CONSUMERS ENERGY JR WHITING
HYDROGEOLOGICAL MONITORING PLAN (HMP)
May 2020 Revision

Consumers Energy Company (CE) has prepare this hydrogeological monitoring plan in the process of renewing Operating License No. 9403 for the JR Whiting Solid Waste Disposal Area located adjacent to 4525 East Erie Road, Erie, Michigan, under the provisions of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 115).

On December 28, 2018, the State of Michigan enacted Public Act No. 640 of 2018 (PA 640) to amend Part 115. These amendments were developed to harmonize oversight of and standards for coal combustion residual (CCR) impoundments and landfills under the existing state of Michigan solid waste management statute with the United States Environmental Protection Agency (USEPA) CCR Resource Conservation and Recovery Act (RCRA) Rule[1] (40 CFR 257 Subpart D) ("CCR Rule") issued April 17, 2015 and effective on October 19, 2015, through a permitting program.

In accordance with Part 115 Rule 4318(2), groundwater monitoring requirements for the JR Whiting Solid Waste Disposal Area are currently waived under the existing Part 115 Hydrogeological Monitoring Plan (HMP), Consumers Power Company, dated October 1995, revised November 10, 1997, and November 26, 1997 per the September 2, 2009 approval letter issued by the Michigan Department of Environmental Quality (MDEQ) (now the Michigan Department of Environment, Great Lakes, and Energy [EGLE]). This waiver was granted by EGLE based on site specific data that supported the fact that groundwater in the uppermost aquifer were protected by a thick layer of low permeability clay that prevented the migration of leachate to groundwater.

Starting in 2015, groundwater monitoring activities have been conducted at the JR Whiting ponds in accordance with the CCR Rule. Data collected as part of the implementation of the RCRA Rule continue to support that there is no potential for groundwater in the uppermost

---

[1] United States Environmental Protection Agency (USEPA) final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) published April 17, 2015, as amended per Phase One, Part One of the CCR Rule (83 FR 36435).

aquifer to be affected by the CCR Units. Although Part 115 provides the authority for EGLE to issue a groundwater waiver, the USEPA has not approved Part 115 to authorize State of Michigan oversight in lieu of the federal CCR Rule. Therefore, CE will continue to monitor in accordance with the RCRA Rule until such a time that the RCRA Rule allows for groundwater monitoring waivers, or until the EGLE has an authorized permit program that has been approved by the USEPA.

Revisions to Part 115 through PA 640, in particular Section 11512(a)(1), require an approved HMP as part of the license renewal. As such, CE is providing the attached revised documentation that details the current JR Whiting RCRA groundwater monitoring program. The components of the monitoring program have been developed in compliance with the CCR Rule and Part 115 in order to document the procedures for the collection and analysis of groundwater data used to monitor groundwater at the JR Whiting Solid Waste Disposal Area at Ponds 1 and 2, and Pond 6. These existing documents will collectively serve to replace the current Part 115 HMP, if approved, in addition to the existing groundwater waiver, for the purposes of renewing the operating license under Part 115. Data reporting related to the monitoring completed to date under the RCRA monitoring program can also be found on the web at: https://www.consumersenergy.com/community/sustainability/environment/waste-management/coal-combustion-residuals#jr-whiting

Attachment A: Arcadis. May 2016. Summary of Monitoring Well Design, Installation, and Development. JR Whiting Electric Generation Facility– Erie, Michigan. Prepared for Consumers Energy Company. and TRC Environmental Corporation. December 2016. 2016 Monitoring Well Design, Installation, Development, and Decommissioning. JR Whiting Electric Generation Facility – Erie, Michigan. Prepared for Consumers Energy Company.

Attachment B: TRC Environmental Corporation. February 2020. Electric Generation Facilities RCRA CCR Detection Monitoring Program for the Pond 1&2 and Pond 6 Areas. Sample and Analysis Plan. JR Whiting Monitoring Program – Erie, Michigan. Prepared for Consumers Energy Company.

Attachment C: TRC Environmental Corporation. February 2020. Groundwater Statistical Evaluation Plan – Former JR Whiting Power Plant, Pond 1&2 and Pond 6, Erie, Michigan. Prepared for Consumers Energy Company.

Attachment D: TRC Environmental Corporation. December 2018. Natural Clay Liner Equivalency Evaluation Report. DTE Electric Company and Consumers Energy Company, Six Southeast Michigan Coal Combustion Residual Units. Prepared for DTE Electric Company and Consumers Energy Company.

Attachment A

Consumers Energy
Count on Us®

A CMS Energy Company

Date: October 17, 2017

To: Operating Record

HDR

From: Harold D. Register, Jr., P.E.

RE: Groundwater Monitoring System Certification, §257.91(f)
JR Whiting Power Plant, Ponds 1&2

Introduction

According to Title 40 Code of Federal Regulations (40 CFR) Part 257, Subpart D, §257.91(f); the owner or operator of a Coal Combustion Residual (CCR) management unit must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system at the CCR management unit has been designed and constructed to meet the requirements of §257.91. Additionally, §257.91(a) details a performance standard requiring the system monitor the uppermost aquifer and include a minimum of at least one upgradient and three downgradient monitoring wells, and that if the uppermost aquifer monitoring system includes the minimum number of wells, the basis supporting use of only the minimum.

Groundwater Monitoring System

A groundwater monitoring system has been established for the JR Whiting Pond 1&2, which established the following locations for determining background groundwater quality and detection monitoring. In the case of JR Whiting Ponds 1&2, an intrawell statistical procedure has been selected; therefore, the groundwater monitoring system consists of only the downgradient monitoring wells. The background monitoring wells used to establish background groundwater quality will be maintained and reused to reestablish background conditions as necessary.

Downgradient:

JRW MW-15001
JRW MW-15002
JRW MW-15003
JRW MW-15004
JRW MW-15005
JRW MW-15006

Provided herein, as required by §257.91(f), is certification from a qualified professional engineer that the groundwater monitoring system at Consumers Energy JR Whiting Pond 1&2 meets the requirements of §257.91.

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.91]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations §257.91 (40 CFR Part 257.91), I attest that this Groundwater Monitoring System has been designed and constructed to meet the requirements of 40 CFR 257.91. The report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.91.

Harold D. Register J.

Signature

October 17, 2017

Date of Certification

Harold D. Register, Jr., P.E.

Name

6201056266

Professional Engineer Certification Number

STATE OF MICHIGAN
HAROLD D.
REGISTER, JR.
ENGINEER
No.
6201056266
LICENSED PROFESSIONAL ENGINEER

10/17/2017

ENCLOSURES

ARCADIS (2016). "*Summary of Monitoring Well Design, Installation, and Development*"

TRC (2016). "*2016 Monitoring Well Design, Installation, Development, and Decommissioning*"

ARCADIS
Design & Consultancy
for natural and
built assets

Consumers Energy Company

SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT

J.R. Whiting Electric Generation Facility – Erie, Michigan

May 13, 2016

Gregory E. Zellmer, P.G.

Certified Project Manager/Senior Geologist

Mark Robert Klemmer, PE

Printed Name of Registered Professional Engineer

Signature of Registered Professional Engineer

Registration Number: 62010-49167 State: MI

Date: 5/13/16

Summary of Monitoring Well Design, Installation, and Development

J.R. Whiting Electric Generation Facility – Erie, MI

Prepared for:

Consumers Energy Company

Jackson, Michigan

Prepared by:

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi

Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

Our Ref.:

DE000722.0005.00006

Date:

May 13, 2016

CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

ARCADIS has prepared this Summary of Monitoring Well Design, Installation, and Development (Report) to summarize monitoring well installation activities for the J.R. Whiting electric generation facility (JRW), located in Erie, Michigan (Site). Monitoring wells were installed to achieve compliance under the recently published 40 CFR Part 257, Subpart D – Standards for the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities (specifically Section 257.91(e)(1)). This Report summarizes the groundwater monitoring well installation activities, including drilling procedures, well locations, well construction details, development activities, and hydraulic testing results. The methodology used in the field activities conforms to federal and state guidance and industry standards.

2 OBJECTIVES

The objectives of this report are to document the work completed at the Site, including:

- Advancement of soil borings
- Monitoring well installation
- Monitoring well development
- Hydraulic testing

The following section describes each of these elements in more detail.

3 FIELD ACTIVITIES

3.1 Soil Borings

Six (6) soil borings were completed into bedrock using rotosonic-drilling methods operated by Stock Drilling, Inc. of Ida, Michigan with oversight provided by an ARCADIS geologist. Rotosonic drilling uses powered equipment to collect subsurface-soil samples. The rotosonic drill rig advances a length of pipe into the ground through a combination of hydraulic force and high-frequency vibration. The high-frequency vibrations allow the pipe to advance through various types of soil and bedrock producing a high-quality, continuous soil core within the pipe. Each length of pipe was extracted from the ground and emptied into a clear plastic liner for logging. This process was repeated until the total depth of the boring was reached.

Continuous soil cores were collected during drilling to provide detailed lithological and stratigraphic data. An on-site geologist inspected each core, classified the contents, and recorded the observations on an ARCADIS boring log field sheet (**Appendix A**). A photographic log showing the general soil types observed at the Site is included as **Appendix B**. All soil borings were completed as monitoring wells, and details of monitoring well installation are provided in the following section.

3.2 Monitoring Well Installation

Once the total depth of the soil boring was reached, a permanent monitoring well was installed in the uppermost usable aquifer unit for completion of monitoring wells. Monitoring wells were installed through the rotosonic drill rig piping allowing the driller to construct the monitoring well, while simultaneously removing the drill piping. Monitoring wells were constructed with 2-inch inside diameter Schedule 40, polyvinyl chloride (PVC) screens and PVC risers. The well screens have a slot size of 0.010 inch and are 10 feet in length. A medium-grained sand pack was placed around each well screen to a height 2 to 3 feet above the top of the well screen. A 3 to 4-foot thick bentonite grout seal was placed on top of the sand pack. The remainder of the annular space was sealed with a cement-bentonite grout.

The wells were finished at the surface using a 3-foot long, locking, stickup well cover set in a 24 inch by 24 inch concrete pad. Well construction logs are included in **Appendix A**; well construction is summarized in **Table 1**; well locations are shown on **Drawing SG-22374**. Wells were labeled according to Consumers Energy's site-specific nomenclature provided to ARCADIS. The CE construction manager supplied keyed-alike locks for each well that match the existing well keys.

3.3 Monitoring Well Development

Newly installed monitoring wells were allowed to set for a minimum of 48 hours, after which the wells were developed. Well development was conducted by air lifting techniques using a tremie pipe to surge and evacuate. Following development with the air lifting technique, a "flow-thru cell" and a turbidity meter were utilized to monitor indicator parameters (turbidity, pH, temperature, oxidation-reduction potential (ORP), and conductivity) to determine if groundwater parameters had appropriately stabilized during the development activities at each monitoring well. The stabilization parameters are provided below in **Table 2**. Indicator parameters were recorded in field notes and the development process continued until development water was free of visible sediment, stabilization of the field parameters, and below 10 Nephelometric Turbidity Units (NTUs). The volume of groundwater removed during development and its appearance was recorded in the field logbook. If drilling fluids were utilized during well installation, the volume of fluids used was recorded in the field logbook. This volume was removed in addition to the volume required for standard development. Monitoring well development details are included in **Table 1**.

Table 2. Groundwater Parameter Stabilization Criteria

Groundwater Parameter	Stabilization Criteria
pH	3 readings within +/- 0.1 Standard Units
Specific Conductance (SpC)	3 readings within +/- 3% mS/cms
Temperature	3 readings within +/- 3%
Oxidation-Reduction Potential (ORP)	3 readings within +/- 10 mV
Turbidity	3 readings within +/- 10% or <1 when < 10 NTU
Dissolved Oxygen (DO)	3 readings within +/- 0.3 mg/L

3.4 Hydraulic Testing

On November 23 and November 24, 2015, Arcadis conducted hydraulic tests (slug tests) at six (6) monitoring wells (JRW MW-15001, JRW MW-15003, JRW MW-15005, JRW MW-15010, JRW MW-15011 and JRW MW-15012) at the Site. Well construction logs are included in **Appendix A**; well construction details are summarized in **Table 1.**

During the slug testing activities, two to three slug tests were completed at each of the monitoring wells. The slug tests were completed to estimate hydraulic conductivity (K) by introducing a water table displacement by removing a known volume of water or depressing the water level by compressed air and measuring the rate of recovery. The tests at J JRW MW-15001, JRW MW-15003, and JRW MW-15005 were completed using the pneumatic slug test method where a manifold and pump was used to depress the water level. The tests at JRW MW-15010, JRW MW-15011 and JRW MW-15012 were completed using a disposable bailer to remove a known volume of water. The bailer used was 1.5-inches in diameter and 36-inches long. All wells have casing and screen diameters of 2-inches and filter pack diameter of 6-inches and are screened in the confined weathered portion of the limestone bedrock aquifer that is found 55 to 80.5 feet below ground surface (bgs). At all the monitoring wells, a pressure transducer was set to record at 0.5 second intervals to measure static head, displacement and recovery data.

Recovery data collected were analyzed using the applicable analytical solution with AQTESOLV® for Windows©. Based on diagnostic analyses, the solution utilized at three of the six wells (JR-MW-15001, JR-MW-15003 and JR-MW-15005) was the confined Hyder et al. KGS model (1994) solution that accounts for partial penetration effects. The confined Hvorslev (1951) and the confined Cooper et al. (1967) solutions were utilized for recovery data at the remaining of the wells (JRW MW-15010, JRW MW-15011 and JRW MW-15012). The results indicated an estimated hydraulic conductivity range from 1.5 to 20 feet per day (ft/d) with an average of 14 ft/d and a geometric mean of 11 ft/d. The results of this test seem to be a reasonable fit for the confined weathered limestone groundwater zone. The monitoring well locations where slug tests were conducted are shown on **Drawing SG-22374** and the results of the hydraulic conductivity tests are presented in **Table 3** and **Appendix C**.

TABLES

Table 1
Monitoring Well Construction and Development Summary
Consumers Energy Co.
J.R. Whiting Generating Facility
Erie, Michigan

MW ID	Former MW ID	Site Coordinates				Date Installed	Geologic Unit of Screen Interval	Well Construction	Well Screen Length (ft)	Screen Interval (ft bgs)	Development Details				
		Northing	Easting	Ground Surface Elevation (ft above msl)	TOC Elevation (ft above msl)						Static DTW (ft below TOC)	Total Depth	Pumping DTW (ft below TOC)	Gallons Removed	Final Turbity (NTU)
Downgradient MW															
JRW MW-15001	---	108330.83	13374236.18	589.60	590.71	10/26/2015	Limestone	2" PVC, 10 slot	10	78 - 88	21.34	91.25	24.45	1450	3.92
JRW MW-15002	---	108651.05	13374586.78	590.60	592.31	10/28/2015	Limestone	2" PVC, 10 slot	10	81 - 91	21.89	94.39	21.92	750	2.35
JRW MW-15003	---	108321.86	13374980.23	589.60	591.36	10/29/2015	Limestone	2" PVC, 10 slot	10	81 - 91	19.87	94.28	21.75	412.5	3.54
JRW MW-15004	---	107881.56	13375045.59	590.80	592.52	10/30/2015	Limestone	2" PVC, 10 slot	10	86 - 96	23.27	99.60	24.34	70	2.80
JRW MW-15005	---	107545.15	13374686.90	592.70	594.25	11/2/2015	Limestone	2" PVC, 10 slot	10	86 - 96	25.28	99.48	30.97	114	5.04
JRW MW-15006	---	107843.22	13374281.80	590.30	592.01	11/4/2015	Limestone	2" PVC, 10 slot	10	81 - 91	25.30	94.36	24.65	650	1.69
Background MW															
JRW MW-15007	82-MW-1	109293.21	13373656.23	587.10	588.38	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	84 - 87	Not developed				
JRW MW-15008	82-MW-2	110906.21	13373613.03	588.40	587.88	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	94 - 97	Not developed				
JRW MW-15009	79-MW-3	109884.39	13374455.32	585.30	586.11	NA	NA	NA	NA	NA	Not developed				
JRW MW-15010	93-MW-4	110458.57	13373631.59	587.10	588.09	6/28/1993	Dolomite/Limestone	2" SS with galvanized riser	3	60 - 63	Not developed				
JRW MW-15011	93-MW-5	109790.80	13373648.04	587.50	588.71	6/30/1993	Dolomite/Limestone	2" SS with galvanized riser	3	62 - 65	Not developed				
JRW MW-15012	93-MW-6	110169.45	13374463.62	585.80	587.19	7/1/1993	Dolomite/Limestone	2" SS with galvanized riser	3	66 - 69	Not developed				

Notes:
ft = feet
bgs = below ground surface
TOC = top of casing
NR = Not recorded
NA = Not applicable
msl = mean sea level

Table 3
Estimated Hydraulic Conductivity (K) Values
Consumers Energy Co.
J.R. Whiting Generating Facility
Erie, Michigan

Well ID	Test	H^0 (ft)	H^* (ft)	K (ft/d)	K (cm/sec)	Slug Test Solution
JRW MW-15001	2	1.25	1.177	7.7	2.7E-03	KGS Model (Hyder et. al, 1994)
	3	2.31	2.02	12	4.2E-03	KGS Model (Hyder et. al, 1994)
	Average			*10*	*3.5E-03*	
JRW MW-15003	1	1.27	1.114	20	7.1E-03	KGS Model (Hyder et. al, 1994)
	3	2.28	2.138	20	7.1E-03	KGS Model (Hyder et. al, 1994)
	Average			*20*	*7.1E-03*	
JRW MW-15005	1	1.18	0.981	18	6.2E-03	KGS Model (Hyder et. al, 1994)
	2	1.20	1.131	8.4	3.0E-03	KGS Model (Hyder et. al, 1994)
	Average			*13*	*4.6E-03*	
JRW MW-15010	3	1.69	1.642	20	7.1E-03	Hvorslev (1951)
JRW MW-15011	2	1.69	1.69	1.5	5.3E-04	Hvorslev (1951)
JRW MW-15012	1	0.844	0.831	15	5.3E-03	Cooper et al. (1967)
	3	1.69	1.625	16	5.5E-03	Cooper et al. (1967)
	Average			*15*	*5.4E-03*	
Over all Average				***14***	***4.9E-03***	
Over all Geometric mean				***11***	***4.0E-03***	
Minimum				***1.5***	***5.3E-04***	
Maximum				***20***	***7.1E-03***	

Note:
K = Conductivity
H^0 = initial displacement
H^* = expected (calculated) displacement
cm/sec = centimeters per second
ft = feet
ft/d = feet per day

References

Cooper, H.H., J.D. Bredehoeft and S.S. Papadopulos, 1967. Response of a finite-diameter well to an instantaneous charge of water, Water Resources Research, vol. 3, no. 1, pp. 263-269

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground Water Observations, Bull. No. 36, Waterways Exper. Stata. Corps of Engineers, U.S. Army, Vicksburg, Mississippi, pp. 1-50.

