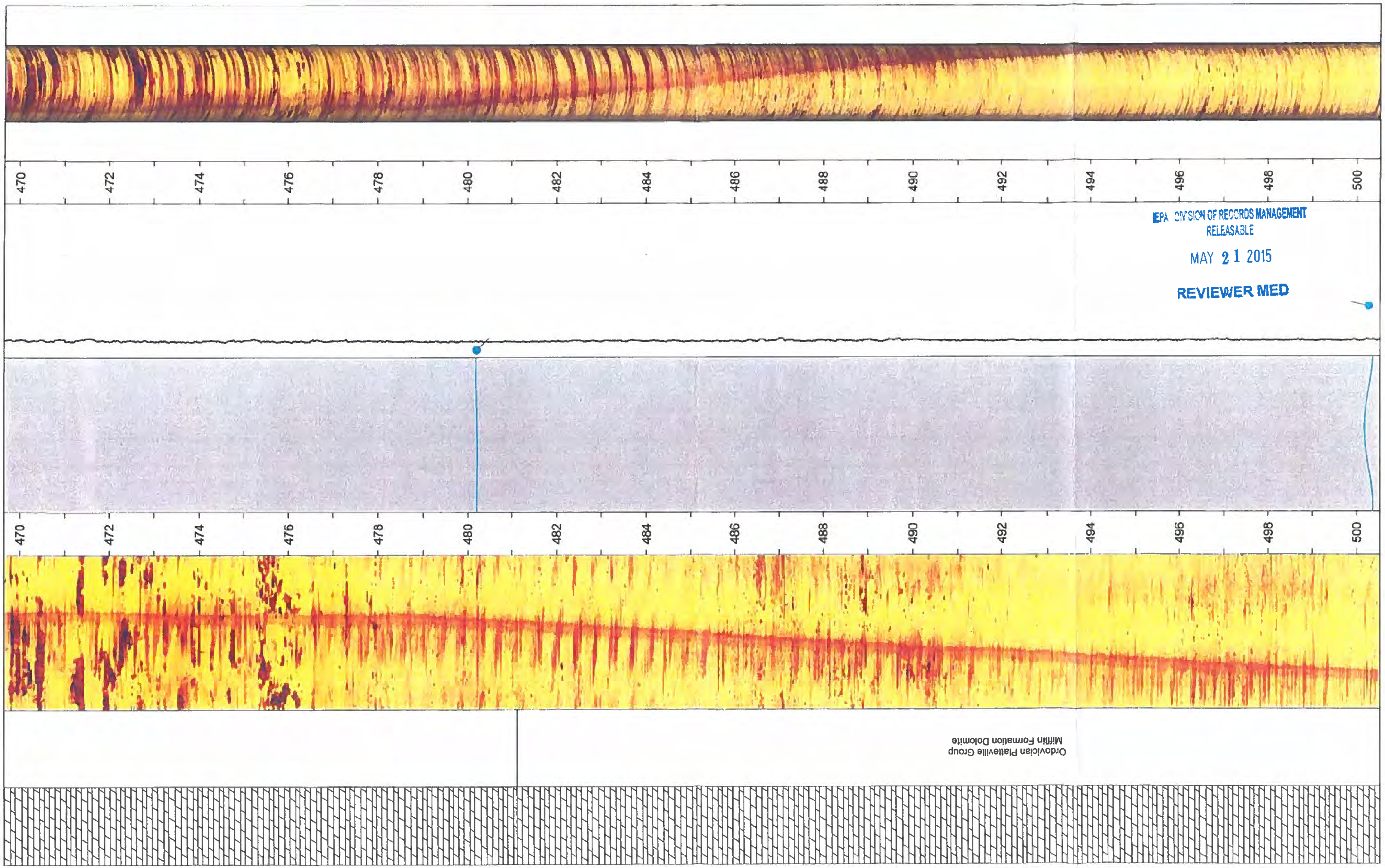
EPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
MAY 21 2015
REVIEWER MED
Ordovician Platteville Group
Nachusa - Grand Detour Formation
(Transitional Zone) Dolomite
Ordovician Platteville Group
Grand Detour Formation Dolomite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492
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498
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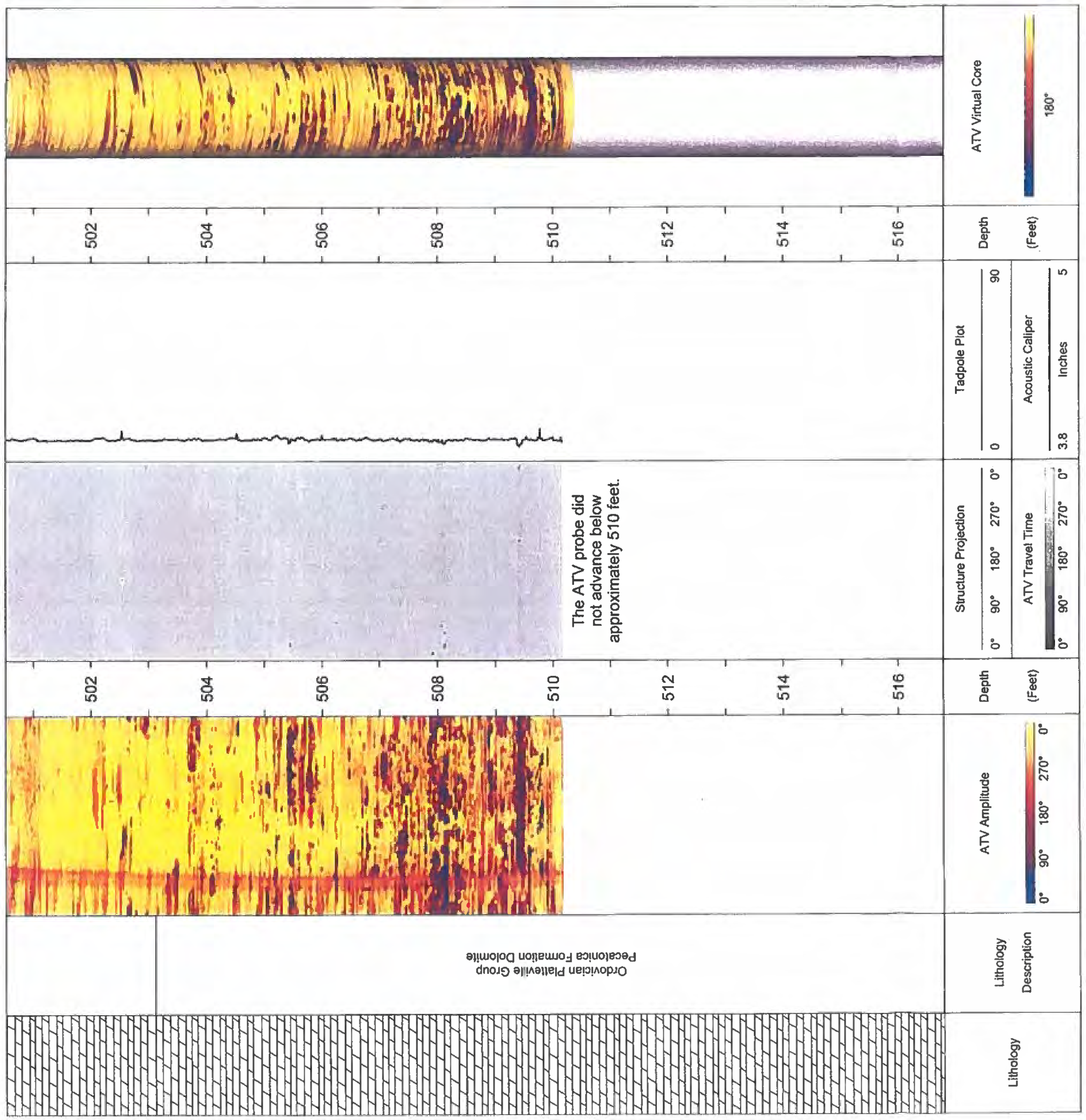
EPA DIVISION OF RECORDS MANAGEMENT
RELEASABLE
MAY 21 2015
REVIEWER MED
Ordovician Platteville Group
Mifflin Formation Dolomite



ATV Virtual Core
180°
Depth
(Feet)
502
504
506
508
510
512
514
516
Tadpole Plot
0
90
Acoustic Caliper
3.8
Inches
5
Structure Projection
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
The ATV probe did not advance below approximately 510 feet.
ATV Amplitude
0° 90° 180° 270° 0°
Lithology Description
Ordovician Platteville Group
Pecatonica Formation Dolomite
Lithology

Page 33 of 62

HAGER-RICHTER GEOSCIENCE, INC.
846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

BOREHOLE ID:	DH-01
DATE LOGGED:	July 23, 2008

CLIENT:	Raimonde Drilling Corporation	H-R FILE:	08RG26
PROJECT:	Deep Core Boring Project	LOG DATUM:	Ground Surface
LOCATION:	Route 25 Repository Site	LOG DATUM ELEVATION:	670 Feet
CITY, STATE:	Aurora, Illinois	ORIENTATION REFERENCE:	Magnetic North
LOGGING GEOPHYSICIST(S):	Robert Garfield & Alexis Martinez	BOREHOLE DIAMETER:	HQ (4 Inches)
PROJECT REPRESENTATIVE(S):	A. Leslie (RDC) & M. Fisher (DEI)	WATER LEVEL DEPTH:	48.5 Feet

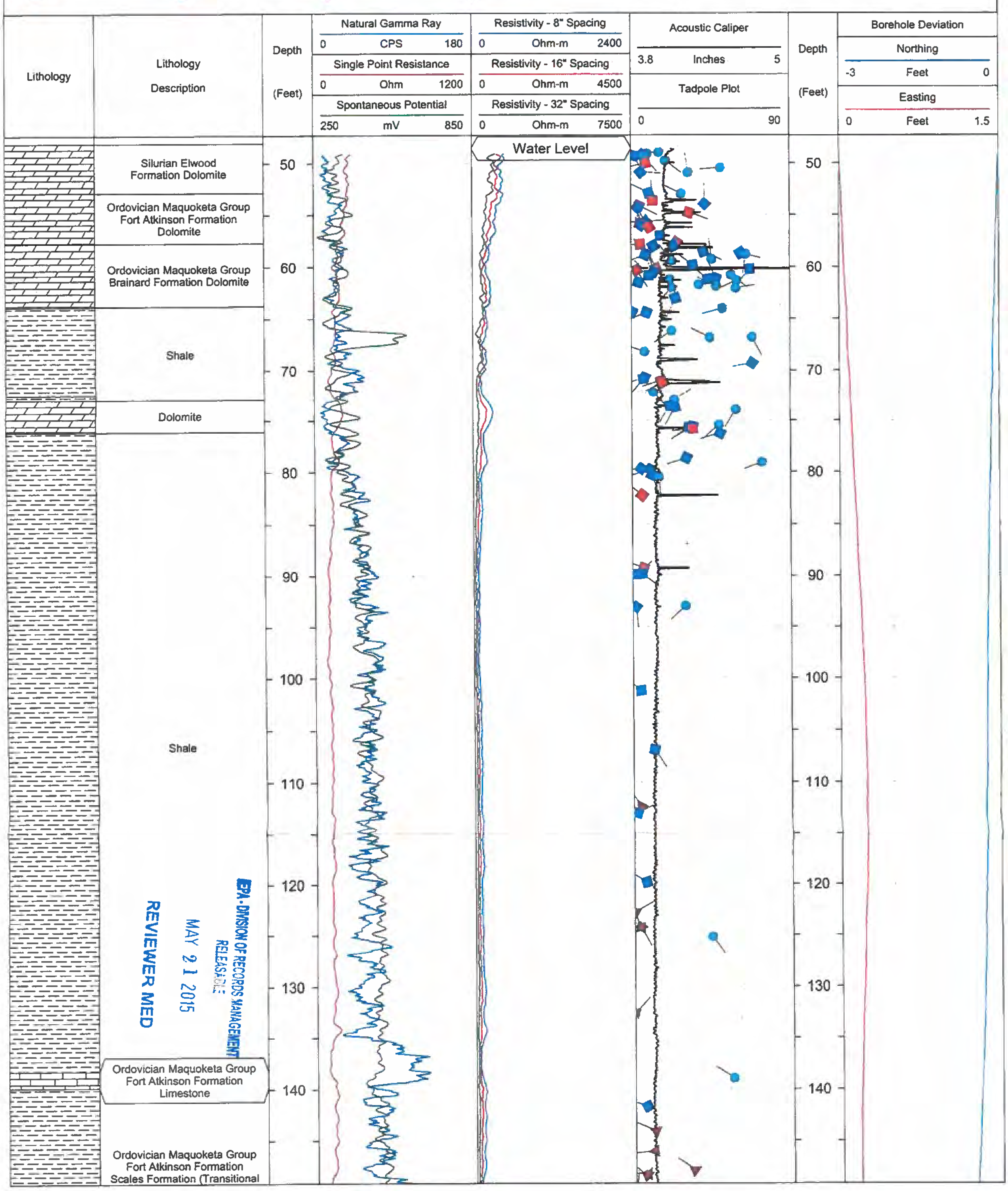
LITHOLOGY LEGEND

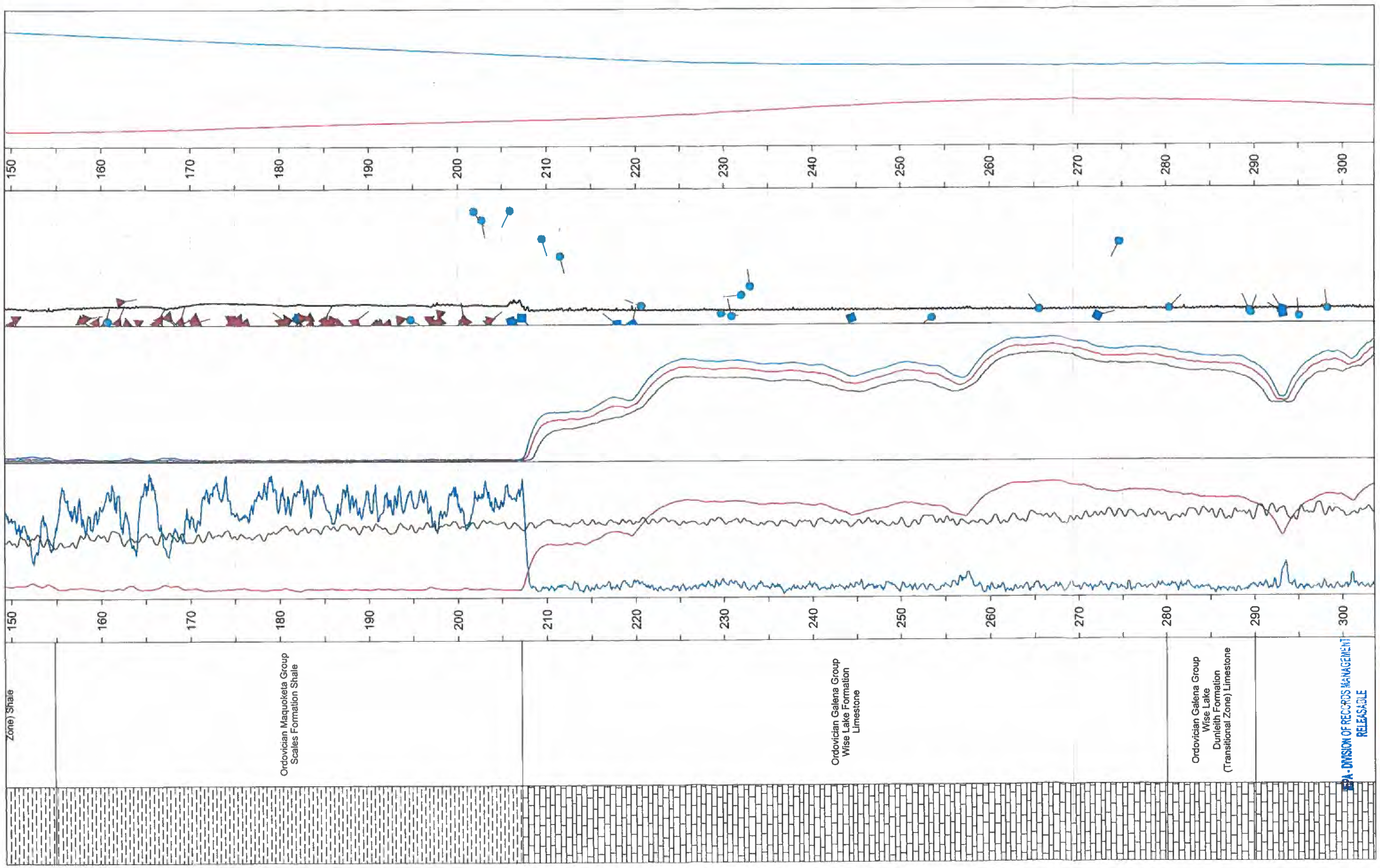
Shale — Dolomite — Limestone — Dolomitic Limestone

NOTE: The lithology logs are based on data provided by GZA and the borehole geophysical logging data.