FIGURES

Typical Background Monitoring Well

Pictures

Typical Surface Impoundment Monitoring Well

Pictures

NOTE: Aerial Image obtained from Google Earth. Image date copyright date 2015 TerraMetrics .

Surface Impoundment Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5902	107843.22	13374281.80	590.3	592.01	JRW MW-15006	41.792150	-83.446597
5904	107545.15	13374686.90	592.7	594.25	JRW MW-15005	41.791322	-83.445125
5906	107881.56	13375045.59	590.8	592.52	JRW MW-15004	41.792233	-83.443797
5908	108321.86	13374980.23	589.6	591.36	JRW MW-15003	41.793444	-83.444017
5910	108651.05	13374586.78	590.6	592.31	JRW MW-15002	41.794358	-83.445447
5912	108330.83	13374236.18	589.6	590.71	JRW MW-15001	41.793492	-83.446744

Background Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5915	109293.21	13373656.23	587.1	588.38	JRW MW-15007	41.796147	-83.448833
5917	109790.80	13373648.04	587.5	588.71	JRW MW-15011	41.797514	-83.448844
5919	110458.57	13373631.59	587.1	588.09	JRW MW-15010	41.799347	-83.448878
5921	110906.21	13373613.03	588.4	587.88	JRW MW-15008	41.800575	-83.448928
5923	110169.45	13374463.62	585.8	587.19	JRW MW-15012	41.798528	-83.445839
5925	109884.39	13374455.32	585.3	586.11	JRW MW-15009	41.797747	-83.445881

Survey Control Points

Pt #	Northing	Easting	Plant Elev	NAVD88	Name	Latitude	Longitude
1	107278.26	13374902.72	590.9	589.99	TP	41.790583	-83.444344
2	108903.66	13374018.38	600.0	599.20	TP	41.795069	-83.447522
4	111273.97	13373688.48	600.1	599.18	TP	41.801583	-83.448636
7	108765.66	13374471.45	577.9	577.09	TP	41.794678	-83.445867
9	108697.62	13372712.75	577.2	576.31	NE Sec. 15	41.794542	-83.452317
10	108610.28	13367111.76	580.4	579.56	BM Q178	41.794467	-83.472856
1918	108101.94	13374607.57	590.4	589.51	TP	41.792850	-83.445394
2168	109013.11	13374349.04	600.8	600.00	TP	41.795358	-83.446306
3081	108683.22	13373439.66	578.0	577.05	CP	41.794481	-83.449653

Elevations are NAVD88 from Benchmark (BM) Q 178 per NGS Data Sheet (Not Shown, Approximately 1.1 miles West of Northeast Corner Section 15. On 11-19-2015, a level loop was performed between BM and Control Point (CP) #3081. A second loop was done from CP to Traverse Point (TP) #1918 and to TP #2168. On 11-20-15, a loop was performed utilizing TP #1918 to determine elevations on Monitoring Wells at Top of Pipe on Pond 1 & 2 and TP #1 (not shown). Another loop was performed from TP #2168, determining elevations for MWs and TP #4 & #2 on Pond 6. Ground elevations at base of MW pipe were obtained on 11-10-15 by GPS observation.

Elevation Basis

BM Q 187
Elevation = 579.56' NAVD88

Coordinate Basis

State Plane Coordinates Michigan South Zone 2113
MDOT CORS VRS (G12AUS)

Legend

- 🟥 -- *CCR UNIT Monitoring Well*
- 🟦 -- *Background Monitoring Well*
- ▲ -- *Traverse Point*
- ⊕ -- *Section Corner*

GRAPHIC SCALE

(IN FEET)
1 inch = 100 ft.

DRAWING NO.	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.	REV.	DATE	DESCRIPTION	BY	APP.	REV.	DATE	DESCRIPTION	BY
SF-19884	Sheet 34, Pond 1 & 2														
SF-19884	Sheet 35, Pond 6														
	FIELD BOOK NO. 1997A												A	12/7 '15	Changes per email request	RST

		DATE
DN.	RST	11-24-15
FLD.	DEE	11-10-15
CHKD.		
APP.		
APP.	DEPARTMENT HEAD	

Consumers Energy

SSC SHERIDAN SURVEYING CO.
910 Fifth Street Michigan Center, MI 49254

Whiting Plant Monitoring Wells
CCR Monitoring

Sec. 11 & 14
City of Luna Pier

SAP WO #25477976

T8S, R8E
Monroe County

SCALE: 1" = 100'
CE FILENAME: 22374base.dwg
SSC FILENAME: 3708_SPCadj.dwg

Drawing No.	Sheet	Rev.
SG-22374	1	A

APPENDIX A

Soil Boring and Monitoring Well Construction Logs

Date Start: 10/23/15
Date Finish: 10/26/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 11.0
Water Level Finish (ft. btoc.): NA

Northing: 108330.83
Easting: 13374236.18
Casing Elevation: 590.71

Borehole Depth (ft. bgs.): 88.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15001**

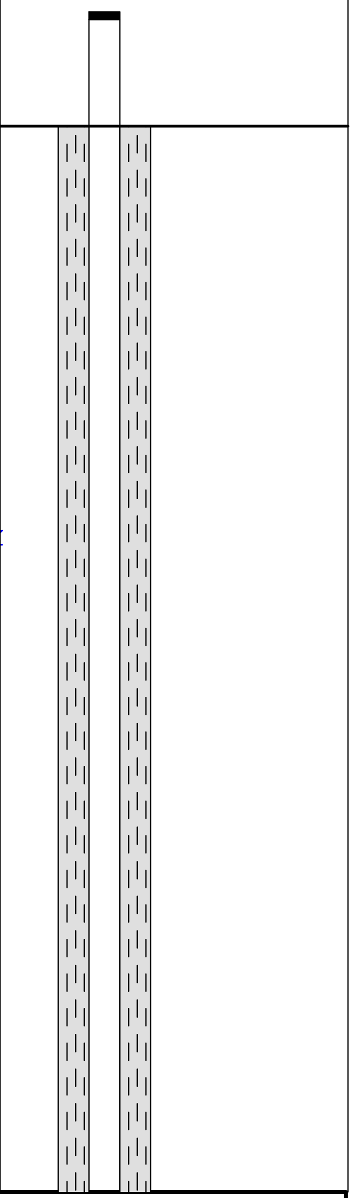
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 50 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	0							(0.0 - 6.0') Hydrovac; no lithology recorded.	
		1	0.0-6.0'	0.0	NA				
5	-5								
		2	6.0-9.0'	3.1	NA		✕	(6.0 - 11.0') Bottm ASH; trace small cobbles, subrounded to subangular; black (10YR 2/1).	
10	-10						✕		
		3	9.0-19.0'	6.6	NA		✕	(11.0 - 17.5') Fly ASH; wet; black (10YR 2/1).	▼
15	-15						✕		
							▨	(17.5 - 29.0') CLAY, high plasticity; dry; medium stiff; olive gray (5Y 4/2) with dark yellowish brown mottling (10YR 4/6).	
20	-20	4	19.0-21.0'	0.0	NA		▨		
25	-25						▨		
		5	21.0-31.0'	4.6	NA		▨		

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 11.0' bgs.
No odor or staining observed.

Date Start: 10/23/15
Date Finish: 10/26/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 11.0
Water Level Finish (ft. btoc.): NA

Northing: 108330.83
Easting: 13374236.18
Casing Elevation: 590.71

Borehole Depth (ft. bgs.): 88.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15001**

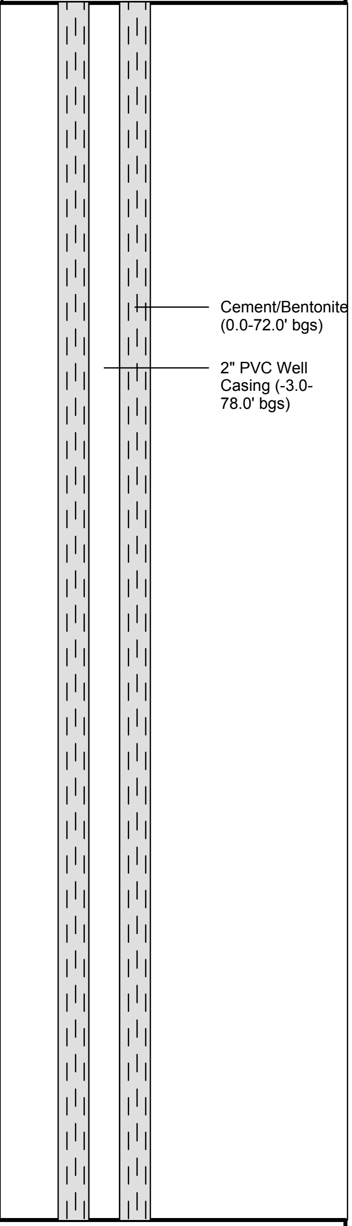
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 50 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
30	-30							(29.0 - 34.0') CLAY, low plasticity; trace silt; trace granule to small pebbles, subrounded to subangular; very stiff; brown (10YR 5/3).	
35	-35	6	31.0-41.0'	12.0	NA			(34.0 - 70.0') CLAY, high plasticity; trace silt; trace very fine to fine sand; trace granule to small pebbles, subrounded to subangular; dry; medium stiff; dark gray (10YR 4/1).	
40	-40								
45	-45	7	41.0-51.0'	8.6	NA			NOTE: Trace medium pebbles to large cobbles, subrounded to subangular starting at 43.0' bgs.	
50	-50								
55	-55	8	51.0-61.0'	6.4	NA			NOTE: Clay is very stiff to hard at 59.0' bgs.	
60	-60								

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 11.0' bgs.
No odor or staining observed.

Date Start: 10/23/15
Date Finish: 10/26/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 11.0
Water Level Finish (ft. btoc.): NA

Northing: 108330.83
Easting: 13374236.18
Casing Elevation: 590.71

Borehole Depth (ft. bgs.): 88.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15001**

Client: Consumers Energy

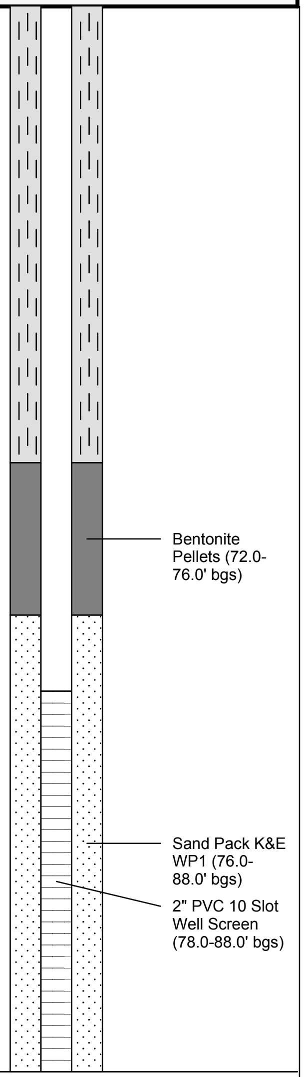
Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 50 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Stratigraphic Description
65	-65	9	61.0-71.0'	6.2	NA		
70	-70						(70.0 - 88.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1).
75	-75	10	71.0-81.0'	6.0	NA		NOTE: Color change; more porous at 78.0' bgs.
80	-80						
85	-85	11	81.0-86.0'	3.7	NA		
		12	86.0-88.0'	0.0	NA		
							End of boring 88.0' bgs.
90	-90						

Water Level (ft. bgs.)

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 11.0' bgs.
No odor or staining observed.

ARCADIS Design & Consultancy for natural and built assets

Date Start: 10/27/15
Date Finish: 10/28/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108651.05
Easting: 13374586.78
Casing Elevation: 592.31

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15002**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 55 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample
0	0					
		1	0.0-6.0'	0.0	NA	
5	-5					
		2	6.0-11.0'	8.0	NA	
10	-10					
15	-15					
		3	11.0-21.0'	10.3	NA	
20	-20					
25	-25					
		4	21.0-31.0'	8.7	NA	

Water Level (ft. bgs.): ▼ 6.0

Stratigraphic Description

(0.0 - 6.0') Hydrovac; no lithology recorded.

(6.0 - 16.5') Fly ASH; wet; dark gray (10YR 2/1).

(16.5 - 17.0') PEAT; moist; black (10YR 2/1).

(17.0 - 18.0') SILT, medium plasticity; trace clay; little organics; moist; medium stiff; very dark grayish brown (10YR 3/2).

(18.0 - 23.5') CLAY, high plasticity; trace silt; dry; medium stiff; olive (5Y 4/3).

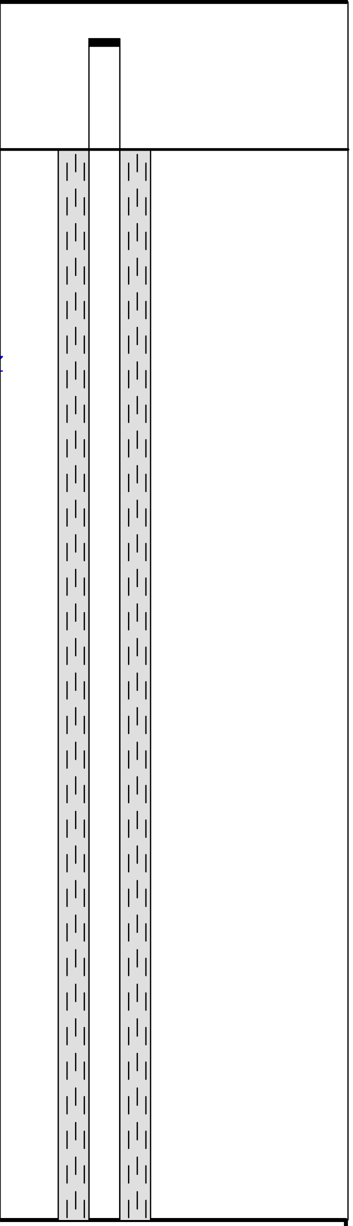
NOTE: Color change to light yellow brown (2.5Y 6/4) with olive yellow mottling (2.5Y 6/6) at 19.0' bgs.

NOTE: Clay becomes soft from 21.0 to 23.5' bgs.

(23.5 - 71.0') CLAY, medium to high plasticity; trace silt; little granule to large pebble, subrounded to subangular; dry; medium stiff to stiff; brownish yellow (10YR 6/6).

NOTE: Color change to brown (10YR 4/3) at 28.0' bgs.

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/27/15
Date Finish: 10/28/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108651.05
Easting: 13374586.78
Casing Elevation: 592.31

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.6

Descriptions By: L. Rogers

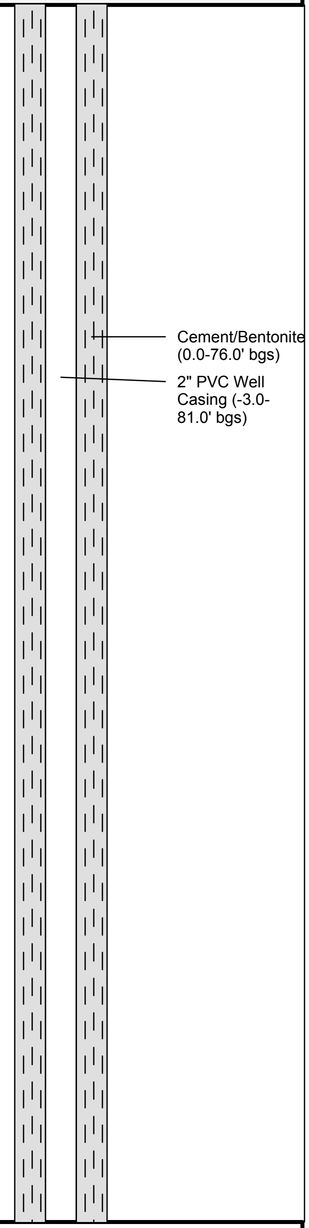
Well/Boring ID: **JRW MW-15002**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 55 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
30	-30									
								NOTE: Color change to dark gray (10YR 4/1) at 31.0' bgs.		
35	-35									
		5	31.0-41.0'	12.0	NA					
40	-40									
								NOTE: Clay is stiff at 41.0' bgs.		
45	-45									
		6	41.0-51.0'	10.3	NA					
50	-50									
55	-55									
		7	51.0-61.0'	12.0	NA					
								NOTE: Little very large pebbles to small cobbles starting at 57.0' bgs.		
60	-60									



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/27/15
Date Finish: 10/28/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108651.05
Easting: 13374586.78
Casing Elevation: 592.31

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.6

Descriptions By: L. Rogers

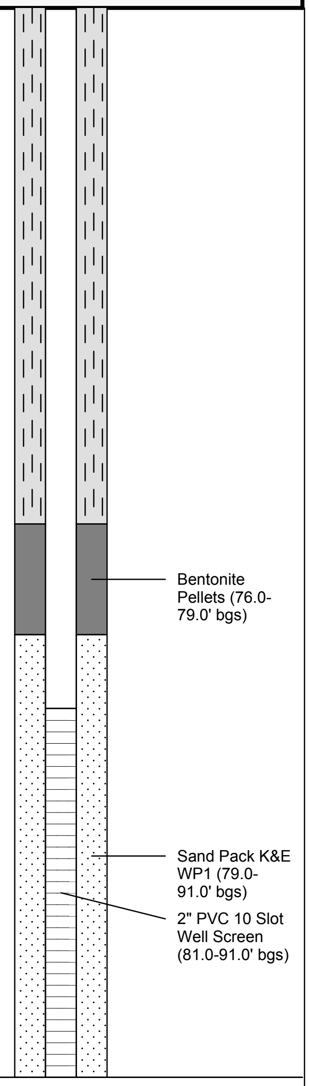
Well/Boring ID: **JRW MW-15002**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 55 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
65 70	-65 -70	8	61.0-71.0'	10.3	NA					
75 80	-75 -80	9	71.0-81.0'	5.0	NA			(71.0 - 91.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1).		
85 90	-85 -90	10	81.0-91.0'	1.0	NA			NOTE: Very low recovery from 81.0 to 91.0' bgs.		
95	-95							End of boring 91.0' bgs.		