STRUCTURE LEGEND

Fracture Rank 1 — Fracture Rank 2 — Fracture Rank 3 — Bedding




150
160
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190
200
210
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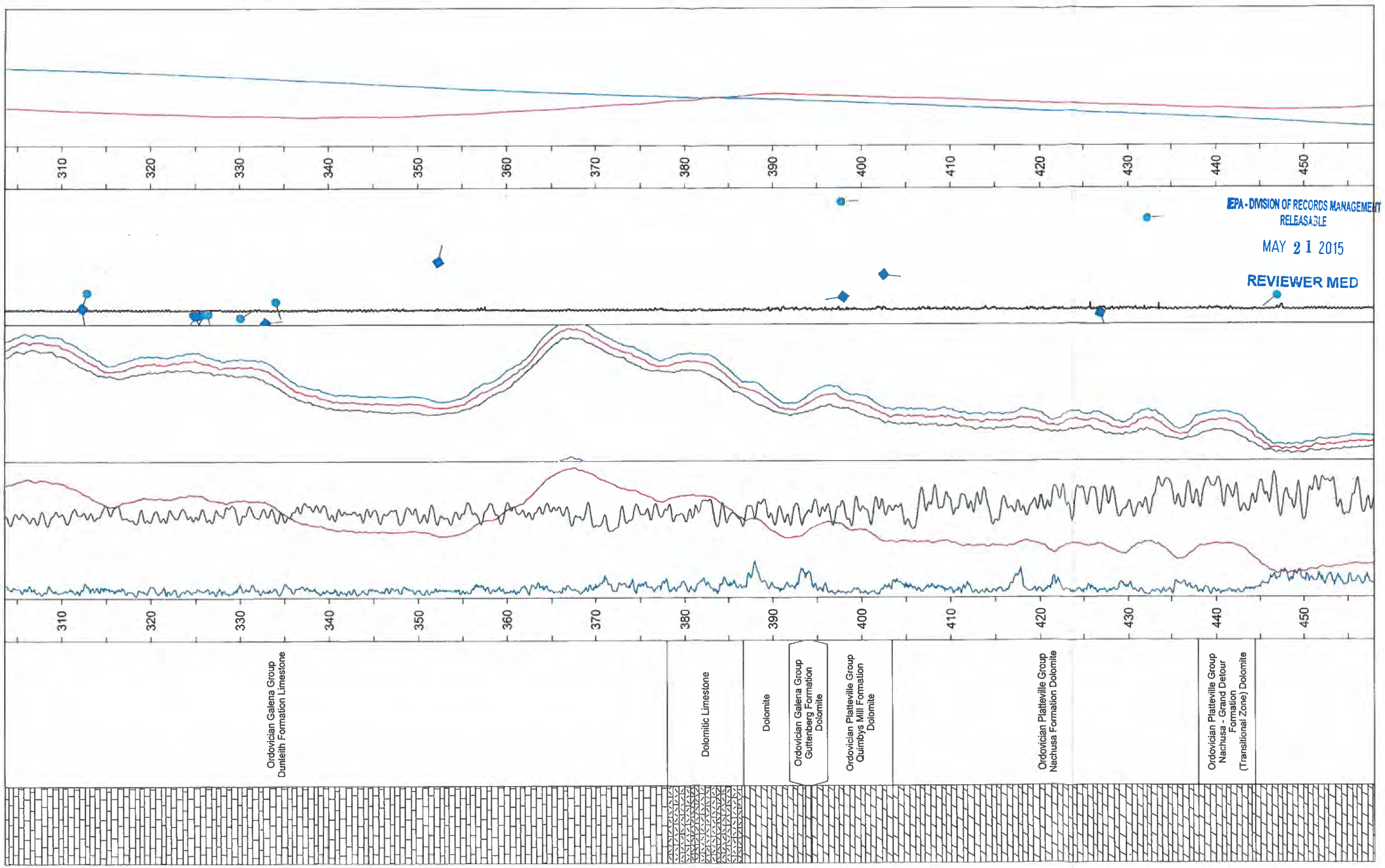
230
240
250
260
270
280
290
300
Zone) Shale
Ordovician Maquoketa Group
Scales Formation Shale
Ordovician Galena Group
Wise Lake Formation
Limestone
Ordovician Galena Group
Wise Lake
Dunleith Formation
(Transitional Zone) Limestone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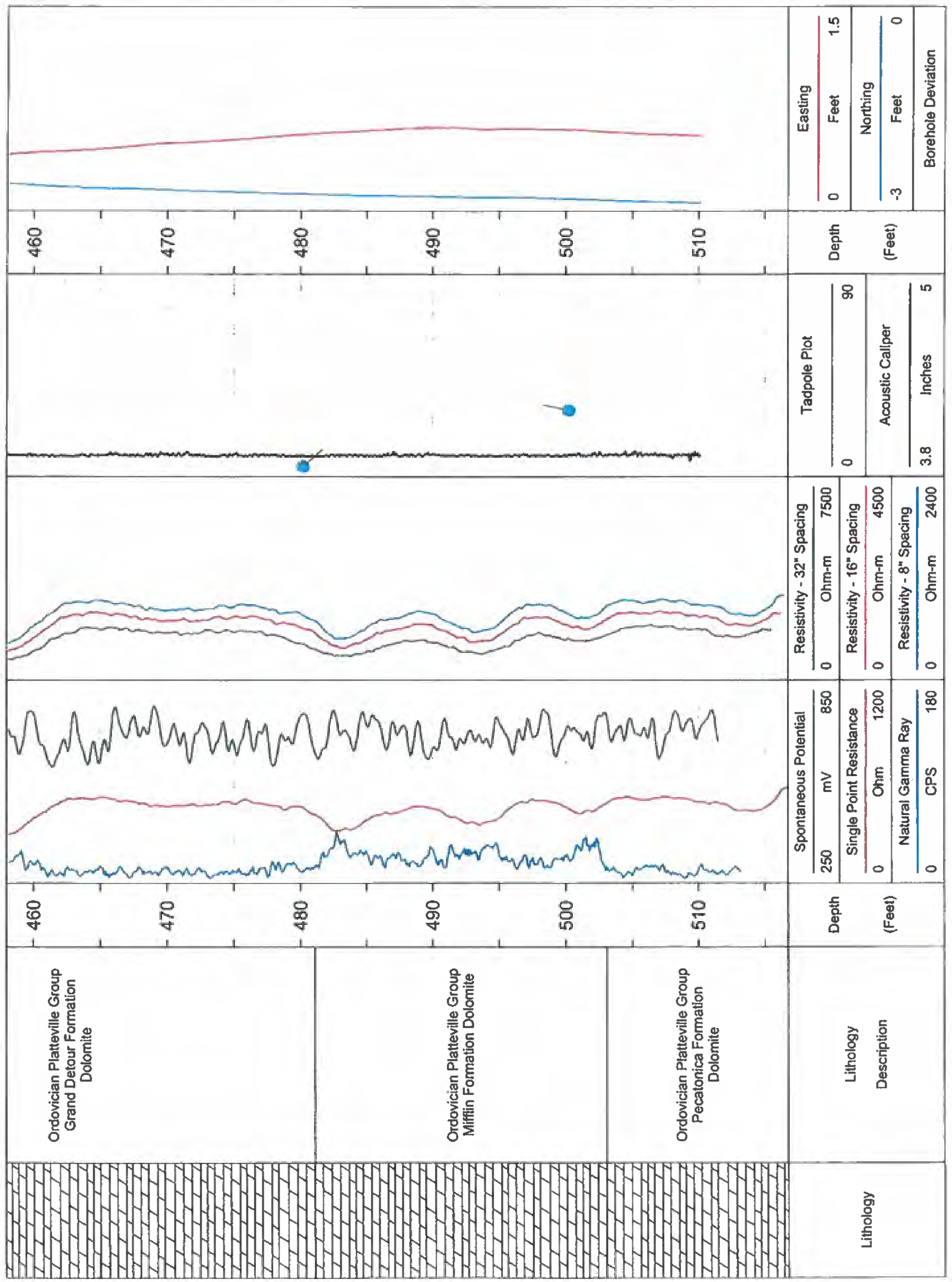
EPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
MAY 21 2015
REVIEWER MED
Ordovician Galena Group
Dunleith Formation Limestone
Dolomitic Limestone
Dolomite
Ordovician Galena Group
Guttenberg Formation
Dolomite
Ordovician Platteville Group
Quimbys Mill Formation
Dolomite
Ordovician Platteville Group
Nachusa Formation Dolomite
Ordovician Platteville Group
Nachusa - Grand Detour
Formation
(Transitional Zone) Dolomite


Easting
Feet
0
1.5
Northing
Feet
-3
0
Borehole Deviation
Depth
(Feet)
460
470
480
490
500
510
Tadpole Plot
0
90
Acoustic Caliper
Inches
3.8
5
Resistivity - 32" Spacing
Ohm-m
0
7500
Resistivity - 16" Spacing
Ohm-m
0
4500
Resistivity - 8" Spacing
Ohm-m
0
2400
Spontaneous Potential
mV
250
850
Single Point Resistance
Ohm
0
1200
Natural Gamma Ray
CPS
0
180
Ordovician Platteville Group
Grand Detour Formation
Dolomite
Ordovician Platteville Group
Mifflin Formation Dolomite
Ordovician Platteville Group
Pecatonica Formation
Dolomite
Lithology
Description
Lithology

APPENDIX 2

CORE LOGS (PROVIDED BY GZA)

GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

DRAFT

Boring No. DH-01
Page No. 1 of 15
File No. 20.0152025.00
Checked By: M. Krumenacher

Drilling Co. Raimonde Drilling Corporation
Foreman Terry Koch
GZA Rep. Erick Staley
Date Start 7/16/08 End 7/24/08
Loc. Coord.
GS. Elev. 670'