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

ARCADIS Design & Consultancy for natural and built assets

Date Start: 10/28/15
Date Finish: 10/29/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108321.86
Easting: 13374980.23
Casing Elevation: 591.36

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15003**

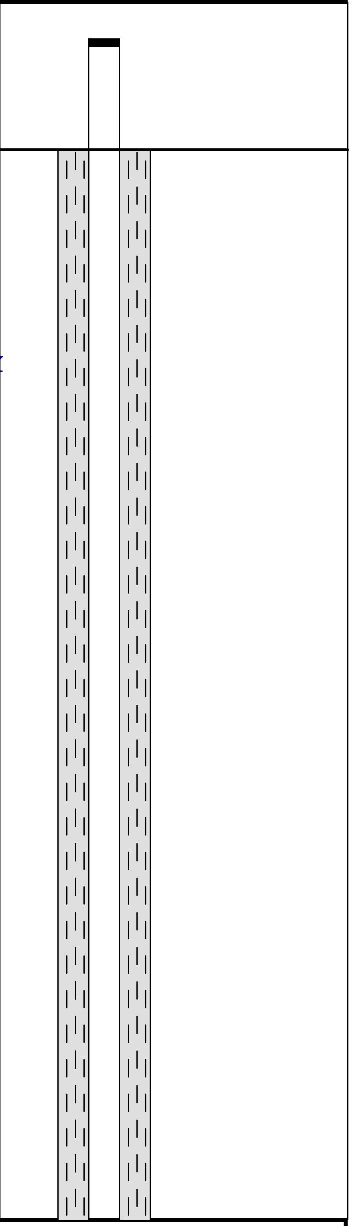
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 60 F Cloudy, rain

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	0	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5	-5								
		2	6.0-11.0'	6.0	NA			(6.0 - 16.8') Fly ASH; wet; black (10YR 2/1).	▼
10	-10								
15	-15	3	11.0-21.0'	9.7	NA				
								(16.8 - 18.4') PEAT and SILT; little organics; moist; dark gray brown (10YR 4/2).	
								(18.4 - 26.0') CLAY, medium to high plasticity; trace silt; dry; medium stiff; olive (5Y 4/4) with brownish yellow mottling (10YR 6/8).	
20	-20								
25	-25	4	21.0-31.0'	12.7	NA			(26.0 - 71.0') CLAY, medium to high plasticity; trace silt; little granule to large pebbles, subrounded to subangular; dry; medium stiff to stiff; very dark gray (10YR 3/1).	

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/28/15
Date Finish: 10/29/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108321.86
Easting: 13374980.23
Casing Elevation: 591.36

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15003**

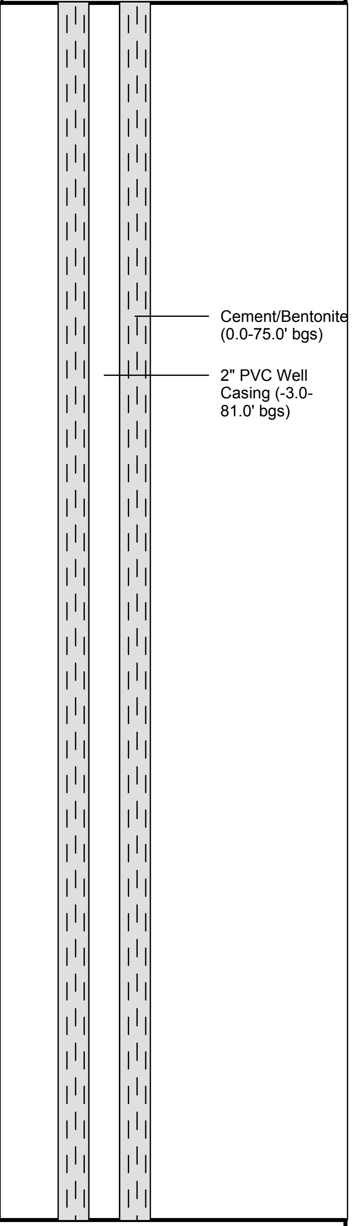
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 60 F Cloudy, rain

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
30	-30								
								NOTE: Clay is stiff at 33.0' bgs.	
35	-35								
		5	31.0-41.0'	10.6	NA				
40	-40								
								NOTE: Clay is stiff to very stiff at 41.0' bgs.	
45	-45								
		6	41.0-51.0'	11.3	NA				
50	-50								
								NOTE: Trace small to large cobbles, subrounded to subangular in sample from 51.0 to 61.0' bgs.	
55	-55								
		7	51.0-61.0'	12.3	NA				
60	-60								
								NOTE: Clay is stiff at 60.5' bgs.	

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/28/15
Date Finish: 10/29/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 108321.86
Easting: 13374980.23
Casing Elevation: 591.36

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 589.6

Descriptions By: L. Rogers

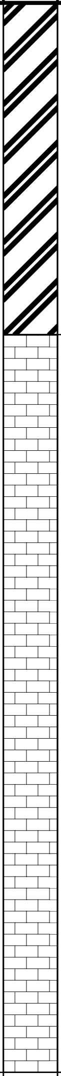
Well/Boring ID: **JRW MW-15003**

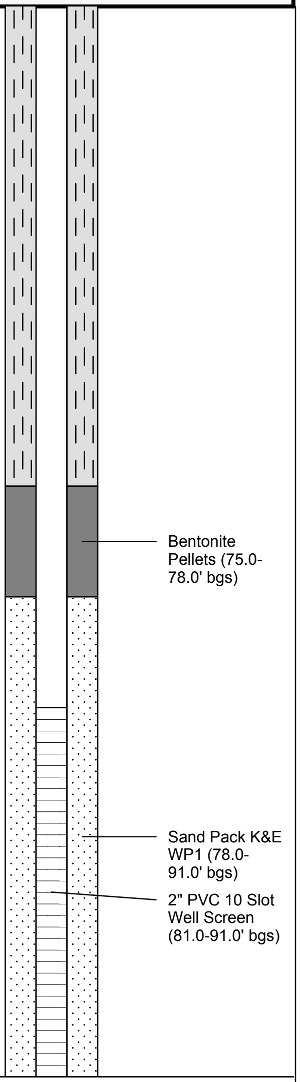
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 60 F Cloudy, rain

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
65 70	-65 -70	8	61.0-71.0'	10.1	NA					
75 80	-75 -80	9	71.0-81.0'	4.0	NA			(71.0 - 91.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1). NOTE: Limestone pulverized from 71.0 to 81.0' bgs.		
85 90	-85 -90	10	81.0-91.0'	7.0	NA					
95	-95							End of boring 91.0' bgs.		





Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/30/15
Date Finish: 11/02/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107881.56
Easting: 13375045.59
Casing Elevation: 592.52

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 590.8

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15004**

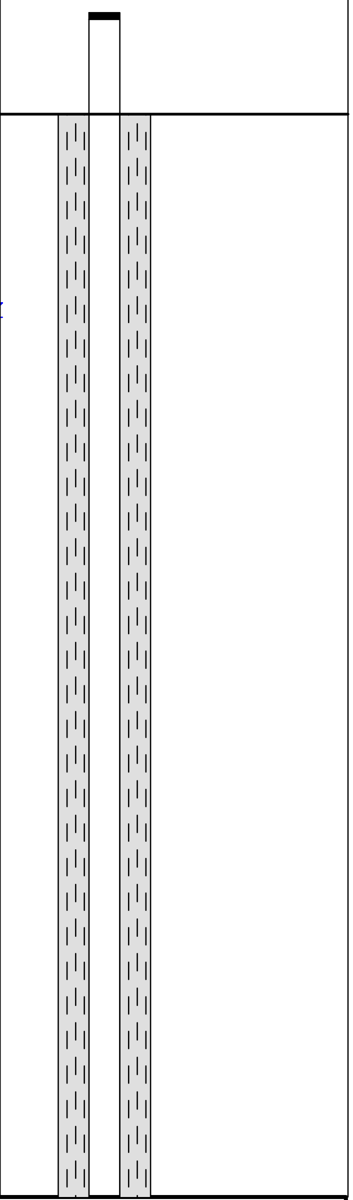
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 46 F Overcast

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	0	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5	-5								
		2	6.0-11.0'	7.0	NA		×	(6.0 - 9.0') Fly ASH; trace bottom ash; wet; black (10YR 2/1).	▼
10	-10						|||	(9.0 - 13.0') SILT; trace clay; little organics, roots; trace peat; moist; soft; dark gray (10YR 4/1).	
15	-15	3	11.0-21.0'	6.5	NA		▨	(13.0 - 17.0') CLAY, high plasticity; little silt; trace bottom ash; moist; soft; brown (10YR 4/3).	
							|||	(17.0 - 19.0') SILT and PEAT; little organics; trace medium to very coarse sand; medium stiff to soft; very dark brown (10YR 2/2).	
20	-20						▨	(19.0 - 23.0') CLAY, medium to high plasticity; trace sillt; dry; medium stiff; olive (5Y 4/4) with brownish yellow mottling (10YR 6/8). NOTE: Clay is soft from 21.0 to 23.0' bgs.	
25	-25	4	21.0-31.0'	8.0	NA		▨	(23.0 - 80.5') CLAY, medium plasticity; trace coarse sand to large pebbles, subrounded to subangular; dry; stiff; dark brown (10YR 3/3).	
30	-30						▨	NOTE: Clay is medium stiff; color change to dark gray (10YR 4/1) at 31.0' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/30/15
Date Finish: 11/02/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107881.56
Easting: 13375045.59
Casing Elevation: 592.52

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 590.8

Descriptions By: L. Rogers

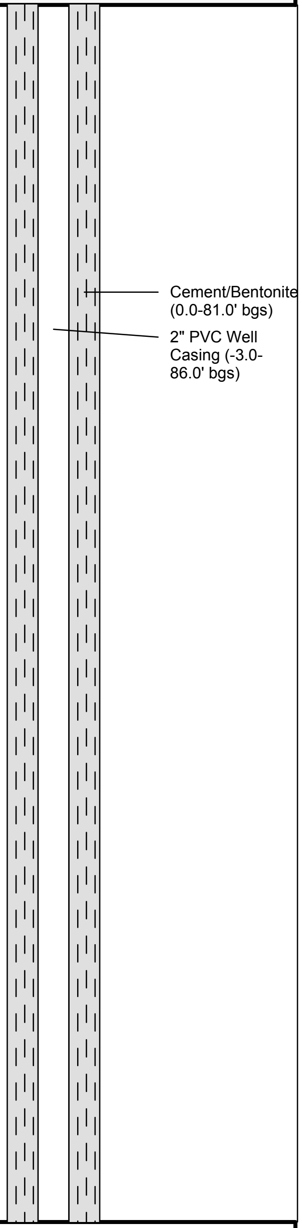
Well/Boring ID: **JRW MW-15004**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 46 F Overcast

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
35	-35									
		5	31.0- 41.0'	12.0	NA					
40	-40									
								NOTE: Clay is very stiff to hard; little granule to large pebbles; trace very large pebbles to small cobbles, subrounded to subangular at 41.0' bgs.		
45	-45									
		6	41.0- 51.0'	12.0	NA					
50	-50									
55	-55									
		7	51.0- 61.0'	11.0	NA					
60	-60									
65	-65									
		8	61.0- 71.0'	11.3	NA					



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 10/30/15
Date Finish: 11/02/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107881.56
Easting: 13375045.59
Casing Elevation: 592.52

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 590.8

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15004**

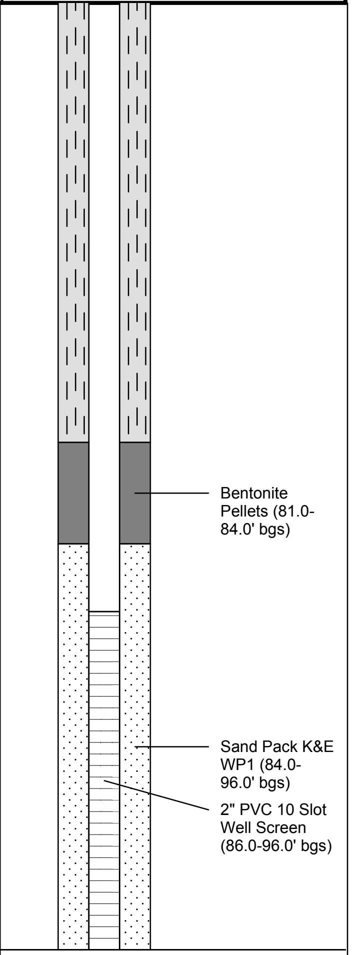
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 46 F Overcast

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
70	-70								
75	-75								
		9	71.0-81.0'	6.0	NA				
80	-80								
								(80.5 - 96.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1). NOTE: Limestone sample was pulverized from 81.0 to 96.0' bgs.	
85	-85								
		10	81.0-91.0'	5.2	NA				
90	-90								
		11	91.0-96.0'	4.0	NA				
95	-95								
								End of boring 96.0' bgs.	
100	-100								

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 11/02/15
Date Finish: 11/03/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107545.15
Easting: 13374686.90
Casing Elevation: 594.25

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 592.7

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15005**

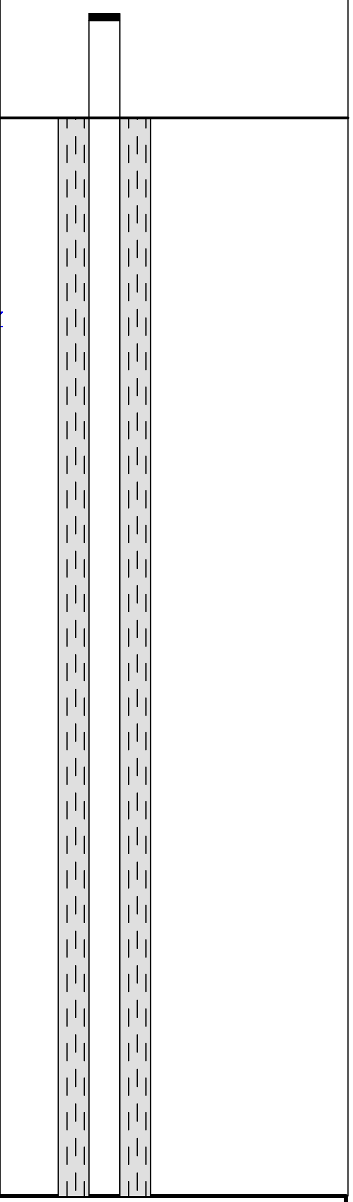
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0 5	0 -5	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	▼
10	-10	2	6.0-11.0'	5.0	NA		× × ×	(6.0 - 31.0') Fly ASH; trace bottom ash; wet; black (10YR 2/1).	
15 20	-15 -20	3	11.0-21.0'	8.3	NA		× × ×		
25 30	-25 -30	4	21.0-31.0'	0.0	NA		× × ×	NOTE: No recovery, material too soft from 21.0 to 31.0' bgs.	

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 11/02/15
Date Finish: 11/03/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107545.15
Easting: 13374686.90
Casing Elevation: 594.25

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 592.7

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15005**

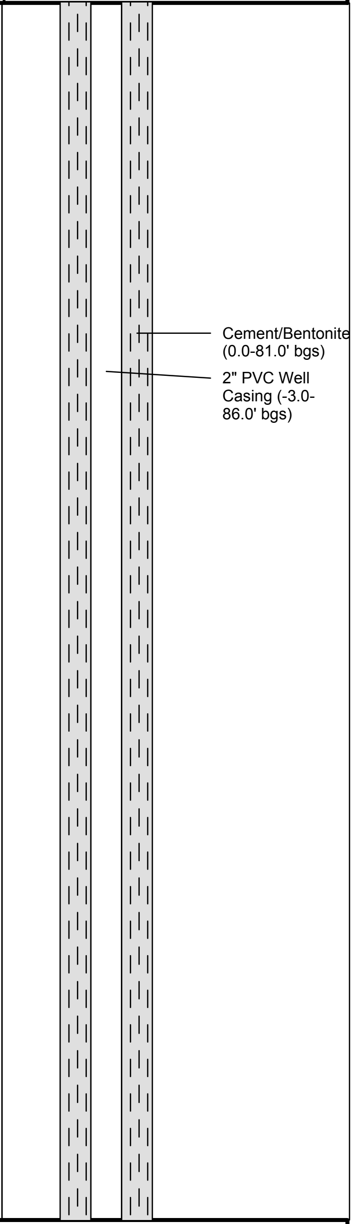
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
								(31.0 - 33.0') PEAT and SILT; trace organics, roots; moist to wet; dark grayish brown (10YR 3/2).	
								(33.0 - 49.0') CLAY, medium plasticity; little granule to medium pebbles; trace large pebbles, subrounded to subangular; trace silt; dry; stiff; very dark gray (10YR 3/1).	
35	-35								
		5	31.0- 41.0'	10.2	NA				
40	-40								
								NOTE: Trace very large pebbles to large cobbles, subrounded to subangular; clay becomes hard from 41.0 to 49.0' bgs.	
45	-45								
		6	41.0- 51.0'	12.2	NA				
								(49.0 - 54.0') SILT and SAND, rapid dilatancy, very fine; wet; medium stiff to soft; very dark gray (10YR 3/1).	
50	-50								
								(54.0 - 80.5') CLAY, medium plasticity; little granule to medium pebbles; trace large pebbles, subrounded to subangular; trace silt; dry; stiff; very dark gray (10YR 3/1).	
55	-55								
		7	51.0- 61.0'	10.0	NA				
60	-60								
65	-65								

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 11/02/15
Date Finish: 11/03/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107545.15
Easting: 13374686.90
Casing Elevation: 594.25

Borehole Depth (ft. bgs.): 96.0
Surface Elevation: 592.7

Descriptions By: L. Rogers

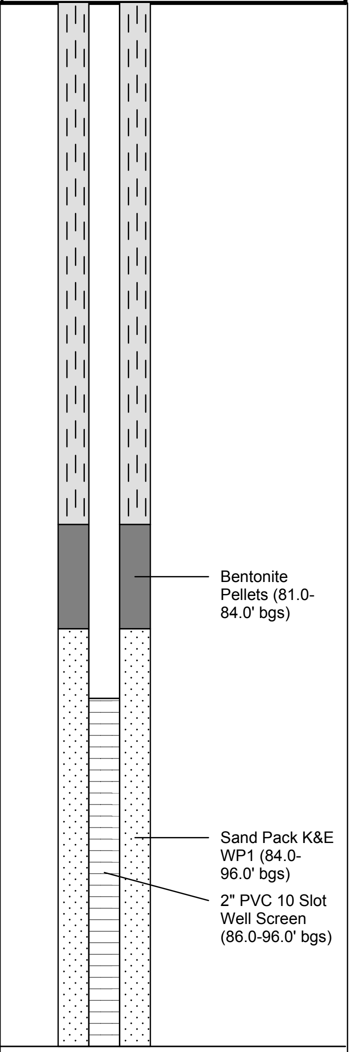
Well/Boring ID: **JRW MW-15005**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
70	-70	8	61.0-71.0'	12.3	NA					
75	-75	9	71.0-81.0'	7.3	NA					
80	-80									
85	-85	10	81.0-91.0'	5.1	NA			(80.5 - 96.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1). NOTE: Limestone is porous with calcite crystals infilling in openings at 89.0' bgs.		
90	-90									
95	-95	11	91.0-96.0'	3.7	NA			NOTE: very fine limestone slurry layer from 94.0 to 95.0' bgs.		
100	-100							End of boring 96.0' bgs.		