Rig Type CME-75 (truck-mounted)
Method
Hole Dia.
Other

Groundwater Readings

Date	Time	Depth (ft)	Casing Depth	Stab. Time

Depth (feet)	Graphic Log	Core Run No.	Core Run Interval Depth (feet)	TCR (%)	SCR (%)	RQD	IF	Sample Description and Classification	Generalized Stratum Description	NOTES
	Over-Burden							0-2.5' **TOPSOIL** and **FILL**	0' TOPSOIL and FILL	1
								2.5-5.5' Crushed rock (FILL)	2.5' FILL	
								5.5-7' Fine to medium **SAND** and **SILT**, brown	5.5' SAND and SILT	
								7-8' Boulders and cobbles	7' BOULDERS and COBBLES	
								8-12' Silty **SAND**	8' SAND and SILT	
								12-41.5' Abrupt change to strong drill resistance at 12'; cuttings consist of very fine grit, light gray/beige (**DOLOMITE**) 41.5-42.5' Cuttings change to dark gray at 41.5' for approx. 1' (**SHALE**) then back to light gray/beige (**DOLOMITE**)	12' DOLOMITE	2 3
48										4
49		1 2	48 - 48.6 48.6 - 58	100 100	100 92	0 85		48-48.6' **DOLOMITE**, strong to very strong, light gray to greenish-gray, microcrystalline w/ rare fossils (brachiopods), fresh, minor pitting/competent, rare vugs associated w/ fossil shelters (<1/4" diameter), core only 7" broken up during retrieval, uppermost sample has 1" pod of white chert 48.6-53.1' **DOLOMITE**, as above, chert pods at approx. 49.5', orange oxidation at 49.6', 50.5' associated w/ increased pitting and vugs up to 1/4" x 1/2" in size, wavy bedding throughout (stylolites)	48' **SILURIAN ELWOOD FORMATION** DOLOMITE	
50										
52										
53										
54								53.1-57.7' **DOLOMITE**, strong, medium to light gray, vuggy w/ abundant small interconnected vugs lined w/ secondary crystals, orange oxide stained at 53.5' and from 55.5 to 57', green clay beds <1/4" thick at 54', 55.4', 55.6', 55.8' and 57.5-57.8', pyrite at approx. 54' in broken zone, mechanical breaks at 48.9', 49.2', 50.1', 51.1', 51.6', 52.1', 52.7', 53-53.2', 54' (pyrite zone), 54.2-54.5', 55.1', 55.3', 56.6', 57' and 57.3', horizontal partings/fractures at 53.5', 53.7', 54', 55.4', 55.6', 55.8' and 57.5-57.8', vertical fracture at 56.6-57'	53' **ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON FORMATION** DOLOMITE	
55										
56										
57										
58										
59		3	58 - 64	100	92	82		57.7-58.2' **DOLOMITE**, as above, interbedded w/ light green/gray, microcrystalline, dolomite w/ few pits and green clay-filled irregular seams 58.2-63.5' **DOLOMITE**, argillaceous, strong, light green/gray, fresh to slightly decomposed, competent, medium to thinly bedded w/ green clay-filled wavy bedding and partings <1/4" thick, rare siliceous pods <1" thick from 62-64' (deleterious chert), no reaction to HCl, horizontal partings and fractures at 58.2', 58.9-59.3', 59.7', 59.9', 60.5', 60.7', 61.1' and 61.5'	57.7' **ORDOVICIAN MAQUOKETA GROUP BRAINARD FORMATION** DOLOMITE	
60										
61										
62										
63										
64								63.5-68' **SHALE**, dolomitic, strong, light green/gray to medium green, fresh, competent, massive to vaguely laminated, green/gray zones more calcareous (more of an argillaceous dolomite), including some solution pitting, chert pods rare throughout up to 2" thick, irregular orientation, mechanical breaks along irregular bed partings	63.5' SHALE	
65		4	64 - 68	100	100	83				
66										
67										
68										

1. Start drilling at 9:06 am on July 16, 2008, using 8-inch diameter tricone bit, no casing. Drill to 19.5 feet.
2. Switch to 6-inch OD casing, advance casing to 19.5 feet
3. Switch to PQ core casing with rock bit set within 6-inch OD casing, drill from 19.5 feet to 48 feet without sampling
4. Switch to HQ coring at 48 feet through PQ casing, start core log of boring

GZA GeoEnvironmental, Inc.
Engineers/Scientists
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

DRAFT

Boring No. DH-01
Page No. 2 of 15
File No. 20 0152025.00
Checked By M. Krumenacher

Depth (ft.)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
69		5	68 - 78	100	100	82		68-72.5' **SHALE**, dolomitic, strong, light green/gray to medium green, massive, vaguely laminated, fresh, competent, green/gray zones more calcareous (more of an argillaceous dolomite), including some solution pitting, chert pods rare throughout up to 2" thick, irregular orientation, mechanical breaks along irregular bed partings, one clay/chert zone brecciated by drilling at 70.7-71.1'	68' SHALE	
70										
71										
72										
73								72.5-75.5' **DOLOMITE**, argillaceous, strong, light green/gray, fresh, pitted, rare light gray chert pods, moderately to slightly fractured, stained red and more intensely pitted along fracture at 75.2', fractures inclined 10 to 30" at 72.3-73.2', 74.1', 75.4', 75.8' and 77.5' (especially along chert boundaries)	72.5' DOLOMITE	
74										
75										
76								75.5-81' **SHALE**, as above, subhorizontal partings around chert pods (moderately fractured)	75.5'	
77										
78										
79		6	78 - 88	100	100	96				
80										
81										
82								81-82' **SHALE**, as above, less fractures, vugs and pits in calcareous zones, horizontal fractures at 79.5' and 79.8' along edges of calcareous zones, no staining 82-98' **SHALE**, strong, green, aphanitic, laminated, fresh, competent, unfractured, has thin dark gray laminations within green fracture at 96-98', chert absent w/ depth		
83										
84										
85										
86										
87									SHALE	
88										
89		7	88 - 98	100	100	100				
90										
91										
92										
93										5
94										
95										
96										
97										
98										
99		8	98 - 108	100	100	100		**SHALE**, as above, green grades out at 100' to alternately dark and medium gray, laminated		
100										
101										
102										
103										

Notes:
5 Driller comment losing water slowly at 93 feet (continue to lose water through remainder of drilling)

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Engineers/Scientists

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Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

DRAFT

Boring No. DH-01
Page No 3 of 15
File No. 20.0152025 00
Checked By M Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
104								SHALE, strong, dark and medium gray, aphanitic, laminated, fresh, competent, unfractured, chert absent w/ depth 104' 2" thick calcareous bed w/ 1-1/2" x 1/2" vug		
105										
106										
107										
108										
109		9	108 - 118	100	100	100		SHALE, as above, similar calcareous/coarser-grained beds at 109 5', 112 2' and 114 4'		
110										
111										
113										
114										
115										
116										
117									SHALE	
118										6 7
119		10	118 - 128	100	100	100		Interstratified, gray SHALE and light gray calcareous SHALE, strong, laminated within each shale type, fresh, competent, fractures (mechanical) along laminations		
120										
121										
122										
123										
124										
125										
126										
127										
128										
129		11	128 - 138	100	100	100	1	128-136.1' SHALE, as above, w/ calcareous, lenticular nodules up to 2" long w/ vugs at center at 134', increasing calcareous material below 135'		
130										
131										
132										
133										
134										
135										
136										
137								136.2-138' SHALE, strong, dark gray, laminated, fresh, competent, unfractured, occasional lenses and stringers of black, fossiliferous zones w/ some white recrystallization		
138										
139		12	138 - 148	100	100	100		138-138 7' SHALE, as above 138 7-139.8' LIMESTONE, argillaceous, strong, thin bedding, slightly decomposed to fresh, slightly disintegrated w/ some pits and pyrite mineralization, unfractured, consists of fossil debris, recrystallized carbonate material, clasts of shale mixed w/ carbonate up to 1/2" diameter	138' ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON FORMATION	

Notes:
6 Stop drilling at 118 feet at 5.50 pm on July 16, 2008.
7 Measure groundwater prior to drilling at 48 feet at 6.40 am on July 17, 2008, resume drilling at 6 57 am on July 17, 2008.

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Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01
Page No. 4 of 15
File No. 20.0152025.00
Checked By M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
140								139 8-155' Interstratified, strong, dark gray **SHALE** and fossiliferous/calcarcous, strong, gray and white **SHALE**, beds thin to laminated, fresh, competent, calcareous beds only weak to no reaction w/ HCl, some pyrite mineralization in calcareous beds, uppermost zone (139.8-140 2') has calcite-filled burrows	139.8' ORDOVICIAN MAQUOKETA GROUP FORT ATKINSON - SCALES FORMATION (Transitional Zone)	
141										
142										
143										
144										
145										
146										
147									SHALE	
148										
149		13	148 - 158	100	100	100				
150										
151										
152										
153										
154										
155										
156								155-158' **SHALE**, strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3"	155' ORDOVICIAN MAQUOKETA GROUP SCALES FORMATION	
157										
158										
159		14	158 - 168	100	100	97	1	158-161.4' **SHALE**, as above, 1/2" diameter pyrite crystal in matrix at 159'		
160										
161										
162								161.4-164.1' **SHALE**, as above, medium gray w/ black stringers and zones, calcareous shale beds <1" thick each at 161.4' and 164.1'		
163										
164									SHALE	
165								164.1-167.2' **SHALE**, strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3", horizontal fractures		
166										
167										
168								167.2-167.6' **SHALE**, medium gray, laminated, several calcareous zones and calcite mineralization		
169		15	168 - 178	100	100	100		167.6-168' **SHALE**, strong to moderate, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3", possible natural fracture (bed parting) at 167.7', ground down by drilling		
170										
171								168-178' **SHALE**, as above		
172										
173										
174										

Notes:

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Engineers/Scientists
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Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