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Project: DE000722.0005.00006 Template: ARCADIS_Analytical Boring-Well 2013_New Logo
Data File: JRW MW-15005.dat Date: 12/15/2015 Created/Edited by: C. Jeffers

Date Start: 11/03/15
Date Finish: 11/05/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107843.22
Easting: 13374281.80
Casing Elevation: 592.01

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.3

Descriptions By: L. Rogers

Well/Boring ID: **JRW MW-15006**

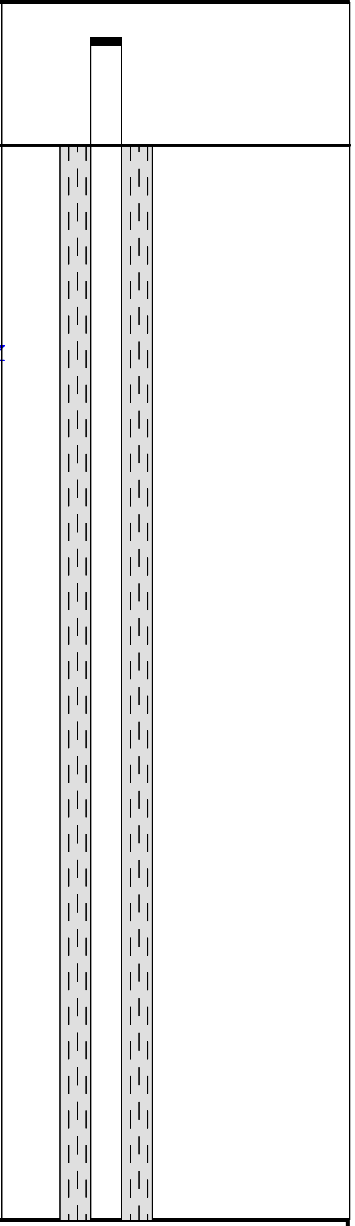
Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	0	1	0.0- 6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5	-5								
		2	6.0- 11.0'	5.7	NA		××	(6.0 - 25.0') Fly and Bottom ASH; wet; black (10YR 2/1).	▼
10	-10						××		
		3	11.0- 21.0'	10.6	NA		××		
15	-15						××		
20	-20						××		
		4	21.0- 31.0'	10.0	NA		××		
25	-25						▨	(25.0 - 47.0') CLAY, medium to high plasticity; little granules to large pebbles, subrounded to subangular; trace silt; dry; medium stiff; brown (10YR 4/3).	
30	-30						▨		

Well/Boring Construction



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 11/03/15
Date Finish: 11/05/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107843.22
Easting: 13374281.80
Casing Elevation: 592.01

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.3

Descriptions By: L. Rogers

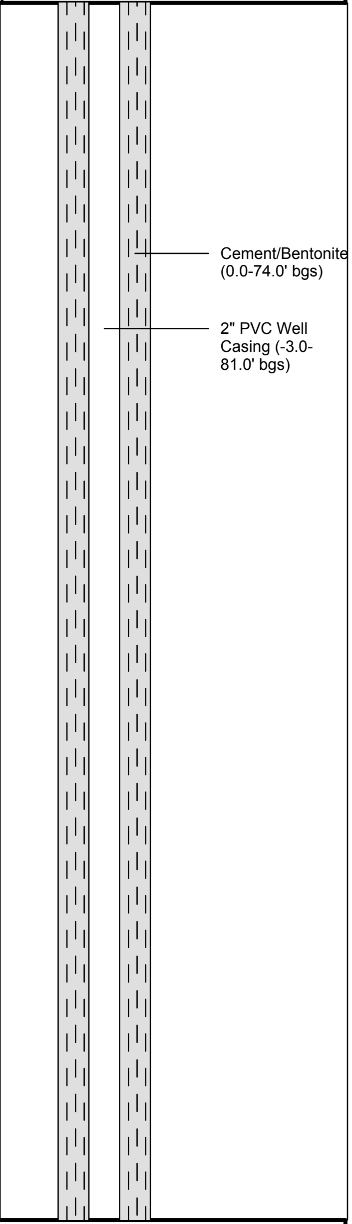
Well/Boring ID: **JRW MW-15006**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
								NOTE: Clay becomes medium stiff to soft; color change to very dark gray (10YR 3/1) at 31.0' bgs.		
35	-35									
		5	31.0-41.0'	8.3	NA					
								NOTE: Clay becomes stiff at 38.0' bgs.		
40	-40									
								NOTE: trace very large pebbles to small cobbles, subrounded to subangular at 41.0' bgs.		
45	-45									
		6	41.0-51.0'	10.3	NA					
								(47.0 - 49.0') SILT, rapid dilatancy; trace very fine sand; wet; medium stiff to soft; very dark gray (10YR 3/1).		
								(49.0 - 71.0') CLAY, medium to high plasticity; little granules to large pebbles, subrounded to subangular; trace silt; dry; stiff to hard; brown (10YR 4/3).		
50	-50									
55	-55									
		7	51.0-61.0'	10.3	NA					
60	-60									



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

Date Start: 11/03/15
Date Finish: 11/05/15
Drilling Company: Stock Drilling
Driller's Name: Austin G.
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 6.0
Water Level Finish (ft. btoc.): NA

Northing: 107843.22
Easting: 13374281.80
Casing Elevation: 592.01

Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.3

Descriptions By: L. Rogers

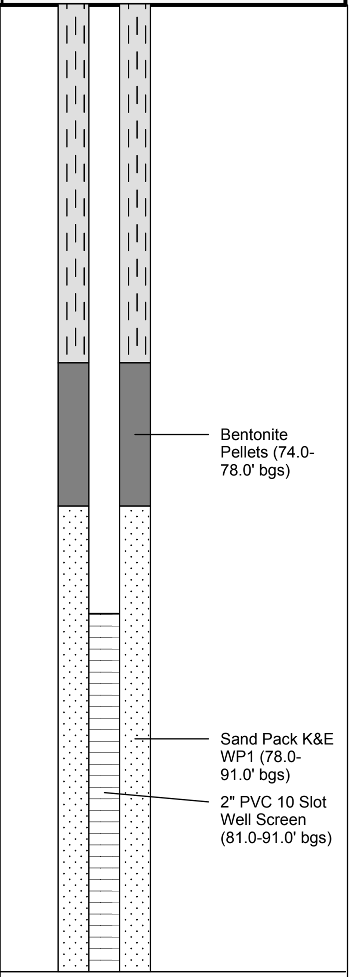
Well/Boring ID: **JRW MW-15006**

Client: Consumers Energy

Location: JR Whiting Facility
4525 East Erie Road
Erie, MI 48133

Weather Conditions: 42 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
65 70	-65 -70	8	61.0-71.0'	12.0	NA			NOTE: Some granule to medium pebbles; little large pebbles to very large pebbles; trace small to large cobbles, subrounded to subangular at 68.0' bgs.		
75 80	-75 -80	9	71.0-81.0'	4.0	NA			(71.0 - 91.0') LIMESTONE BEDROCK, sedimentary rock, very fine grained, homogeneous grain size and distribution; reacts with HCL when crushed; little large pores infilled with dark calcite crystals; rock core is hard to very hard; light gray (10YR 7/1).		
85 90	-85 -90	10	81.0-91.0'	5.0	NA					
95	-95							End of boring 91.0' bgs.		



Remarks: bgs = below ground surface

Hydrovac to 6.0' bgs.
Groundwater encountered at 6.0' bgs.
No odor or staining observed.

SOIL DESCRIPTION

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Description	Criteria
Nonplastic	A $^1/_8$ inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

APPENDIX B

Photographic Logs

Photograph #1

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Site Location:
Consumers Energy Co.
JR Whiting Generating Facility
Erie, Michigan

Photograph Taken By:
Lance Rogers

Date of Photograph:
October 27, 2015

Photograph #2

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Consumers Energy Co.
JR Whiting Generating Facility
Erie, Michigan

Photograph Taken By:
Lance Rogers

Date of Photograph:
October23, 2015

Photograph #3

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Site Location:
Consumers Energy Co.
JR Whiting Generating Facility
Erie, Michigan

Photograph Taken By:
Lance Rogers

Date of Photograph:
October 27, 2015

Photograph #4

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Consumers Energy Co.
JR Whiting Generating Facility
Erie, Michigan

Photograph Taken By:
Lance Rogers

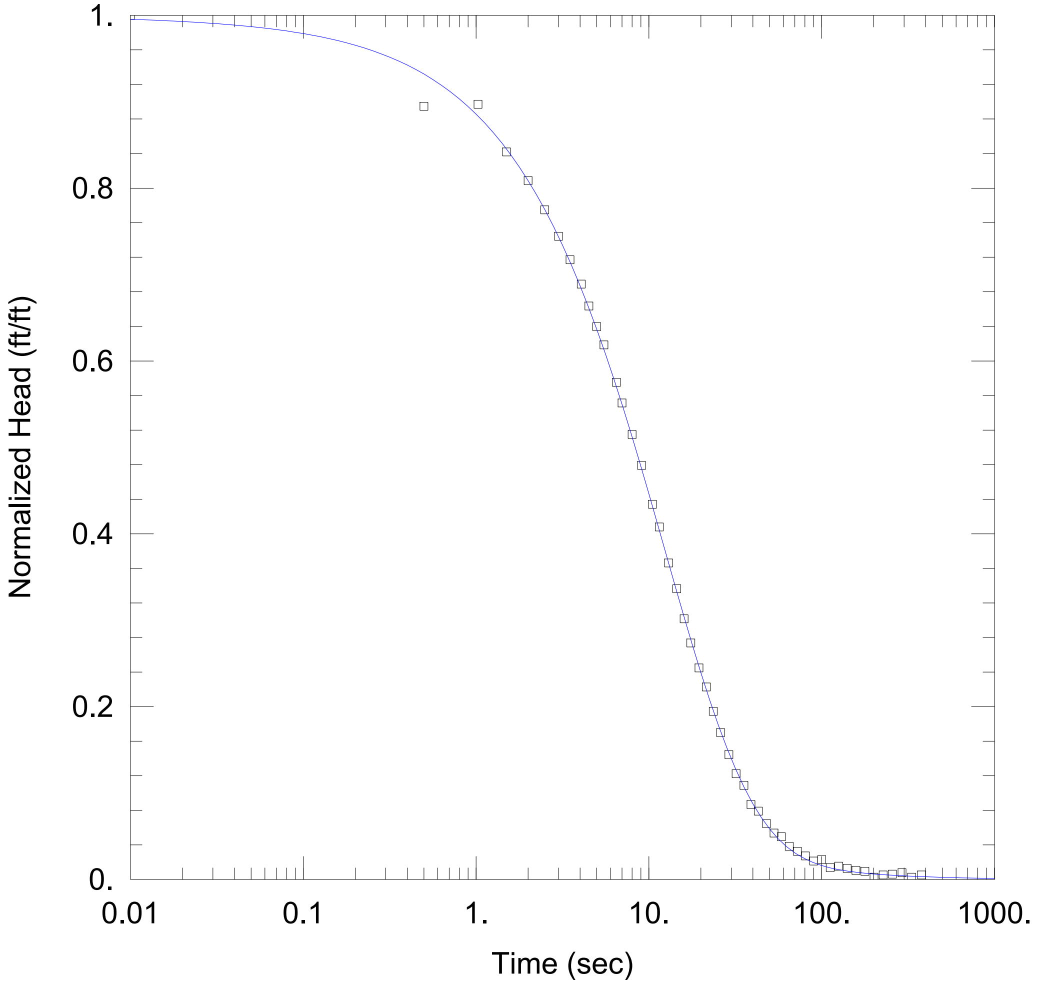
Date of Photograph:
October 29, 2015

APPENDIX C

Hydraulic Test Logs

Slug Test Analysis Results for JRW MW-15001 -Test 2

Prepared By: **Arcadis**	Prepared For: **Consumer Energy**
Project:	Location: **Erie, MI**



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 7.7 ft/day Ss = 2.0E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

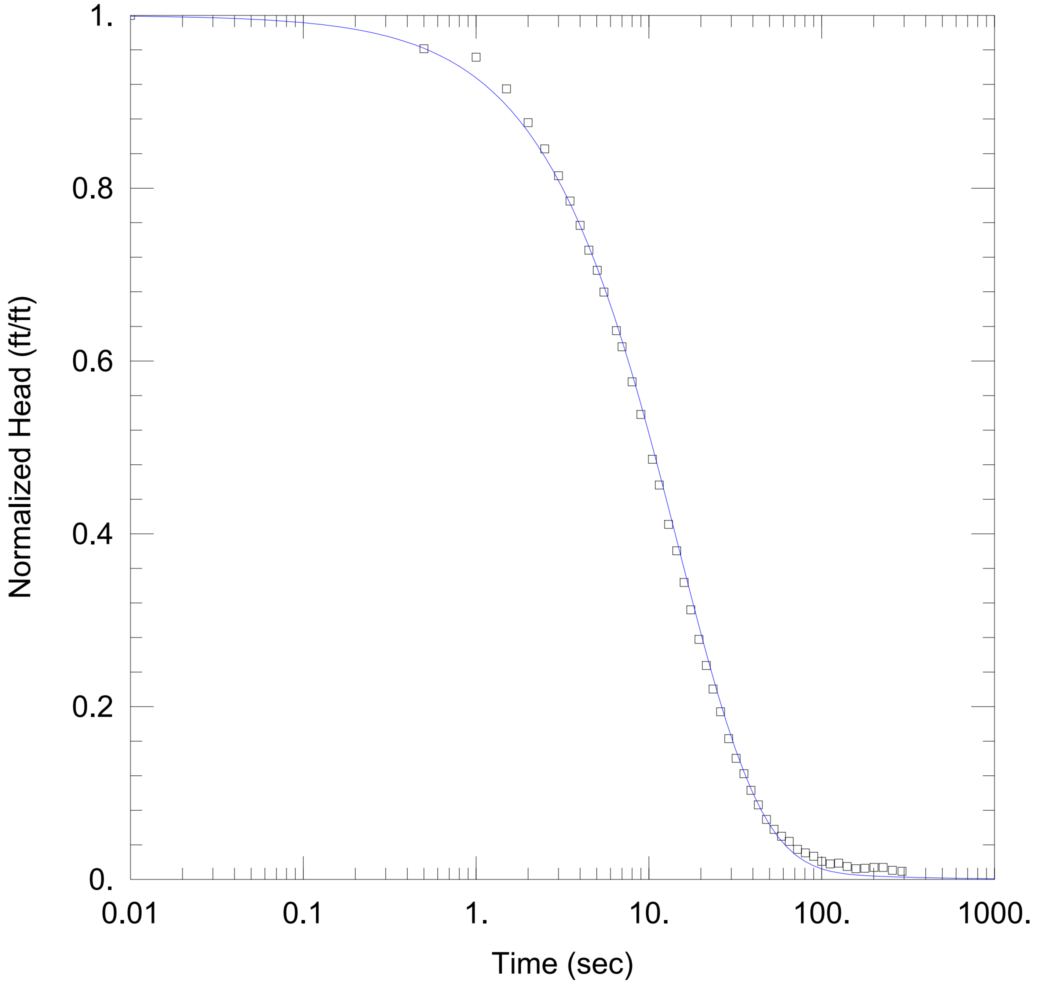
Saturated Thickness: 18. ft

WELL DATA (JRW-MW-15001)

Initial Displacement: 1.177 ft
Static Water Column Height: 69.28 ft
Total Well Penetration Depth: 18. ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

Slug Test Analysis Results for JRW MW-15001 -Test 3

Prepared By: **Arcadis**	Prepared For: **Consumer Energy**
Project:	Location: **Erie, MI**



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 12. ft/day
Ss = 9.0E-10 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