Boring No. DH-01
Page No. 5 of 15
File No. 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Core Run No.	Core Run Interval Depth (feet)	TCR (%)	SCR (%)	RQD	IF	Sample Description and Classification	Generalized Stratum Description	NOTES
175								SHALE, dark gray, laminated, no obvious calcareous material, bedding approx. 2-3" horizontal fractures, ground down by drilling		
176										
177										
178										
179		16	178 - 188	100	100	93	4	178-182.8' SHALE, as above		
180										
181										
182										
183								182.8-183.2' SHALE, moderate to weak, green/gray, brecciated along horizontal and vertical cracks (very intensely fractured), decomposed to green clay along fractures, slightly decomposed away from fractures, sticky clay-healed fractures 183.2-183.5' SHALE, strong to moderate, dark gray, laminated, vertical fractures, fresh, no infilling, abruptly terminates at bed plane 183.5-188' SHALE, as above, w/out natural fractures		
184										
185										
186										
187										
188										
189		17	188 - 198	100	100	100		SHALE, strong to moderate, dark gray, laminated, fresh, competent, unfractured, rare pyrite mineralization/nodules throughout up to approx. 1/2" diameter	SHALE	
190										
191										
192										
193										
194										
195										
196										
197										
198										
199		18	198 - 208	89	78	78		198-207' SHALE, as above, some brecciated zones at 202.8', 204.5' and 205.5'		8
200										
201										
202										
203										
204										
205										
206										
207								207-208' DOLOMITE, argillaceous, strong, light gray and white banded, microcrystalline, laminated, slightly decomposed but abundant recrystallization as pyrite and calcite, vertical fracture at 207.5' w/ pyrite and calcite cement	207'	
208									ORDOVICIAN GALENA GROUP WISE LAKE FORMATION	
209		19	208 - 218	100	100	100		See Page 6		

Notes:
8 Recovered approximately 5 feet in first pull, went back down and retrieved remaining core with some rotation (probably brecciated core and accounts for last 1.1 feet of core length

GZA GeoEnvironmental, Inc.
Engineers/Scientists

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Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

DRAFT

Boring No	DH-01
Page No	6 of 15
File No	20.0152025.00
Checked By	M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
210								208-218' LIMESTONE, strong to very strong, light brownish-gray, microcrystalline w/ abundant white recrystallized laminations of calcite, thickly to thinly bedded along stylolitic bed contacts, slightly decomposed, pitted and w/ vugs <1", lined w/ calcite pyrite and black mineralization (sulfides?), only mechanically fractured along stylolitic partings (weak reaction to HCl except for white seams and bodies), partings mostly coated w/ black mud and mineralization <1 mm thick		
211										
212										
213										
214										
215										
216										
217										
218										
219		20	218 - 228	100	100	100		218-219.7' LIMESTONE, as above		
220								219.7-219.8' Moderately disintegrated zone w/ iron staining and abundant stylolites, horizontal fracture coated w/ mineralization		
221								219.8-228' LIMESTONE, strong to very strong, light brownish-gray, microcrystalline w/ abundant white recrystallized laminations of calcite, some white recrystallized zones, thickly to thinly bedded along stylolitic bed contacts, slightly decomposed, pitted and w/ vugs <1", only mechanically fractured along stylolitic partings		
222										
223									LIMESTONE	
224										
225										
226										
227										
228										
229		21	228 - 238	100	100	100		228-233' LIMESTONE, as above		
230										
231										
232										
233										
234								233-238' LIMESTONE, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl		
235										
236										
237										
238										
239		33	238 - 248	100	100	100		LIMESTONE, as above		
240										
241										
242										
243										
244										

otes:

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GZA GeoEnvironmental, Inc.
Engineers/Scientists

20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186

ROCK CORE LOG
Aurora, Illinois

DRAFT

Boring No: DH-01
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File No: 20.0152025.00
Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
245								LIMESTONE, brown/gray, strong to very strong, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl		
246										
247										
248										
249		23	248 - 258	100	100	100	1	LIMESTONE, as above, occasional dolomitic zones (lesser reaction to HCl), natural, horizontal fracture at intensely stylolitized zone at 257.6'		
250										
251										
252										
253										
254										
255										
256										
257										
258									LIMESTONE	
259		24	258 - 268	100	100	100		LIMESTONE, as above		
260										
261										
262										
263										
264										
265										
266										
267										
268										9
269		25	268 - 278	100	100	100		LIMESTONE, as above, mechanical breaks at 280.5', 281.8', 282.5' and 285.5' at stylolitic partings		10
270										
271										
272										
273										
274										
275										
276										
277										
278										
279		26	278 - 288	100	100	100		LIMESTONE, as above, mechanical breaks at 278.3', 280.3', 280.6', 282.3', 284.9', and 287.8'		

otes:

9 Stop drilling at 268 feet at 5:45 pm on July 17, 2008, measure groundwater at 45.5 feet at 5:48 pm on July 17, 2008

10 Measure groundwater prior to drilling at 48.1 feet at 6:39 am on July 18, 2008, resume drilling at 7:53 am on July 18, 2008

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Aurora, Illinois

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
280								**LIMESTONE**, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), strong reaction to HCl w/ occasional dolomitic zone (lesser reaction to HCl)	280' ORDOVICIAN GALENA GROUP WISE LAKE - DUNLEITH FORMATION (Transitional Zone)	
281										
282										
283										
284										
285									LIMESTONE	
286										
287										
288										
289		27	288 - 298	100	100	100	1	**LIMESTONE**, as above, mechanical breaks at 289.8', 292 2', 294 5', 296.9' and 297.7', horizontal fracture in heavily stylolitized zone (w/ 1" thick zone) at 293.4', approx. 2" irregular void at 297 6' filled in w/ sparry calcite		
290									290' ORDOVICIAN GALENA GROUP DUNLEITH FORMATION	
291										
292										
293										
294										
295										
296										
297										
298										
299		28	298 - 308	100	100	100	1	**LIMESTONE**, as above, some gray, recrystallized zones (slightly coarser-grained, dolomitic crystals visible), mechanical break at 299 4', 302.1' and 303.1', horizontal fracture in approx 1/2" thick stylolitized zone at 301.4', mechanical break at 302 1' ground-up to tapered ends		
300										
301									LIMESTONE	
302										
303										
304										
305										
306										
307										
308										
309		29	308 - 318	100	100	100		**LIMESTONE**, as above, dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter, mechanical break at 309.3', 310.7', 311.8', 312.5' (ground-up), 314 8' and 317.5'		
310										
311										
312										
313										
314										

Notes:

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ROCK CORE LOG
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Checked By: M. Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
315								LIMESTONE, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, fossils scattered throughout including some fossiliferous beds <1" thick (mostly brachiopods), dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter		
316										
317										
318										
319		30	318 - 328	100	100	100		LIMESTONE, as above, stylolitic partings have less clayey debris, mechanical breaks at 320 6', 322 3' (ground-up), 325 1' and 326.8'		
320										
321										
322										
323										
324										
325										
326										
327										
328										
329		31	328 - 338	100	100	100		LIMESTONE, as above, mechanical breaks at 330.4', 332 3', 334 4' and 337.1'	LIMESTONE	
330										
331										
332										
333										
334										
335										
336										
337										
338										
339		32	338 - 348	100	100	100		LIMESTONE, as above, mechanical breaks at 341 2', 346' and 347 5', 3" x 4" irregular body filled w/ harder microcrystalline siliceous material which is offset by fine fractures and filled w/ sparry calcite at 347 1', bodies have many fossils (replacement by silica)		
340										
341										
342										
343										
344										
345										
346										
347										
348										
349		33	348 - 358	100	100	100		LIMESTONE, as above, more fossiliferous, similar siliceous bodies at 348 4' and 352 8', both >2" diameter, mechanical breaks at 352.1', 352.6', 355.8' and 357.2'		

Notes:

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
350								**LIMESTONE**, strong to very strong, brown/gray, microcrystalline, thinly bedded along wavy irregular stylolite partings, fresh, competent, mechanical fractures along stylolites otherwise unfractured, more fossiliferous, dolomitic recrystallized zones generally <6" thick and w/ sparry-calcite filled vugs up to 1" diameter		
351										
352										
353										
354										
355										
356										
357										
358										
359		34	358 - 368	100	100	100		**LIMESTONE**, as above, w/out siliceous bodies, mechanical breaks at 360.8', 362.4' and 365.7'		
360										
361										
362									LIMESTONE	
363										
364										
365										
366										
367										
368										
369		35	368 - 378	100	100	100		**LIMESTONE**, as above, mechanical breaks at 368.9', 372.5', 375.1' and 377.3', increasing dolomitization from 377.2' and below 378 to 387'		
370										
371										
372										
373										
374										
375										
376										
377										
378										11
379		36	378 - 388	100	100	100		378-387' **DOLOMITIC LIMESTONE**, brown-gray bands (Dolomite) surrounding light brown/gray Limestone zones 2-4" thick, increasing stylolites, gray recrystallized zones from 384.5-387', mechanical breaks at 379.2', 380', 382.4', 383.2', 384.6', 386.2' and 387.2'	378'	12
380										
381									DOLOMITIC LIMESTONE	
382										
383										
384										

Notes:

11 Stop drilling at 378 feet at 4:29 pm on July 18, 2008; measure groundwater at 49.3 feet at 4:50 pm on July 18, 2008

12 Measure groundwater prior to drilling at 47.3 feet at 9:15 am on July 21, 2008, resume drilling at 9:25 am on July 21, 2008