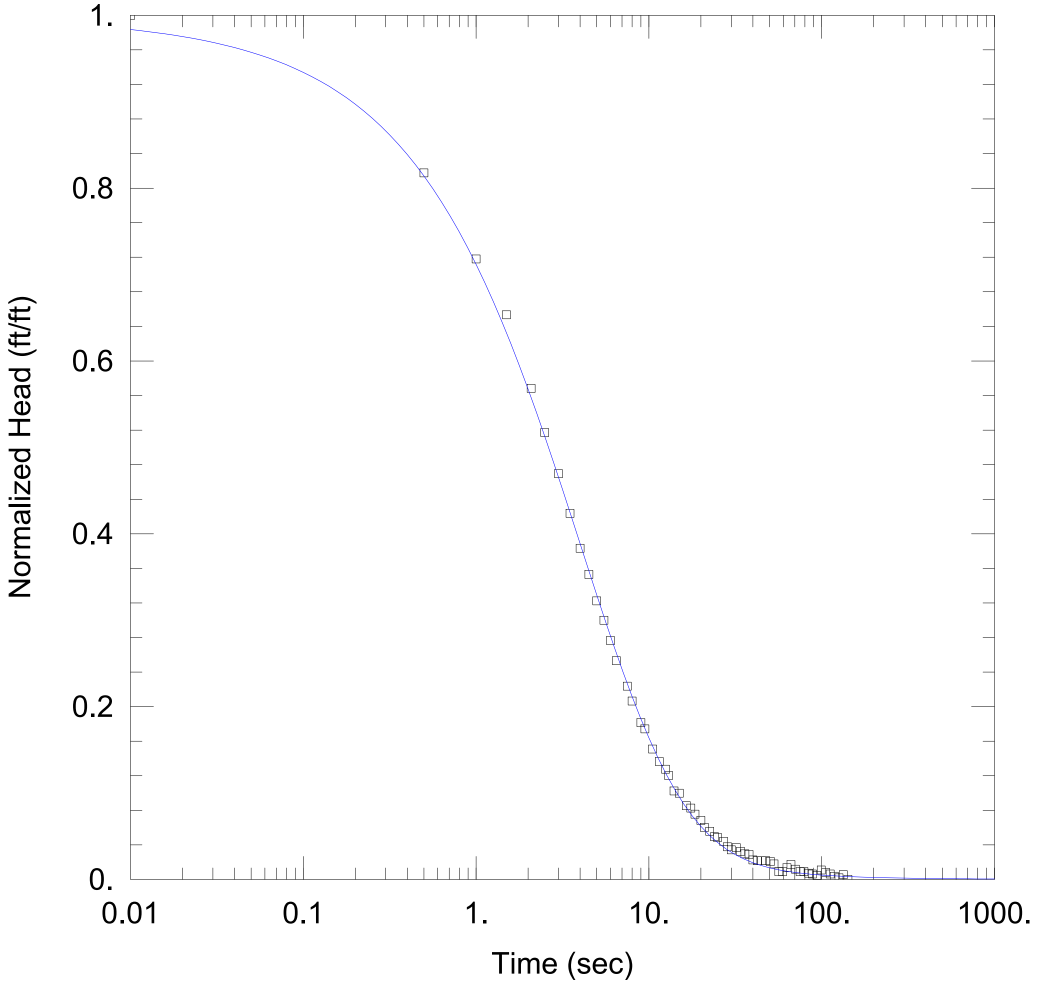
Saturated Thickness: 18. ft

WELL DATA (JRW-MW-15001)

Initial Displacement: 2.02 ft
Static Water Column Height: 69.28 ft
Total Well Penetration Depth: 18. ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

Slug Test Analysis Results for JRW MW-15003 -Test 1

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 20. ft/day
Ss = 0.00016 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 20. ft

WELL DATA (JRW-MW-15003)

Initial Displacement: 1.114 ft
Static Water Column Height: 74. ft
Total Well Penetration Depth: 20. ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

ARCADIS

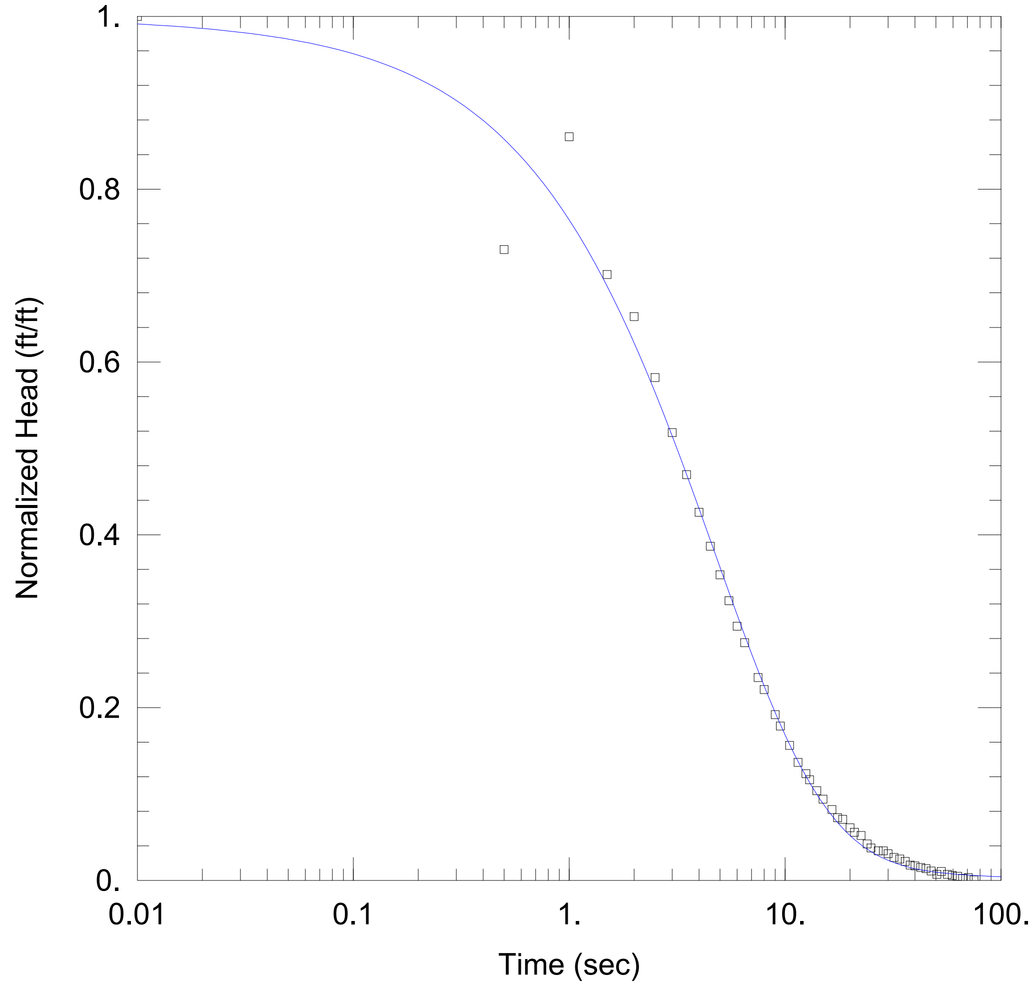
Slug Test Analysis Results for JRW MW-15003 -Test 3

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 20. ft/day
Ss = 2.3E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 20. ft

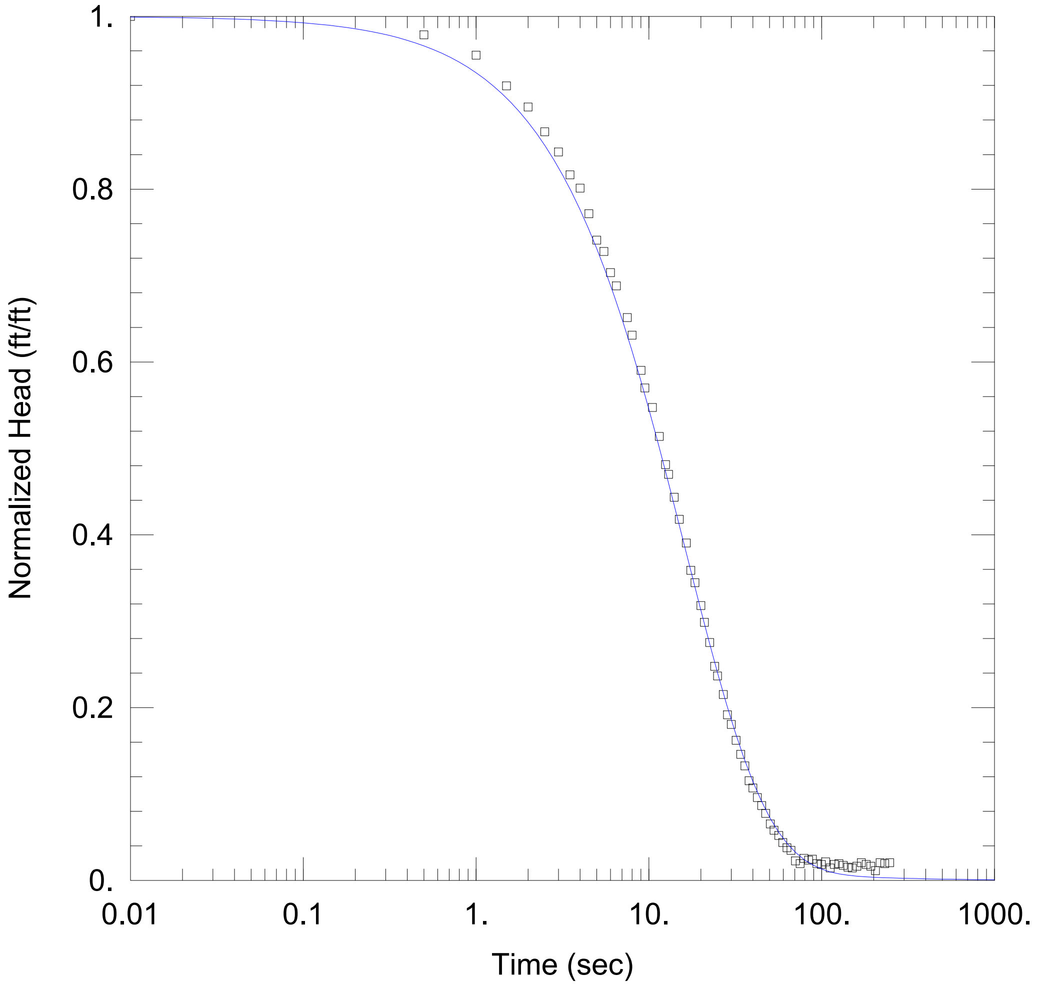
WELL DATA (JRW-MW-15003)

Initial Displacement: 2.138 ft
Static Water Column Height: 74. ft
Total Well Penetration Depth: 20. ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

Slug Test Analysis Results for JRW MW-15005 -Test 1

Prepared By:	Prepared For:
Arcadis	**Consumer Energy**

Project:	Location:
	Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 18. ft/day
Ss = 5.6E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 15.5 ft

WELL DATA (JRW-MW-15005)

Initial Displacement: 0.981 ft
Static Water Column Height: 74.54 ft
Total Well Penetration Depth: 15.5 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

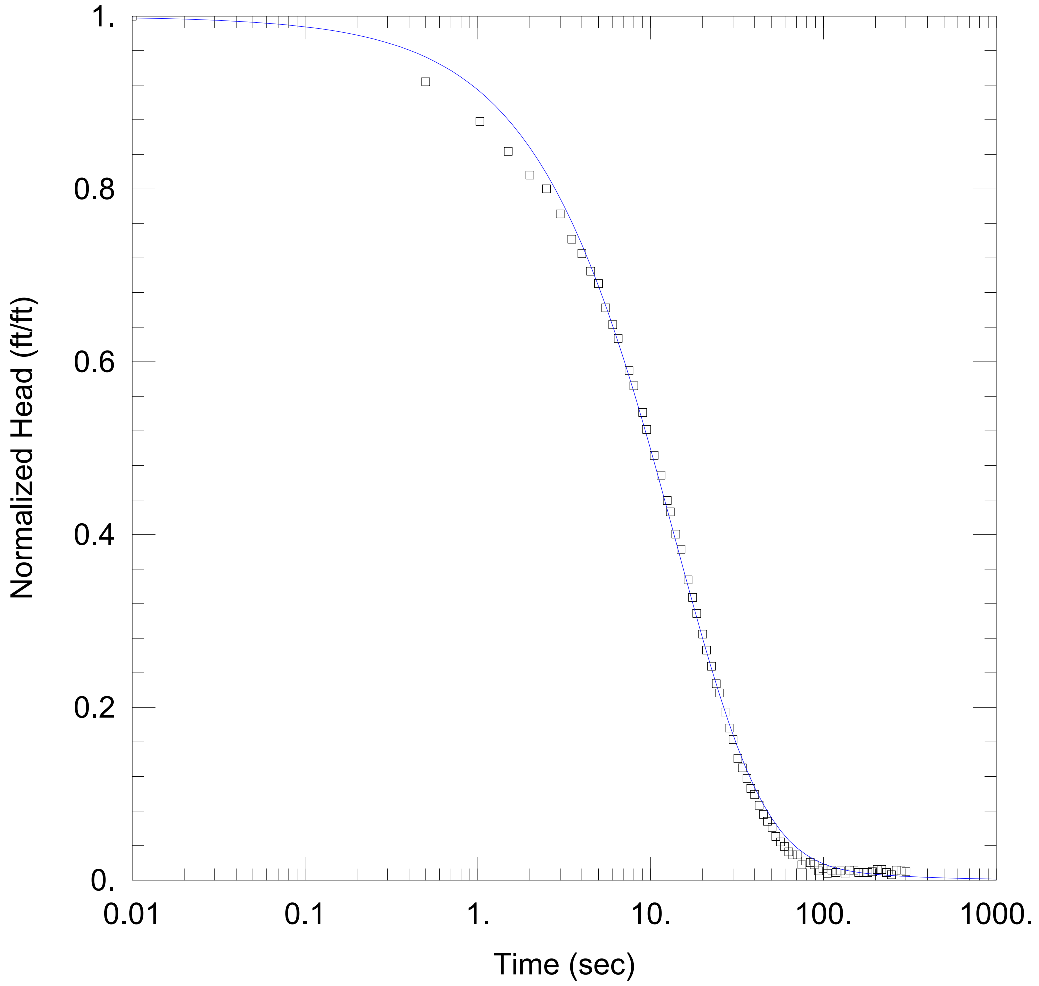
Slug Test Analysis Results for JRW MW-15005 -Test 2

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 8.4 ft/day
Ss = 1.5E-6 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 15.5 ft

WELL DATA (JRW-MW-15005)

Initial Displacement: 1.131 ft
Static Water Column Height: 74.54 ft
Total Well Penetration Depth: 15.5 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

ARCADIS

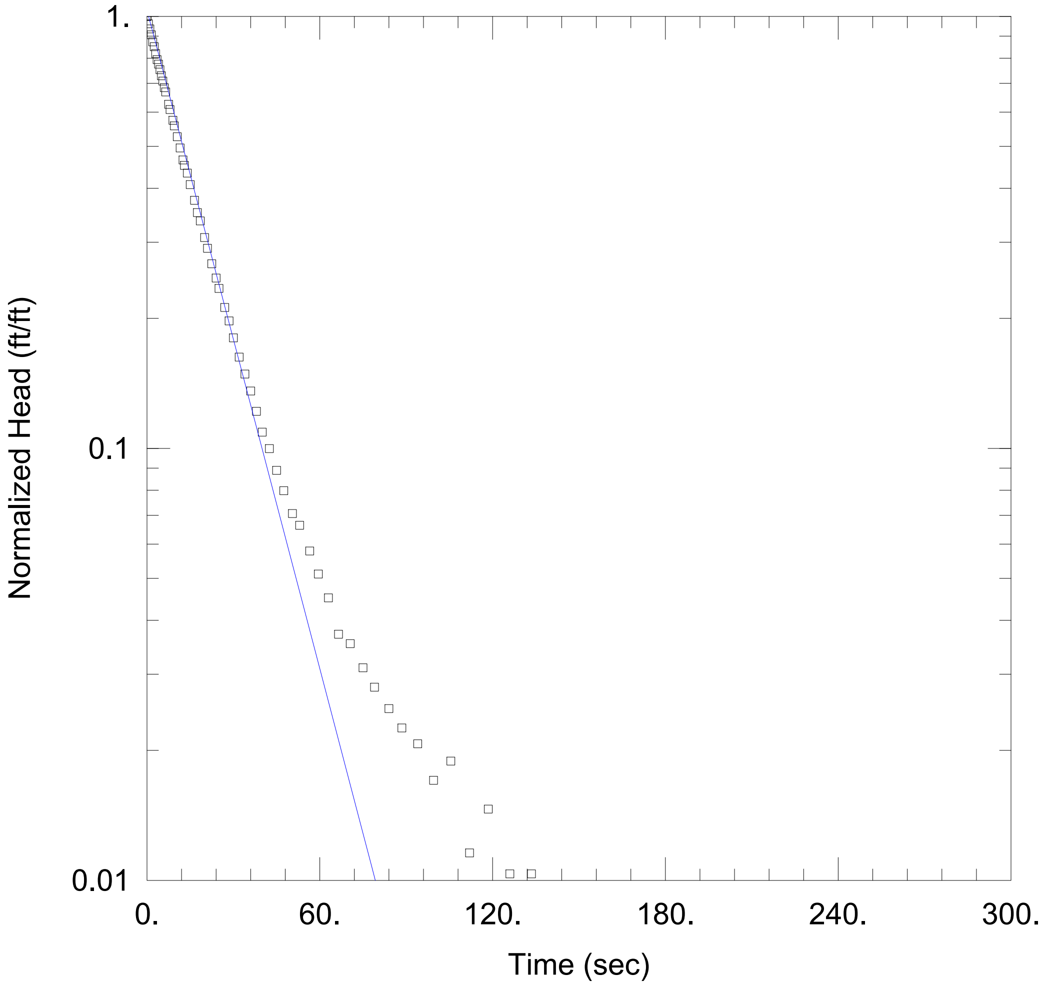
Slug Test Analysis Results for JRW MW-15010 - Test 3

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 20. ft/day

y0 = 1.7 ft

AQUIFER DATA

Saturated Thickness: 8. ft

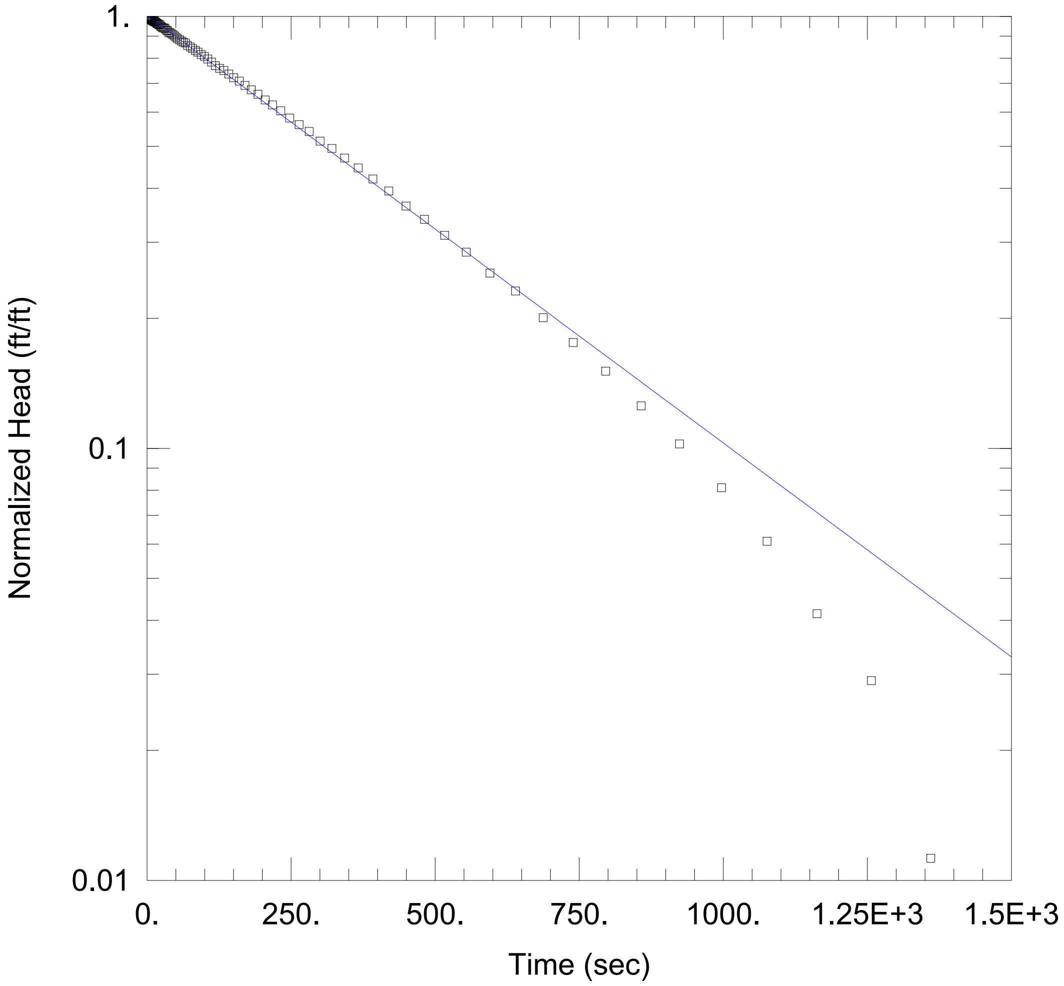
WELL DATA (JRW-MW-15010)

Initial Displacement: 1.642 ft
Static Water Column Height: 28.57 ft
Total Well Penetration Depth: 8. ft
Screen Length: 3. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

ARCADIS

Slug Test Analysis Results for JRW MW-15011 - Test 2

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location:
	Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.5 ft/day
y0 = 1.7 ft

AQUIFER DATA

Saturated Thickness: 7. ft

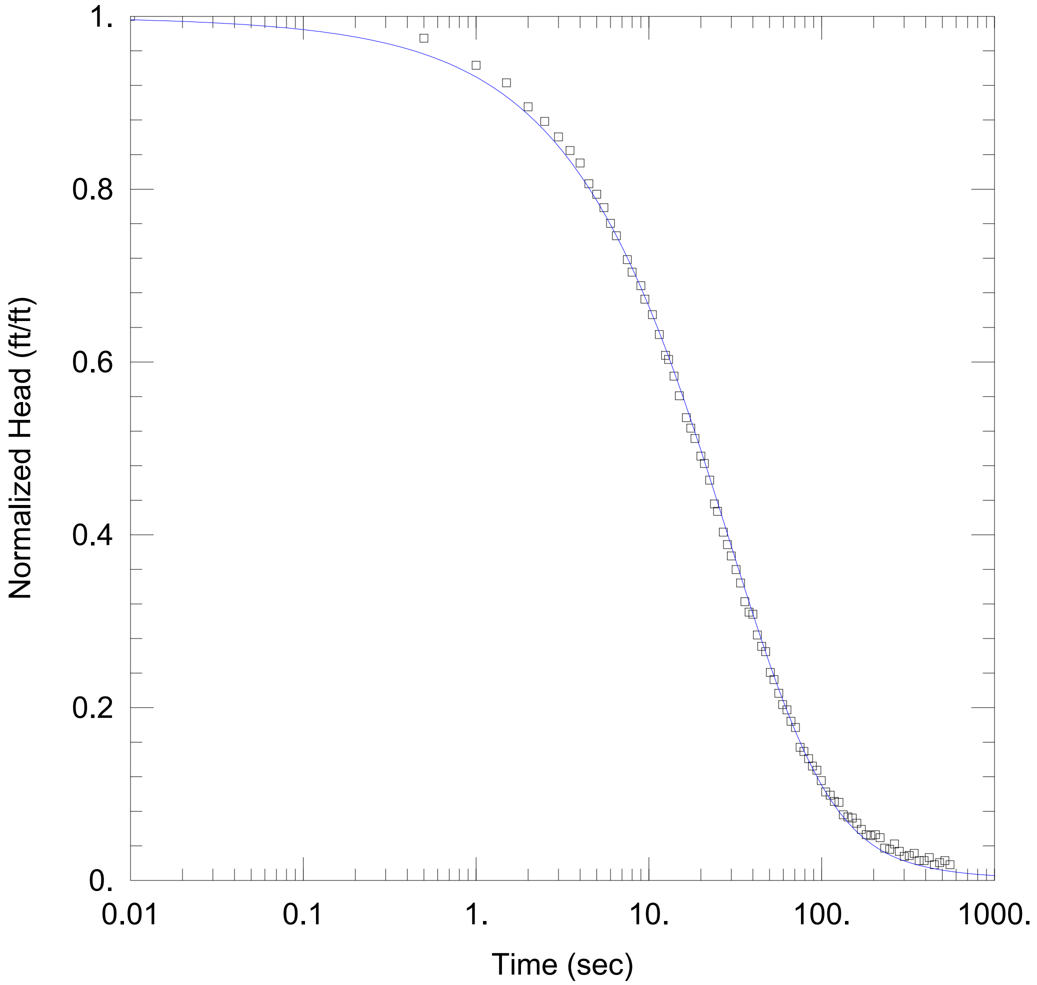
WELL DATA (JRW-MW-15011)

Initial Displacement: 1.69 ft
Static Water Column Height: 56.55 ft
Total Well Penetration Depth: 7. ft
Screen Length: 3. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

ARCADIS

Slug Test Analysis Results for JRW MW-15012 - Test1

Prepared By: **Arcadis**	Prepared For: **Consumer Energy**
Project:	Location: **Erie, MI**



SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 30. ft^2/day   S = 0.00053

AQUIFER DATA

Saturated Thickness: 13.

WELL DATA (JRW-MW-15012)

Initial Displacement: 0.831 ft
Static Water Column Height: 61.1 ft
Total Well Penetration Depth: 12. ft
Screen Length: 2. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

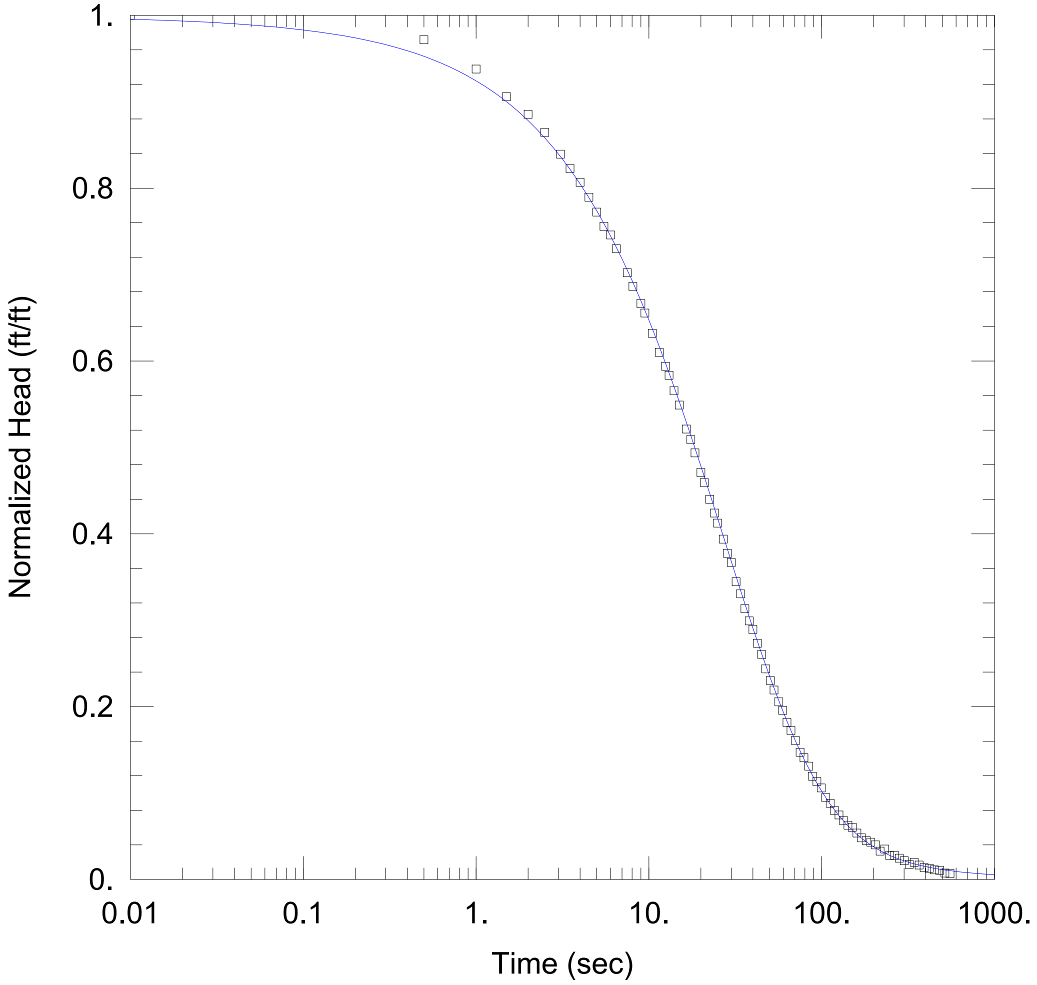
Slug Test Analysis Results for JRW MW-15012 - Test 3

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
Erie, MI



SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos

T = 31. ft^2/day S = 0.00065

AQUIFER DATA

Saturated Thickness: 13.

WELL DATA (JRW-MW-15012)

Initial Displacement: 1.625 ft
Static Water Column Height: 61.1 ft
Total Well Penetration Depth: 12. ft
Screen Length: 2. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi, Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

www.arcadis.com

Consumers Energy
Count on Us®

A CMS Energy Company

Date: April 17, 2019

To: Operating Record

From: Harold D. Register, Jr., P.E.

RE: Groundwater Monitoring System Certification, §257.91(f)
JR Whiting Power Plant, Pond 6

Introduction

According to Title 40 Code of Federal Regulations (40 CFR) Part 257, Subpart D, §257.91(f); the owner or operator of a Coal Combustion Residual (CCR) management unit must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system at the CCR management unit has been designed and constructed to meet the requirements of §257.91. Additionally, §257.91(a) details a performance standard requiring the system monitor the uppermost aquifer and include a minimum of at least one upgradient and three downgradient monitoring wells, and that if the uppermost aquifer monitoring system includes the minimum number of wells, the basis supporting use of only the minimum.

Groundwater Monitoring System

A groundwater monitoring system has been established for the JR Whiting Pond 6, which established the following locations for determining background groundwater quality and detection monitoring. In the case of JR Whiting Pond 6, an intrawell statistical procedure has been selected; therefore, the groundwater monitoring system consists of only the downgradient monitoring wells. The background monitoring wells used to establish background groundwater quality will be maintained and reused to reestablish background conditions as necessary.

Downgradient:

JRW MW-16001
JRW MW-16002
JRW MW-16003
JRW MW-16004
JRW MW-16005
JRW MW-16006

Provided herein, as required by §257.91(f), is certification from a qualified professional engineer that the groundwater monitoring system at Consumers Energy JR Whiting Pond 6 meets the requirements of §257.91.

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.91]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations §257.91 (40 CFR Part 257.91), I attest that this Groundwater Monitoring System has been designed and constructed to meet the requirements of 40 CFR 257.91. The report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.91.

Harold D. Register Jr.

Signature

April 17, 2019

Date of Certification

Harold D. Register, Jr., P.E.

Name

6201056266

Professional Engineer Certification Number

STATE OF MICHIGAN
HAROLD D.
REGISTER, JR.
ENGINEER
No.
6201056266
LICENSED PROFESSIONAL ENGINEER

04/17/2019

ENCLOSURES

TRC (2016). “*2016 Monitoring Well Design, Installation, Development, and Decommissioning*”

2016 Monitoring Well Design, Installation Development, and Decommissioning

JR Whiting Electric Generation Facility
Erie, Michigan

December 2016

2016 Monitoring Well Design, Installation Development, and Decommissioning

JR Whiting Electric Generation Facility
Erie, Michigan

December 2016

Prepared For
Consumers Energy Company

Vincent E. Buening

Vincent E. Buening, CPG
Senior Project Manager

Dad McKenzie

David B. McKenzie, PE
Senior Project Engineer

TRC Engineers Michigan | Consumers Energy
Final
X:\WPAAM\PJT2\262636\0000\R262636-002 FINAL.DOCX

1540 Eisenhower Place, Ann Arbor, MI 48108 ● 734.971.7080 Phone ● 734.971.9022 Fax
www.TRCsolutions.com

Table of Contents

List of Tables

List of Figures

List of Appendices

Section 1

Introduction

TRC Engineers Michigan, Inc. (TRC) has prepared this Monitoring Well Design, Installation, Development, and Decommissioning Report to summarize monitoring well installation and well decommissioning (also often referred to as well abandonment) activities conducted from October 18, 2016 to December 2, 2016 at the J.R. Whiting electric generation facility (JRW), located at 4525 East Erie Road, Erie, Michigan (Site). This effort specifically documents six monitoring well installations overseen by FK Engineering Associates (FKE) around Pond 6 that has been identified as an inactive CCR surface impoundment as defined in 40 CFR Part 257, Subpart D – Standards for the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities and three monitoring well installations to measure background conditions to the disposal areas. Additionally, the abandonment of six existing monitoring wells around Pond 6 was also overseen by FKE. These monitoring wells had been constructed in 1979, 1982, and 1993 with galvanized steel casing and stainless steel well screens and were found to have compromised integrity. The six new wells replace the six abandoned wells in kind.

This Report summarizes the groundwater monitoring well installation and well abandonment activities by FKE, including drilling procedures, well decommissioning procedures, well locations, well construction details, well decommissioning details, well development activities, boring logs, and hydraulic testing results. The methodologies used in the field activities conform to state guidance, and recognized and generally accepted good engineering practices.

Section 2
Objectives

The objectives of this report are to document the work completed by FKE at the Site, including:

- Advancement of soil borings—Section 3.1
- Monitoring well installation—Section 3.2
- Monitoring well development—Section 3.3
- Hydraulic testing—Section 3.4
- Monitoring well abandonment—Section 3.5

Section 3
Field Activities

Well installation and abandonment activities were performed from October 18 to December 2, 2016 by Cascade Drilling, LLC (Cascade) under continuous oversight performed by FK Engineering Associates (FKE) with technical assistance provided by TRC. Field activities were preceded by an on-site project kick-off meeting on October 14, 2016 to discuss the project approach and health & safety protocols.

The well drilling consisted of the installation of nine groundwater monitoring wells designated as JRW MW-16001 through JRW MW-16009 and the proper decommissioning of six existing wells previously designated as JRW MW-15007 through JRW MW-15012. The locations of the new and abandoned wells are shown on **Drawing SG-22374, Sheet 1, Rev. C**.

3.1 Soil/Bedrock Borings

Prior to the start of drilling at each proposed well location, a 5-foot deep hand-augered boring was advanced to verify underground utility clearance by FKE. Then Cascade completed nine (9) soil/bedrock borings using rotosonic-drilling methods to sufficient depth to install monitoring wells in the upper portion of the bedrock aquifer as directed by FKE with technical input from TRC. Rotosonic drilling uses powered equipment to collect subsurface-soil and bedrock samples. The rotosonic drill rig advances a length of pipe into the ground through a combination of hydraulic force and high-frequency vibration. The high-frequency vibrations allow the pipe to advance through various types of soil and bedrock producing a high-quality, continuous soil core within the pipe. Each length of pipe was extracted from the ground and emptied into a clear plastic liner for logging. This process was repeated until the total depth of the boring was reached.

Continuous soil cores were collected during drilling to provide detailed lithological and stratigraphic data. FKE’s on-site engineer inspected each core, classified the contents, and recorded the observations on a boring log field sheet (**Appendix A**). A photographic log showing the typical soil and bedrock types observed at the Site during soil boring advancement is included as **Appendix B**. All soil borings were completed as monitoring wells, and details of the monitoring wells installation are provided in the following section.

3.2 Monitoring Well Installation

Once the total depth of each soil/bedrock boring was reached, Cascade installed a permanent monitoring well as directed by FKE with technical input from TRC in the uppermost usable limestone bedrock aquifer unit for completion of monitoring wells. Monitoring wells were installed through the rotosonic drill rig piping allowing the driller to construct the monitoring well, while simultaneously removing the drill piping. Monitoring wells were constructed with 2-inch inside diameter Schedule 40, polyvinyl chloride (PVC) screens and PVC risers. At each location, the screen tip was positioned at the bottom of the borehole and within the limestone bedrock. Each well screen is 10 feet long except for at monitoring well JRW-MW-16008 which is 5 feet long, and all screens have a slot size of 0.010-inch (10 slot). A medium-grained sand pack was placed around each well screen to a height of at least 4 feet above the top of the well screen, and at least a 3-foot thick bentonite pellet seal was placed on top of the sand pack. The remaining annular space was tremie-grouted with a cement-bentonite grout.