GZA GeoEnvironmental, Inc. Engineers/Scientists 20900 Swenson Drive, Suite 150 Waukesha, Wisconsin 53186	ROCK CORE LOG Aurora, Illinois	Boring No.	DB-01
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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	SCR (%)	RQD	IF	Sample Description and Classification	Generalized Stratum Description	NOTES
385								**DOLOMITIC LIMESTONE**, brown-gray bands (Dolomite) surrounding light brown/gray Limestone zones 2-4" thick, increasing stylolites	DOLOMITIC LIMESTONE	
386										
387										
388								387-388.6' **DOLOMITE**, strong to very strong, gray to brown/gray, microcrystalline, thinly bedded w/ stylolitic partings, slightly decomposed, pitted, vugs at 387.5' approx. 1" x 1/2", lined w/ dolomite and pyrite crystals, smaller vugs spread throughout below 387.5' w/ similar mineralization, vugs truncated at 387.5' along apparently uniform surface which is also marked by dark/light color contrast (possible contact) 388.6-389.9' **DOLOMITE**, very strong, gray w/ light brown/gray mottles, microcrystalline, medium bedded along stylolites, some pitting, no vugs 389.9-393.6' **DOLOMITE**, strong, gray, microcrystalline, medium to thinly bedded, slightly decomposed and pitted, but w/ 1/2" to 2" beds and lenses of tan, heavily pitted Dolomite or large vugs up to 2" diameter, moderately fractured at pitted dolomite/vug zones, 2" thick white chert pod (flinty) at 392.4', mechanical break at 393', 395.8' and 396.5', horizontal weakness/fracture at 390.8' (along large vug >2" diameter), 391.6', 391.9', 392.4' (above chert pod), 390.3' (several vugs) and 393.4' 393.6-394.3' **DOLOMITE**, strong, red/brown, microcrystalline, thinly bedded along abundant stylolites, slightly decomposed, slightly disintegrated, abrupt contact w/ gray dolomite at 394.3' 394.3-398' **DOLOMITE**, very strong, tan w/ some light gray mottling, microcrystalline, massive to thickly bedded, fresh, competent, moderately fractured along vertical planes, but healed (no cement evident, no staining), scattered vugs mostly <1/4" and some pitting	387	
389		37	388 - 398	100	100	97	7			
390										
391									DOLOMITE	
392										
393										
394									393.6' **ORDOVICIAN GALENA GROUP GUTTENBERG FORMATION**	
395										
396										
397									394.3' **ORDOVICIAN PLATTEVILLE GROUP QUIMBYS MILL FORMATION**	
398										
399		38	398 - 408	100	100	100	1	398-403.4' **DOLOMITE**, as above, white chert pods (deleterious) <1" thick at 399.1' and 399.4', mechanical breaks at 399.3', 400.1', 402.4' and 403', horizontal fracture at chert/dolomite contact at 399.4'		
400										
401									DOLOMITE	
402										
403										
404								403.4-405.5' **DOLOMITE**, very strong, mottled gray and tan, microcrystalline, massive to thickly bedded, fresh, competent to slightly disintegrated w/ 1" to 2" zones of more strongly pitted rock, mechanical breaks at 403.8' and 405'	403.4' **ORDOVICIAN PLATTEVILLE GROUP NACHUSA FORMATION**	
405										
406								405.5-408' **DOLOMITE**, as above, mottling grades out to more uniform brown/gray color, less pitting, mechanical breaks at 405.9' and 406.3'		
407										
408										
409		39	408 - 418	98	98	97	5	**DOLOMITE**, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, bound by stylolites, fresh, competent to pitted, vugs throughout up to 1" diameter, clustered, stylolites lead to horizontal fractures at 408.6', 409.3', 413.2' and 417.9', parting w/ beige chert pod (deleterious) at 416.3', mechanical breaks at 409.7', 410.4', 412', 412.5', 413.7', 414.7' and 415.6'		
410										
411									DOLOMITE	
412										
413										
414										
415										
416										
417										
418										
419		40	418 - 428	100	100	100	3	**DOLOMITE**, as above, stylolite clusters create horizontal fractures at 421.5', 424.6' and 425.6', mechanical breaks at 419.7', 420.9', 424.5' and 427'		

Notes:

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ROCK CORE LOG
Aurora, Illinois

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Checked By	M Krumenacher

Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
420								**DOLOMITE**, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, bound by stylolites, fresh, pitted, vugs throughout up to 1" diameter		
421										
422										
423										
424										
425										
426										
427									DOLOMITE	
428										
429		41	428 - 438	100	99	97	2	**DOLOMITE**, as above, zones colored/mottled gray to dark gray w/ more stylolites from 429.3' to 430.5' and 435.5' to 438', stylolite clusters create horizontal fractures at 428.9' and 430.3', other horizontal fracture at boundary w/ light gray chert pod (flinty) at 434.3', vug-rich zone at 432 5', mechanical breaks at 430 9', 431.7', 433 4', 435 2', 436 1' and 436.8'		
430										
431										
432										
433										
434										
435										
436										
437										
438										
439		42	438 - 448	100	99	99	2	438-444 4' **DOLOMITE**, as above, brown, vugs and white chert pods (flinty), horizontal fracture at chert pod at 439.4', mechanical breaks at 440.2 , 440.6' and 442 5'	438' **ORDOVICIAN PLATTEVILLE GROUP NACHUSA - GRAND DETOUR FORMATION (Transitional Zone)**	
440										
441										
442										
443									DOLOMITE	
444										
445								444.4-448' **DOLOMITE**, as above, gray and light brown mottled, fine clay partings <1 mm thick, wavy (may be clustered stylolites or fine clay laminations), horizontal fracture at 444 6', mechanical breaks at 445.8' and 447.3'	444.4' **ORODIVICIAN PLATTEVILLE GROUP GRAND DETOUR FORMATION**	
446										
447										
448										
449		43	448 - 458	100	100	100		**DOLOMITE**, as above, competent, no vugs or pits, breaks after several hammer strikes w/ conchoidal fracture, mechanical breaks at 452.3', 453 2', 454.5', 456 7' and 457 6'		
450									DOLOMITE	
451										
452										
453										
454										

Notes:

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Depth (ft)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
455								**DOLOMITE**, strong to very strong, brown/gray, sometimes mottled, thinly to moderately bedded, fresh, no vugs or pits, competent, break after several hammer strikes w/ conchoidal fracture		
456										
457										
458										
459		44	458 - 468	100	100	100	5	458-466' **DOLOMITE**, as above, decreasing mottling w/ depth, horizontal/irregular fractures along shale partings at 459 2', 461.4', 463.6', 464 4' and 464 9', mechanical breaks at 460 2', 460.6', 462.3', 463.2', 464 2' and 465.5'		
460										
461										
462										
463										
464										
465										
466										
467								466-468' **DOLOMITE**, very strong, brown, microcrystalline, medium bedded, fresh, competent, mechanical breaks at 466.2', 466.4', 466 7' and 467 3'		
468										13
469		45	468 - 478	100	100	93	9	**DOLOMITE**, as above, thin shale partings leading to horizontal fractures in core, planar to wavy, 0-4" orientation, smooth to rough, wide to moderately narrow spaced, have <1 mm of shale, upper surfaces typically have fossil debris, lower surfaces have burrows and trails, horizontal fractures along flat or wavy shale partings at 468.8', 470.6', 471.3', 471 6', 472 9', 474.5', 476.8', 477.1' and 477 4', mechanical breaks at 469 8' and 473 5'		14
470										
471										
472									DOLOMITE	
473										
474										
475										
476										
477										
478										
479		46	478 - 488	98	98	98	4	478-481 1' **DOLOMITE**, as above		
480										
481									481.1'	
482								481 1-488' **DOLOMITE**, very strong, gray, microcrystalline, thinly bedded to laminated w/ wavy shale partings (most <1 mm thick), fresh, competent, some pits and vugs, horizontal fractures along wavy/irregular partings, rare macrofossils up to 1", horizontal (bed partings) at 479 4', 481 3', 474 5' and 476 9'	**ORODIVICIAN PLATTEVILLE GROUP MIFFLIN FORMATION**	
483										
484										
485										
486									DOLOMITE	
487										
488										
489		47	488 - 498	102	102	97	4	**DOLOMITE**, as above, clusters of shale laminations around bodies of Dolomite, horizontal (bed partings) at 488', 491', 494 1', 497 7' and 498'		15

Notes:

13 Stop drilling at 468 feet at 6 11 pm on July 21, 2008, measure groundwater at 42 7 feet at 6 34 pm on July 21, 2008

14 Measure groundwater prior to drilling at 47 2 feet at 6 21 am on July 22, 2008, resume drilling at 6 31 am on July 22, 2008

15 Rods have been tight/not easily advancing down hole after past three packer tests

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
490								**DOLOMITE**, very strong, gray, microcrystalline, thinly bedded to laminated w/ wavy shale partings (most <1 mm thick), fresh, competent, some pits and vugs		
491										
492										
493										
494										
495									DOLOMITE	
496										
497										
498										
499		48	498 - 508	100	100	100		498-503.1' **DOLOMITE**, as above, bed parting at 501.3'		
500										
501										
502										
503										
504								503.1-508' **DOLOMITE**, very strong, light brown/gray, microcrystalline, massive, fresh, competent w/ some lenticular vugs up to 1" diameter, no shale partings, stylolites below 506', rare chert pods and lenticular siliceous zones, horizontal fracture at 506.7', mechanical breaks at 504.4', 505.9' and 507.6'	503.1' ORODIVICIAN PLATTEVILLE GROUP PECATONICA FORMATION	16
505										
506										
507										
508										
509		49	508 - 518	100	100	98	4	**DOLOMITE**, as above, pitted, increasing vugs up to 2" across, increasing chert (deleterious) and siliceous bodies up to width of core and 2" thick, horizontal fractures (bed parting/stylolite) at 514.6', 515.6', 517.3' and 517.5', mechanical breaks at 511.3', 513.9' and 516.5'		
510										
511										
512										
513										
514									DOLOMITE	
515										
516										
517										
518										17 18
519		50	518 - 525.7	100	100	100	3	518-522 **DOLOMITE**, as above, increasing pitted zones/recrystallized zones, mechanical breaks at 518.7', 519.4' and 521.7'		
520										
521										
522										
523								522-525.7' **DOLOMITE**, as above, gray to gray/brown, thin (<1 mm) black shale partings, medium to thinly bedded, wavy bed partings, some vugs, horizontal fractures at 522.4', 523.9' and 524.7', mechanical breaks at 525.1' and 525.5'		
524										