An above-ground, lockable, steel protective cover and a concrete well pad were installed at each monitoring well. In addition, three bollards were installed around the protective covers at each well except at JRW MW-16008, where only two bollards were installed due to limited space. The total well depth and screened interval below the ground surface (bgs) for each monitoring well is shown in Table 1. Well construction logs are included in **Appendix A**; well locations are shown on **Drawing SG-22374, Sheet 1, Rev. C.** Wells were labeled according to Consumers Energy's site-specific nomenclature provided to FKE and TRC. The CE construction manager supplied keyed-alike locks for each well that match the existing well keys.

3.3 Monitoring Well Development

Newly installed monitoring wells were allowed to set for a minimum of 48 hours, after which the wells were developed. Well development was conducted by FKE using air lifting techniques using a tremie pipe to surge and evacuate until the water flowed relatively clear. Following development with the air lifting technique, FKE used a submersible pump and/or air driven pump that was surged across the well screen while groundwater was pumped from the well. During pumping, the evacuated groundwater was monitored for turbidity and pH. Well development continued until the turbidity stabilized under 10 Nephelometric Turbidity Units (NTUs) and pH was stable and below 8.2 pH units at each monitoring well. FKE collected NTU and pH measurements using hand-held monitoring devices. Initially, all the monitoring wells were developed by FKE with a submersible pump that discharged water at a rate of approximately 2 to 2.5 gallons per minute. Wells that had groundwater with a pH reading higher than 8.2 were subsequently further developed by FKE with an air driven pump that was capable of discharging water at 5 to 6 gallons per minute until their pH values stabilized below 8.2 pH units and the turbidly was stabilized to below 10 NTUs.

The volume of groundwater removed during well development, along with the stabilized water level prior to development, and the stabilized turbidity during well development are summarized in Table 1.

3.4 Hydraulic Testing

For single well recovery testing (herein after referred to as “slug testing”) activities, FKE performed four to five slug tests at each of the new monitoring wells. FKE performed each slug test generally by releasing a volume displacement apparatus that induced an immediate water table shift within the well. This resulting water table recovery within the well was monitored using a pressure transducer set to record at 0.25-second intervals, or logarithmic intervals to measure static head, displacement and recovery data. This information was used by FKE to provide an estimate of aquifer hydraulic conductivity (K) in the uppermost portion of the limestone bedrock unit.

The data collected was analyzed by FKE using analytical solutions found in the hydraulic software program AQTESOLV (Version 4.5) using the specific well construction parameters and depth into the limestone unit. The slug test data were evaluated using the confined Hvorslev (1951) and the confined Bouwer and Rice (1976) solutions. The results indicated an estimated hydraulic conductivity range from 3.6 to 11.9 feet per day with an average of 6.9 feet per day. A summary of the results of the hydraulic conductivity tests are presented in Table 2, and full results are included in **Appendix C**.

3.5 Monitoring Well Decommissioning

Existing wells JRW MW-15007 through JRW MW-15012 located around the perimeter of Pond 6 were decommissioned by Cascade under FKE oversight by first removing the steel vaults and concrete barriers around each well, and then over-drilling using a 6-inch diameter roto-sonic casing. Over-drilling to the full depth of the well was accomplished at all wells except JRW MW-15007 and JRW MW-15008. Following over-drilling and well casing extraction, each borehole was tremie grouted with cement-bentonite to grade. Table 3 summarizes the measured well depth and bentonite plug placement (where applicable) prior to over-drilling, the over-drilling depth, and the amount of well casing recovered during the decommissioning of each well.

Tables

Table 1
Monitoring Well Construction and Development Summary
Consumers Energy Co.
J.R. Whiting Generating Facility
Erie, Michigan

MW ID	Former MW ID	Site Coordinates				Date Installed	Geologic Unit of Screen Interval	Well Construction	Well Screen Length (ft)	Screen Interval (ft bgs)	Development Details			
		Northing	Easting	Ground Surface Elevation (ft above msl)	TOC Elevation (ft above msl)						Static DTW (ft below TOC)	Total Depth	Gallons Removed	Final Turbity (NTU)
Ponds 1 & 2 MW														
JRW MW-15001	---	108330.83	13374236.18	589.60	590.71	10/26/2015	Limestone	2" PVC, 10 slot	10	78 - 88	21.34	91.25	1,450	3.92
JRW MW-15002	---	108651.05	13374586.78	590.60	592.31	10/28/2015	Limestone	2" PVC, 10 slot	10	81 - 91	21.89	94.39	750	2.35
JRW MW-15003	---	108321.86	13374980.23	589.60	591.36	10/29/2015	Limestone	2" PVC, 10 slot	10	81 - 91	19.87	94.28	412.5	3.54
JRW MW-15004	---	107881.56	13375045.59	590.80	592.52	10/30/2015	Limestone	2" PVC, 10 slot	10	86 - 96	23.27	99.60	70	2.80
JRW MW-15005	---	107545.15	13374686.90	592.70	594.25	11/2/2015	Limestone	2" PVC, 10 slot	10	86 - 96	25.28	99.48	114	5.04
JRW MW-15006	---	107843.22	13374281.80	590.30	592.01	11/4/2015	Limestone	2" PVC, 10 slot	10	81 - 91	25.30	94.36	650	1.69
Pond 6 MW														
JRW MW-16001	---	111255.91	13374012.08	589.19	592.32	10/25/2016	Limestone	2" PVC, 10 slot	10	71 - 81	17.41	83.92	780	8.40
JRW MW-16002	---	110463.28	13374460.66	585.78	588.68	10/24/2016	Limestone	2" PVC, 10 slot	10	81 - 91	13.80	94.44	480	9.00
JRW MW-16003	---	109687.92	13374452.98	586.19	589.02	10/23/2016	Limestone	2" PVC, 10 slot	10	73 - 83	14.10	85.95	700	8.90
JRW MW-16004	---	108834.64	13374076.00	586.48	589.35	10/23/2016	Limestone	2" PVC, 10 slot	10	75 - 85	14.45	88.76	1,700	9.20
JRW MW-16005	---	110509.27	13373630.27	589.29	592.13	10/25/2016	Limestone	2" PVC, 10 slot	10	78 - 88	17.22	91.32	970	5.60
JRW MW-16006	---	109719.88	13373640.49	588.26	591.03	10/19/2016	Limestone	2" PVC, 10 slot	10	79 - 89	16.11	91.60	1,260	7.70
Background MW														
JRW MW-16007	---	108397.13	13372561.93	579.47	582.32	10/19/2016	Limestone	2" PVC, 10 slot	10	68 - 78	7.58	81.00	650	9.30
JRW MW-16008	---	108021.97	13372562.48	579.95	582.84	10/27/2016	Limestone	2" PVC, 10 slot	5	68 - 73	7.93	76.23	1,900	8.80
JRW MW-16009	---	107653.55	13372573.73	579.90	582.59	10/18/2016	Limestone	2" PVC, 10 slot	10	69 - 79	7.70	81.95	160	8.00
Decommissioned MW														
JRW MW-15007	82-MW-1	109293.21	13373656.23	587.10	588.38	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	84 - 87	Not developed			
JRW MW-15008	82-MW-2	110906.21	13373613.03	588.40	587.88	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	94 - 97	Not developed			
JRW MW-15009	79-MW-3	109884.39	13374455.32	585.30	586.11	NA	NA	NA	NA	NA	Not developed			
JRW MW-15010	93-MW-4	110458.57	13373631.59	587.10	588.09	6/28/1993	Dolomite/Limestone	2" SS with galvanized riser	3	60 - 63	Not developed			
JRW MW-15011	93-MW-5	109790.80	13373648.04	587.50	588.71	6/30/1993	Dolomite/Limestone	2" SS with galvanized riser	3	62 - 65	Not developed			
JRW MW-15012	93-MW-6	110169.45	13374463.62	585.80	587.19	7/1/1993	Dolomite/Limestone	2" SS with galvanized riser	3	66 - 69	Not developed			

Notes:
ft = feet
bgs = below ground surface
TOC = top of casing NR = Not recorded NA = Not applicable msl = mean sea level

Table 2
Estimated Monitoring Well Hydraulic Conductivities

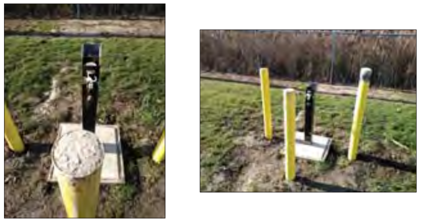
MONITORING WELL NO.	AVERAGE HYDRAULIC CONDUCTIVITY FROM ANALYTICAL SOLUTIONS (FT/D)
JRW MW-16001	4.74
JRW MW-16002	3.56
JRW MW-16003	6.09
JRW MW-16004	4.50
JRW MW-16005	9.95
JRW MW-16006	9.41
JRW MW-16007	3.51
JRW MW-16008	11.85
JRW MW-16009	8.63
Average Pond 6 Wells	6.375
Average Background Wells	8.00
Average All Wells	6.92

FT/D = Feet per day.

Table 3
Monitoring Well Abandonment Information

MONITORING WELL NO.	MEASURED WELL DEPTH (FT)	BENTONITE PLUG DEPTH WITHIN WELL (FT) (BEFORE OVER-DRILLING)	OVER-DRILLED DEPTH (FT)	WELL CASING REMOVED (FT)
JRW MW-15007	99.5	99.5 to 93.7	73	11
JRW MW-15008	110.3	110.3 to 55	53	9
JRW MW-15009	71.5	71.5 to 66	72	49
JRW MW-15010	44.0	44 to 37	46	28
JRW MW-15011	73.3	73.3 to 63	74	44
JRW MW-15012	73.5	None	74	52

Figures

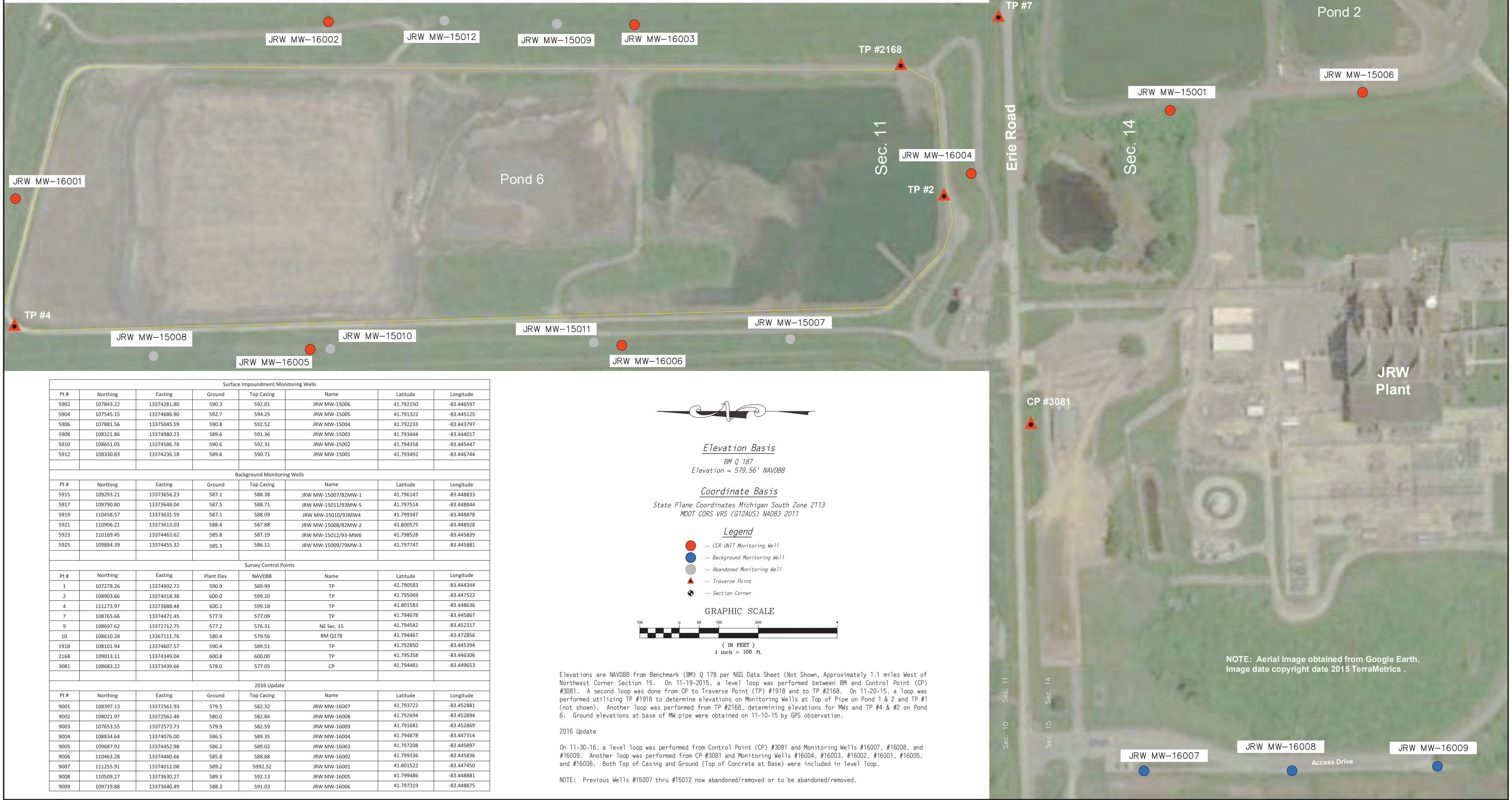


2016 Update Typical Mon. Well

Pictures

2015 Typical Surface Impoundment Monitoring Well

Pictures



NOTE: Aerial Image obtained from Google Earth.
Image date copyright date 2015 TerraMetrics .

Surface Impoundment Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5902	107843.22	13374281.80	590.3	592.01	JRW MW-15006	41.792150	-83.446597
5904	107545.15	13374686.90	592.7	594.25	JRW MW-15005	41.791322	-83.445125
5906	107881.56	13375045.59	590.8	592.52	JRW MW-15004	41.792233	-83.443797
5908	108321.86	13374980.23	589.6	591.36	JRW MW-15003	41.793444	-83.444017
5910	108651.05	13374586.78	590.6	592.31	JRW MW-15002	41.794358	-83.445447
5912	108330.83	13374236.18	589.6	590.71	JRW MW-15001	41.793492	-83.446744

Background Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5915	109293.21	13373656.23	587.1	588.38	JRW MW-15007/82MW-1	41.796147	-83.448833
5917	109790.80	13373648.04	587.5	588.71	JRW MW-15011/93MW-5	41.797514	-83.448844
5919	110458.57	13373631.59	587.1	588.09	JRW MW-15010/93MW4	41.799347	-83.448878
5921	110906.21	13373613.03	588.4	587.88	JRW MW-15008/82MW-2	41.800575	-83.448928
5923	110169.45	13374463.62	585.8	587.19	JRW MW-15012/93-MW6	41.798528	-83.445839
5925	109884.39	13374455.32	585.3	586.11	JRW MW-15009/79MW-3	41.797747	-83.445881

Survey Control Points

Pt #	Northing	Easting	Plant Elev	NAVD88	Name	Latitude	Longitude
1	107278.26	13374902.72	590.9	589.99	TP	41.790583	-83.444344
2	108903.66	13374018.38	600.0	599.20	TP	41.795069	-83.447522
4	111273.97	13373688.48	600.1	599.18	TP	41.801583	-83.448636
7	108765.66	13374471.45	577.9	577.09	TP	41.794678	-83.445867
9	108697.62	13372712.75	577.2	576.31	NE Sec. 15	41.794542	-83.452317
10	108610.28	13367111.76	580.4	579.56	BM Q178	41.794467	-83.472856
1918	108101.94	13374607.57	590.4	589.51	TP	41.792850	-83.445394
2168	109013.11	13374349.04	600.8	600.00	TP	41.795358	-83.446306
3081	108683.22	13373439.66	578.0	577.05	CP	41.794481	-83.449653

2016 Update

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
9001	108397.13	13372561.93	579.5	582.32	JRW MW-16007	41.793722	-83.452881
9002	108021.97	13372562.48	580.0	582.84	JRW MW-16008	41.792694	-83.452894
9003	107653.55	13372573.73	579.9	582.59	JRW MW-16009	41.791681	-83.452869
9004	108834.64	13374076.00	586.5	589.35	JRW MW-16004	41.794878	-83.447314
9005	109687.92	13374452.98	586.2	589.02	JRW MW-16003	41.797208	-83.445897
9006	110463.28	13374460.66	585.8	588.68	JRW MW-16002	41.799336	-83.445836
9007	111255.91	13374012.08	589.2	5992.32	JRW MW-16001	41.801522	-83.447450
9008	110509.27	13373630.27	589.3	592.13	JRW MW-16005	41.799486	-83.448881
9009	109719.88	13373640.49	588.3	591.03	JRW MW-16006	41.797319	-83.448875

Elevation Basis

BM Q 187
Elevation = 579.56' NAVD88

Coordinate Basis

State Plane Coordinates Michigan South Zone 2113
MDOT CORS VRS (G12AUS) NAD83 2011

Legend

- 🔴 -- *CCR UNIT Monitoring Well*
- 🔵 -- *Background Monitoring Well*
- ⚪ -- *Abandoned Monitoring Well*
- ▲ -- *Traverse Point*
- ◈ -- *Section Corner*

GRAPHIC SCALE

100 0 50 100 200 4

(IN FEET)
1 inch = 100 ft.

Elevations are NAVD88 from Benchmark (BM) Q 178 per NGS Data Sheet (Not Shown, Approximately 1.1 miles West of Northeast Corner Section 15. On 11-19-2015, a level loop was performed between BM and Control Point (CP) #3081. A second loop was done from CP to Traverse Point (TP) #1918 and to TP #2168. On 11-20-15, a loop was performed utilizing TP #1918 to determine elevations on Monitoring Wells at Top of Pipe on Pond 1 & 2 and TP #1 (not shown). Another loop was performed from TP #2168, determining elevations for MWs and TP #4 & #2 on Pond 6. Ground elevations at base of MW pipe were obtained on 11-10-15 by GPS observation.