Notes:
16 Abrupt contact, flat at 503.1 feet
17 Stop drilling at 518 feet at 11:09 am on July 22, 2008, measure groundwater at 50.1 feet at 12:15 pm on July 22, 2008
18 Switch to NQ coring at 518 feet through HQ casing; start drilling at 11:40 am on July 24, 2008

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Depth (feet)	Graphic Log	Sample Information: Core Run No.	Sample Information: Core Run Interval Depth (feet)	Mechanical Core Log: TCR (%)	Mechanical Core Log: SCR (%)	Mechanical Core Log: RQD	Mechanical Core Log: IF	Sample Description and Classification	Generalized Stratum Description	NOTES
525										
526		51	525.7 - 535.7	100	94	91	12	**DOLOMITE**, very strong, gray to gray/brown, microcrystalline, medium to thinly bedded, fresh, competent to vuggy w/ pitted/recyrstallized zones, increasing shale partings and clustered stylolites leading to horizontal fractures/partings, some horizontal breaks along vug-rich zones, two fractures oblique to core at 531' (65° from horizontal, very narrow, not healed, stained, rough) and 533.5' (60° from horizontal, extremely narrow, not healed, stained, mineralized, undulating), horizontal fractures at 527.1', 528.5', 529.1', 530.7', 531.2', 531.6', 532.3', 533.9', 534.4' and 534.9', mechanical breaks at 529.6', 532.9', 533.2', 534.6', 535.4' and 535.6'		
527										
528										
529										
530										
531										
532									DOLOMITE	
533										
534										
535										
536		52	535.7 - 545.7	82	80	39	3	535.7-538.8' **DOLOMITE**, as above, horizontal fractures at 536.8' and 538', mechanical breaks at 535.8', 536.1' and 536.5'		
537										
538										
539								538.8-539.6' **DOLOMITE**, as above, w/ some rounded, gray, fine Sand (quartz), sand content dramatically increases at 539.4'		
540								539.6-543.9' **SANDSTONE**, moderately strong, gray, fine-grained, massive, fresh, competent to slightly disintegrated, many mechanical breaks (horizontal) generally 1 to 3" apart, well cemented	539.6' ORDOVICIAN ANCELL GROUP GLENWOOD FORMATION	
541										
542										
543									SANDSTONE	19
544										
545										
546								**END OF ROCK CORE AT 545.7'**		
547										
548										
549										
550										
551										
552										
553										
554										
555										
556										
557										
558										
559										

Notes:
19 Did not recover 1.8' of core, collected approx. 100 g of light gray to white, loose Sand that came from core barrel. St. Peter Sandstone may have washed out of core barrel from 543.9-545.7'

APPENDIX 3

TABLE OF BEDROCK STRUCTURES

CLIENT	Raimonde Drilling Corporation
PROJECT	Deep Core Boring Project
LOCATION	Route 25 Repository Site
CITY, STATE	Aurora, Illinois
H-R FILE	08RG26

BOREHOLE ID	DH-01
DATE LOGGED	July 23, 2008
LOG DATUM	Ground Surface
DIP AZIMUTH	Referenced to Magnetic North
DIP ANGLE	Measured as the Angle from Horizontal

TABLE OF BEDROCK STRUCTURES FOR BOREHOLE DH-01

Depth (Feet)	Dip Azimuth (Degrees)	Dip Angle (Degrees)	Bedrock Structure Category
48.9	268	16	Fracture Rank 1
49.0	251	9	Fracture Rank 1
49.1	267	6	Fracture Rank 2
49.2	156	2	Fracture Rank 2
49.3	139	7	Fracture Rank 1
49.7	127	19	Fracture Rank 1
50.0	256	8	Fracture Rank 3
50.4	266	51	Fracture Rank 1
50.9	93	5	Fracture Rank 2
50.9	352	32	Fracture Rank 1
52.8	295	10	Fracture Rank 2
53.0	296	28	Fracture Rank 1
53.6	358	12	Fracture Rank 3
53.9	360	42	Fracture Rank 2
54.1	116	4	Fracture Rank 3
54.3	178	4	Fracture Rank 2
54.8	109	33	Fracture Rank 3
55.7	85	8	Fracture Rank 2
55.8	277	5	Fracture Rank 3
56.0	352	5	Fracture Rank 2
56.2	327	10	Fracture Rank 3
57.0	220	17	Fracture Rank 2
57.7	218	26	Fracture Rank 3
57.8	263	5	Fracture Rank 3
58.0	194	13	Fracture Rank 2
58.0	200	24	Fracture Rank 2
58.5	115	41	Fracture Rank 2
58.7	103	62	Fracture Rank 2
58.8	187	65	Fracture Rank 1
58.8	248	8	Fracture Rank 2
59.2	353	46	Fracture Rank 1
59.4	323	23	Fracture Rank 1
59.8	306	35	Fracture Rank 2
60.1	336	14	Fracture Rank 3
60.2	219	67	Fracture Rank 2

TABLE OF BEDROCK STRUCTURES FOR BOREHOLE DH-01

Depth (Feet)	Dip Azimuth (Degrees)	Dip Angle (Degrees)	Bedrock Structure Category
60.3	147	3	Fracture Rank 3
60.5	346	13	Fracture Rank 2
60.8	128	57	Fracture Rank 1
60.8	316	10	Fracture Rank 2
61.2	337	48	Fracture Rank 2
61.2	307	44	Fracture Rank 2
61.2	158	22	Fracture Rank 1
61.3	245	60	Fracture Rank 1
61.5	64	4	Fracture Rank 2
61.7	67	38	Fracture Rank 1
61.9	294	48	Fracture Rank 1
62.0	221	23	Fracture Rank 1
62.1	80	59	Fracture Rank 1
63.0	205	25	Fracture Rank 2
64.0	256	52	Fracture Rank 1
64.3	343	0	Fracture Rank 2
64.4	247	9	Fracture Rank 2
66.2	237	23	Fracture Rank 1
66.8	151	68	Fracture Rank 1
66.8	296	44	Fracture Rank 1
68.1	288	7	Fracture Rank 1
69.2	258	68	Fracture Rank 2
70.7	250	7	Fracture Rank 2
70.8	218	7	Fracture Rank 2
71.0	254	17	Fracture Rank 3
71.1	239	18	Fracture Rank 3
71.2	237	17	Fracture Rank 3
72.2	138	12	Fracture Rank 1
73.0	55	24	Fracture Rank 1
73.5	213	22	Fracture Rank 2
73.7	209	25	Fracture Rank 2
74.0	212	59	Fracture Rank 1
75.4	229	49	Fracture Rank 1
75.6	239	35	Fracture Rank 2
75.7	235	32	Fracture Rank 2
75.8	265	34	Fracture Rank 3
76.3	255	50	Fracture Rank 2
78.6	252	31	Fracture Rank 2
79.1	249	74	Fracture Rank 1
79.7	264	5	Fracture Rank 2
79.8	253	10	Fracture Rank 2
80.3	161	11	Fracture Rank 2
80.5	176	15	Fracture Rank 1
82.2	309	5	Fracture Rank 3
89.3	290	6	Fracture Rank 3
89.8	127	5	Fracture Rank 2
89.9	50	2	Fracture Rank 2

TABLE OF BEDROCK STRUCTURES FOR BOREHOLE DH-01

Depth (Feet)	Dip Azimuth (Degrees)	Dip Angle (Degrees)	Bedrock Structure Category
92.9	226	30	Fracture Rank 1
93.0	174	2	Fracture Rank 2
101.2	308	4	Fracture Rank 2
106.8	146	12	Fracture Rank 2
112.2	325	4	Bedding
112.9	63	2	Fracture Rank 2
119.8	300	7	Fracture Rank 2
122.7	59	0	Bedding
124.2	339	3	Bedding
124.3	152	4	Bedding
125.2	144	44	Fracture Rank 1
132.5	43	0	Bedding
138.9	303	56	Fracture Rank 1
141.6	286	7	Fracture Rank 2
144.1	294	11	Bedding
146.0	264	11	Bedding
147.9	305	33	Bedding
148.3	272	7	Bedding
148.4	307	6	Bedding
150.0	4	0	Bedding
150.6	273	5	Bedding
157.7	208	4	Bedding
158.3	172	5	Bedding
159.4	238	2	Bedding
160.4	106	1	Bedding
160.8	279	3	Fracture Rank 1
161.9	112	2	Bedding
162.2	170	16	Bedding
162.9	201	2	Bedding
164.2	274	2	Bedding
166.2	121	1	Bedding
166.6	244	4	Bedding
167.5	230	6	Bedding
167.6	226	6	Bedding
168.9	106	3	Bedding
170.3	163	2	Bedding
170.5	337	5	Bedding
170.8	211	2	Bedding
174.4	340	1	Bedding
174.5	270	5	Bedding
175.2	294	1	Bedding
175.4	238	5	Bedding
175.5	233	3	Bedding
176.0	345	1	Bedding
176.2	220	1	Bedding
180.1	270	2	Bedding
180.5	275	2	Bedding

TABLE OF BEDROCK STRUCTURES FOR BOREHOLE DH-01

Depth (Feet)	Dip Azimuth (Degrees)	Dip Angle (Degrees)	Bedrock Structure Category
180.8	183	4	Bedding
180.9	35	2	Bedding
182.1	276	5	Fracture Rank 2
182.2	239	5	Fracture Rank 2
182.5	280	5	Bedding
183.4	331	5	Bedding
183.5	348	1	Bedding
185.0	118	4	Bedding
185.2	343	2	Bedding
185.7	217	3	Bedding
185.9	296	3	Bedding
186.6	315	1	Bedding
188.4	142	2	Bedding
188.7	346	1	Bedding
190.7	346	1	Bedding
190.8	346	1	Bedding
191.2	343	1	Bedding
191.3	346	1	Bedding
192.1	347	1	Bedding
192.2	346	1	Bedding
193.5	292	3	Bedding
193.6	288	4	Bedding
194.8	208	4	Fracture Rank 1
196.8	269	4	Bedding
197.2	285	2	Bedding
197.5	349	1	Bedding
197.6	349	1	Bedding
198.0	285	8	Bedding
198.1	314	3	Bedding
200.5	335	2	Fracture Rank 1
200.7	82	4	Bedding
201.0	303	2	Bedding
201.8	234	75	Fracture Rank 1
202.8	259	69	Fracture Rank 1
203.5	140	2	Bedding
203.7	283	3	Bedding
205.9	296	76	Fracture Rank 1
206.0	207	3	Fracture Rank 2
206.2	236	2	Fracture Rank 2
207.2	227	5	Fracture Rank 2
209.5	253	57	Fracture Rank 1
211.5	255	45	Fracture Rank 1
218.0	38	0	Fracture Rank 2
219.6	101	0	Fracture Rank 2
220.6	22	12	Fracture Rank 1
229.7	188	7	Fracture Rank 1
230.9	77	6	Fracture Rank 1

TABLE OF BEDROCK STRUCTURES FOR BOREHOLE DH-01

Depth (Feet)	Dip Azimuth (Degrees)	Dip Angle (Degrees)	Bedrock Structure Category
232.0	355	19	Fracture Rank 1
233.0	84	25	Fracture Rank 1
244.4	293	4	Fracture Rank 2
253.5	323	4	Fracture Rank 1
265.5	56	10	Fracture Rank 1
272.3	165	5	Fracture Rank 2
274.7	296	54	Fracture Rank 1
280.4	134	10	Fracture Rank 1
289.5	65	8	Fracture Rank 1
289.6	109	7	Fracture Rank 1
293.1	60	9	Fracture Rank 2
293.2	33	6	Fracture Rank 2
295.1	84	4	Fracture Rank 1
298.3	83	9	Fracture Rank 1
312.3	260	11	Fracture Rank 2
312.9	286	21	Fracture Rank 1
324.8	238	7	Fracture Rank 1
325.1	304	6	Fracture Rank 2
326.1	302	7	Fracture Rank 1
326.5	263	7	Fracture Rank 1
330.1	148	4	Fracture Rank 1
332.9	174	1	Fracture Rank 2
334.1	253	15	Fracture Rank 1
352.3	103	41	Fracture Rank 2
397.7	176	81	Fracture Rank 1
398.0	352	18	Fracture Rank 2
402.5	186	33	Fracture Rank 2
427.0	250	7	Fracture Rank 2
432.2	175	70	Fracture Rank 1
447.0	321	19	Fracture Rank 1
480.2	138	5	Fracture Rank 1
500.3	13	29	Fracture Rank 1

APPENDIX 4

BEDROCK STRUCTURE STATISTICS PLOTS

HAGER-RICHTER GEOSCIENCE, INC.
846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

FRACTURE STATISTICS PLOTS

BOREHOLE ID: DH-01

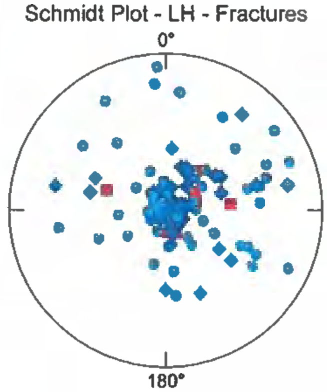
CLIENT:	Raimonde Drilling Corporation	H-R FILE:	08RG26
PROJECT:	Deep Core Boring Project	DATE LOGGED:	July 23, 2008
LOCATION:	Route 25 Repository Site	ORIENTATION REFERENCE:	Magnetic North
CITY, STATE:	Aurora, Illinois	MAGNETIC DECLINATION:	Not Applicable

STRUCTURE LEGEND

● Fracture Rank 1 ■ Fracture Rank 2 ◆ Fracture Rank 3 ▼ Bedding

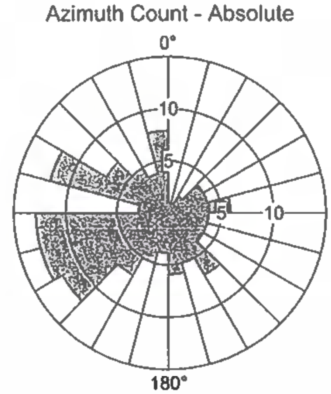
Stereogram of Fractures	Dip Azimuth Rose Diagram of Fractures	Dip Angle Histogram of Fractures

Stereogram of Fractures



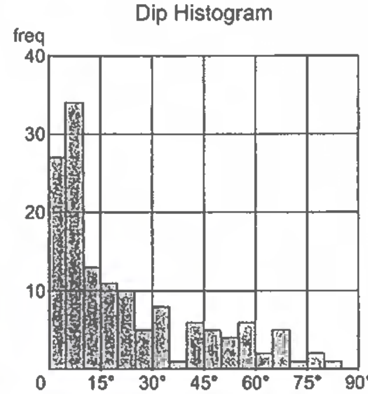
	Counts	Dip[deg]	Azi[deg]
Mean	141	21.85	246.89
●	63	30.28	241.95
◆	62	15.83	242.09
■	16	13.60	267.44

Dip Azimuth Rose Diagram of Fractures



Counts: 141
Mean: 246.89
Std.Dev.: 92.62
Min: 13.03
Max: 359.76

Dip Angle Histogram of Fractures



Counts: 141
Mean: 21.85
Std.Dev.: 21.27
Min: 0.27
Max: 80.86

HAGER-RICHTER GEOSCIENCE, INC.
846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

BEDDING STATISTICS PLOTS

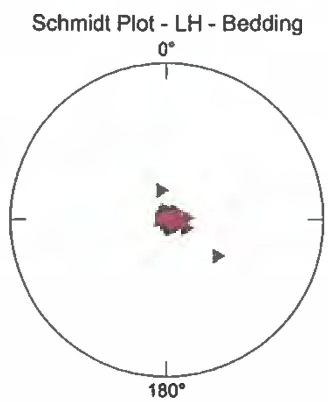
BOREHOLE ID: DH-01

CLIENT:	Raimonde Drilling Corporation	H-R FILE:	08RG26
PROJECT:	Deep Core Boring Project	DATE LOGGED:	July 23, 2008
LOCATION:	Route 25 Repository Site	ORIENTATION REFERENCE:	Magnetic North
CITY, STATE:	Aurora, Illinois	MAGNETIC DECLINATION:	Not Applicable

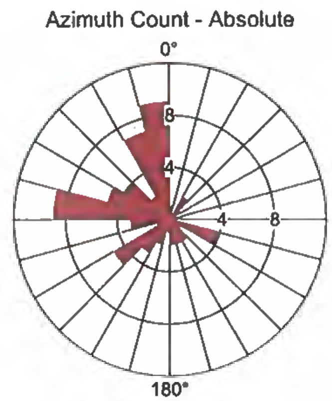
STRUCTURE LEGEND

● Fracture Rank 1 ■ Fracture Rank 2 ◆ Fracture Rank 3 ◀ Bedding

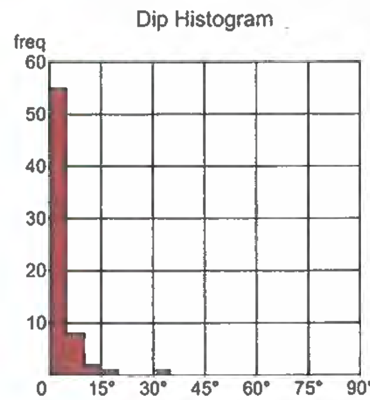
Stereogram of Bedding	Dip Azimuth Rose Diagram of Bedding	Dip Angle Histogram of Bedding



	Counts	Dip[deg]	Azi[deg]
Mean	67	3.55	292.59
▶	67	3.55	292.59



Counts: 67
Mean: 292.59
Std.Dev.: 80.94
Min: 3.90
Max: 349.10



Counts: 67
Mean: 3.55
Std.Dev.: 4.53
Min: 0.30
Max: 33.00