2016 Update

On 11-30-16, a level loop was performed from Control Point (CP) #3081 and Monitoring Wells #16007, #16008, and #16009. Another loop was performed from CP #3081 and Monitoring Wells #16004, #16003, #16002, #16001, #16005, and #16006. Both Top of Casing and Ground (Top of Concrete at Base) were included in level loop.

NOTE: Previous Wells #15007 thru #15012 now abandoned/removed or to be abandoned/removed.

DRAWING NO.	REFERENCE DRAWINGS
SF-19884	Sheet 34, Pond 1 & 2
SF-19884	Sheet 35, Pond 6
	FIELD BOOK NO. 1997A

REV.	DATE	DESCRIPTION	BY	APP.
C	12/9 '16	Abandoned Wells, Historic Well ID, Pictures	RST	
B	12/1 '16	New Mon. Wells JRW MW #16001 thru #16009	RST	
A	12/7 '15	Changes per email request	RST	

		DATE
DN.	RST	11-24-15
FLD.	DEE	11-10-15
CHKD.		
APP.		
APP.	DEPARTMENT HEAD	

Consumers Energy

SSC SHERIDAN SURVEYING CO.
910 Fifth Street Michigan Center, MI 49254

Whiting Plant Monitoring Wells
CCR Monitoring

Sec. 11 & 14
City of Luna Pier

SAP WO #25477976

T8S, R8E
Monroe County

SCALE: 1" = 100'
CE FILENAME: 22374base.dwg
SSC FILENAME: 3708_SPCadj.dwg

Drawing No.	Sheet	Rev.
SG-22374	1	C

Appendix A
Soil Boring and Monitoring Well Construction Logs

FK ENGINEERING

SOIL AND ROCK CLASSIFICATION SYSTEM

SUMMARY OF SOIL NOMENCLATURE

Soils are to be classified by the fraction which has the greatest impact on the engineering behavior. Soils will be described according to a strength or density followed by color then by primary and secondary/tertiary components (i.e. soft gray silty clay or loose brown silty sand). United Soil Classification System (USCS) descriptors (ASTM D2487) may also be used. Soils which exhibit unconfined shear strength will in most cases be described as cohesive soils regardless of their clay content whereas soils without unconfined strength will be described as cohesionless soils.

COHESIVE SOIL

Strength	Unconfined Compressive Strength (psf) (Primary)	Pocket Penetrometer Test (tsf) (Primary)	SPT Value (N) (Secondary)
Very Soft	0-500	0-0.25	0-2
Soft	500-1000	0.25-0.5	3-4
Medium	1000-2000	0. 5-1.0	5-8
Stiff	2000-4000	1.0-2.0	9-15
Very Stiff	4000-8000	2.0-4.0	16-30
Hard	8000-16000	4.0-8.0	31-50
Very Hard	>16000	>8.0	>50

COHESIONLESS SOIL

Density	SPT Value (N)
Very Loose	<4
Loose	4-10
Medium Compact	11-30
Compact	31-50
Very Compact	>50

MATERIAL SIZES AND IDENTIFIER GUIDE

Gravel	3/16 inches (No. 4 Sieve) to 3 inches	Generally rounded rock particles
Coarse Sand	3/16 inches to 2 mm (No. 10 Sieve)	Grains easily seen
Medium Sand	2 mm to 0.425 mm (No. 40 Sieve)	Grains can be seen and felt
Fine Sand	0.425 mm to 0.075 mm (No. 200 Sieve)	Grains can be felt
Silt	0.075 mm to 0.005 mm	Easily cracks when rolled. Gritty feel. Dilatant.
Clay	<0.005 mm	Can be rolled. No particle size visible.

SECONDARY/TERTIARY SOIL COMPONENTS

Use secondary components when other than the primary soil appears in significant percentages. Generally the secondary component will compromise between 12 and 30 percent of the total soil weight. Tertiary components would be described as “little” and “trace” when the tertiary components are between 5 and 12 percent and less than 5 percent, respectively. The tertiary components would be inserted after the secondary and primary description (i.e. soft gray silty clay with little gravel and trace sand).

SAMPLE CODES

S	Split Spoon Sample	AU	Auger Sample
LS	Split Spoon Sample with Liner	ST	Shelby Tube Sample
BS	Bag Sample	P	Piston Tube Sample

This system is based on the USCS and MDOT’s Uniform Field Soil Classification System

SUMMARY OF ROCK NOMENCLATURE

The rock classification system is generally based on FHWA-NHI-01-031 and noted references therein.

ROCK TYPE

Should be classified according to origin into one of the three major groups: igneous, sedimentary, and metamorphic (i.e. Limestone, Shale, etc.)

COLOR

Use basic colors (i.e. brown, gray, etc.) and combinations of colors if applicable (i.e. brown-gray) and the color's intensity (light, medium, dark).

GRAIN SIZE/SHAPE

Grain size terminology should be based on the following:

Very Coarse (VCO)	Grain sizes greater than popcorn kernels, >1/4 in.
Coarse (CO)	Individual grains can be easily seen by naked eye, 1/4 - 1/8 in.
Medium (MD)	Individual grains can be seen by naked eye, up to 1/8 in.
Fine (FN)	Individual grains can be barely seen by naked eye
Amorphous (AM)	Individual grains cannot be seen by naked eye

In addition, the shape of the grains should be used when applicable (i.e. rounded, sharp, etc.).

STRATIFICATION/BEDDING

Stratification features should be described according to the following:

Very Thick (VTH)	>3 feet or not visible
Thick (TH)	1-3 feet
Medium (M)	2 - 12 in.
Thin (TN)	1/2 - 2 in.
Very Thin (VTN)	1/4 - 1/2 in.
Laminated (LAM)	>1/4 in.

In addition if layers are angled make note with respect to the horizontal.

WEATHERING/ALTERATION

Weathering is physical disintegration due to atmospheric processes; while alteration is due to geothermal processes. Terms and abbreviations should be used according to the following:

Fresh (FR)	No discoloration or any other effect of weathering/alteration.
Slight (SL)	Slightly discolored with little to no effect on strength.
Moderate (MOD)	Discolored and is in a weakened state but less than half is decomposed. Large sample cannot be broken by hand.
High (HI)	More than half is decomposed. Large sample can be broken by hand.
Complete (CPL)	Almost completely decomposed with some original fabric intact.
Residual Soil (RS)	Completely decomposed with no original rock fabric left. Can be easily broken by hand.

DISCONTINUITIES

Rock discontinuities are breaks or fractures separating the rock and should be classified according to the following:

Type

Crack (C)	An incomplete fracture
Joint (J)	A fracture with little to no visible displacement
Shear (S)	A fracture with visible displacement that may have slickness or is polished
Fault (F)	A major fracture with major displacement with possible clayey gouge

Spacing

Very Wide (VW)	3 - 1 feet
Wide (W)	1 - 0.5 feet
Open (O)	6-4 in.
Tight (TG)	4-2 in.
Very Tight (VTG)	< 2 in.

Orientation

Horizontal (H)	0 - 5 degrees
Low Angle (LA)	5 - 30 degrees
Moderate Angle (MA)	30 - 60 degrees
Steep Angle (SA)	60 - 85 degrees
Vertical (V)	85 - 90 degrees

Surface Texture

Slickened (SLK)	Surface has smooth, glassy finish with visual evidence of striations
Smooth (SM)	Surface appears smooth and feels so to the touch
Slightly Rough (SR)	Asperities on the discontinuity surface are distinguishable and can be felt
Rough (R)	Some ridges and side-angle steps are evident: asperities are clearly visible and discontinuity surface feels very abrasive
Very Rough (VR)	Near vertical steps and ridges occur on the discontinuity surface

Infilling	**Type of Infilling**
Surface Stain (Su)	Clay (Cl)
Spotty (Sp)	Calcite (Ca)
Partially Filled (Pa)	Chlorite (Ch)
Filled (Fi)	Iron Oxide (Fe)
None (No)	Gypsum/Talc (Gy)
	Healed (H)
	None (No)
	Pyrite (Py)
	Quartz (Qz)
	Sand (Sd)

HARDNESS

Should be assessed by a scratch test with terms and abbreviations according to the following:

Soft (SO)	Reserved for plastic material only
Friable (FRI)	Easily crumbled by hand and is too soft to be cut with a pocket knife.
Low Hardness (LH)	Can be gouged deeply or carved with a pocket knife.
Moderately Hard (MH)	Can be readily scratched by a knife blade. Scratch leaves a heavy trace of dust and scratch is readily visible after powder is blown away.
Hard (HD)	Can be scratched with difficulty. Scratch produces little powder and is often faintly visible. Traces of the knife steel may be visible.
Very Hard (VHD)	Cannot be scratched with a pocket knife.

DEFECTS

The following descriptions can be described as few, occasional, or frequent:

Fossil (FOS)	Preserved remain or trace of animals, plants, and other organisms from the distant past
Pit	<3/16 inch
Vug	>3/16 inch and <2 inches
Cavity (Cav)	>2 inches
Carbonaceous Band (CB)	Black carbon styolitic deposit than can be straight or wavy
Solution Feature (SF)	Features formed by water and acids dissolving calcium carbonate sedimentary rock

The following descriptions can be described as light, moderate, or dense:

Hydrocarbon Staining (HCS)	Staining due to petroleum products being released from the rock

ROCK RECOVERY

Rock recovery is defined as:

$$Recovery\ (\%) = 100\ \times \frac{Length\ of\ Core\ Recovered}{Length\ of\ Core\ Run}$$

ROCK QUALITY DESIGINATION (RQD)

RQD is defined as:

$$RQD\ (\%) = 100\ \times \frac{Length\ of\ Core\ Recovered > 4\ inches}{Length\ of\ Core\ Run}$$

Monitoring Well JRW MW-16001

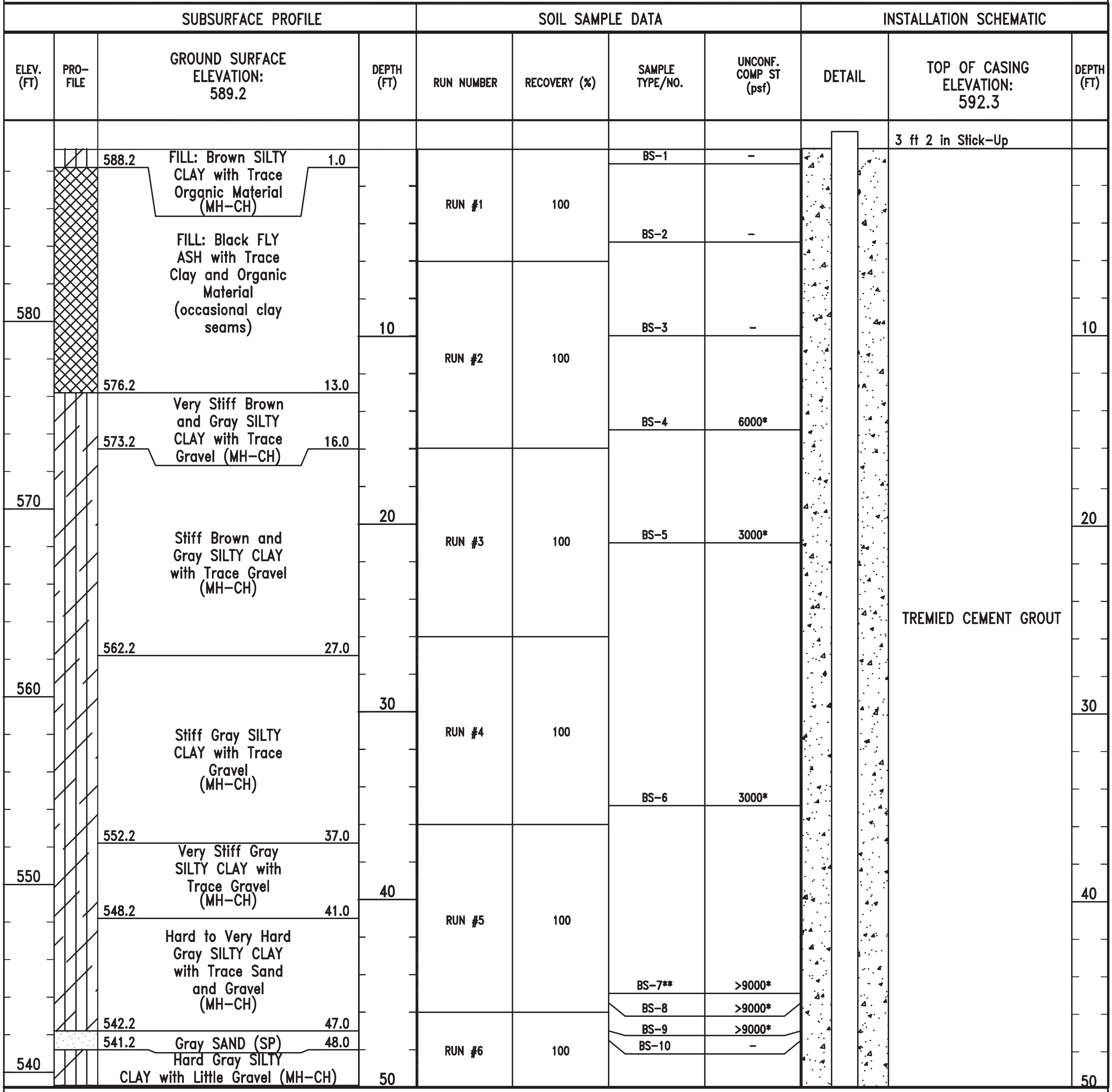
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



GROUND SURFACE ELEVATION: 589.2

Elevation	Description	Depth
588.2	FILL: Brown SILTY CLAY with Trace Organic Material (MH-CH)	1.0
	FILL: Black FLY ASH with Trace Clay and Organic Material (occasional clay seams)	
576.2	Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	13.0
573.2	Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	16.0
562.2	Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	27.0
552.2	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	37.0
548.2	Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)	41.0
542.2		47.0
541.2	Gray SAND (SP)	48.0
	Hard Gray SILTY CLAY with Little Gravel (MH-CH)	

RUN NUMBER	RECOVERY (%)
RUN #1	100
RUN #2	100
RUN #3	100
RUN #4	100
RUN #5	100
RUN #6	100

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-1	-
BS-2	-
BS-3	-
BS-4	6000*
BS-5	3000*
BS-6	3000*
BS-7**	>9000*
BS-8	>9000*
BS-9	>9000*
BS-10	-

TOP OF CASING ELEVATION: 592.3

Total Depth:	*81.0 ft*
Drilling Date:	*10/25/2016*
Inspector:	*N. Bassett, P.E.*
Contractor:	*Cascade Drilling*
Driller:	*I. Young*
Equipment:	*600T Truck-Mount*
Casing Diameter:	*2 in*
Casing Length:	*71 ft*
Casing Type:	*PVC (SCH 40)*
Screen Diameter:	*2 in*
Screen Length:	*10 ft*
Screen Mesh:	*2 in*
Screen Type:	*0.01 in Slotted PVC*
Protective Casing:	3 ft 2 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-111255.91 Easting-13374012.08

FIGURE NO. 3

NO: JRW MW-16001

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE

ELEV. (FT)	GROUND SURFACE ELEVATION: 589.2	DEPTH (FT)
538.2		51.0
537.7	SILTY SAND Seam (SM)	51.5
	Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (brittle, breaks into small fragments) (MH-CH)	
523.2		66.0
522.7	GRAVEL/BOULDERS (not all reactive with HCL)	66.5
521.2	Very Hard SANDY CLAY/ CLAYEY SAND (CH-SC)	68.0
516.2	Possible Highly Weathered LIMESTONE (washwater turned white, no recovery in this area)	73.0
	LIMESTONE with Occasional Dark Gray Clay Infilling (Reacted to HCL)	
508.2		81.0

Elevation scale (FT): 530, 520, 510, 500, 490, 480

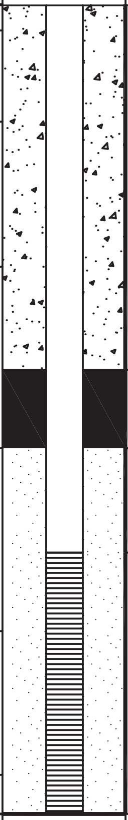
Depth scale (FT): 60, 70, 80

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #6	100
RUN #7	100
RUN #8	50
RUN #9	67

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-11	>9000*
BS-12	>9000*
BS-13	>9000*
BS-14	-
BS-15	-
BS-16	-

INSTALLATION SCHEMATIC



TOP OF CASING ELEVATION: 592.3	DEPTH (FT)
TREMIED CEMENT GROUT	
64.0	
BENTONITE PELLETS	
67.0	
FILTER SAND	
71.0	
81.0	
END OF BORING	

Depth scale (FT): 60, 70, 80

Monitoring Well JRW MW-16002

Project Name: J.R. Whiting Observation Wells
Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates
Project No: 16-085
Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 585.8

ELEV. (FT)	DESCRIPTION	DEPTH (FT)
584.3	FILL: Brown SILTY CLAY with Trace Organic Material (MH-CH)	1.5
568.3	FILL: Black FLY ASH with Clay Seams	17.5
558.8	Medium to Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	27.0
553.8	Stiff to Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	32.0
547.8	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	38.0
542.8	Hard to Very Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	43.0
539.8	APPARENT BOULDER	46.0

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #1	100
RUN #2	100
RUN #3	67
RUN #4	100
RUN #5	100
RUN #6	0
RUN #7	100

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-1	-
BS-2	-
BS-3	-
BS-4	2000*
BS-5**	6000*
BS-6	6000*
BS-7	>9000*
BS-8	-
BS-8A	-

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 588.7

2 ft 11 in Stick-Up

TREMIED CEMENT GROUT

Total Depth:	*91.0 ft*
Drilling Date:	*10/24/2016*
Inspector:	*N. Bassett, P.E.*
Contractor:	*Cascade Drilling*
Driller:	*I. Young*
Equipment:	*600T Truck-Mount*
Casing Diameter:	*2 in*
Casing Length:	*81 ft*
Casing Type:	*PVC (SCH 40)*
Screen Diameter:	*2 in*
Screen Length:	*10 ft*
Screen Mesh:	*2 in*
Screen Type:	*0.01 in Slotted PVC*
Protective Casing:	2 ft 11 in Stick-Up

Notes:
1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-110463.28 Easting-13374460.66

FIGURE NO. 4

NO: JRW MW-16002

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

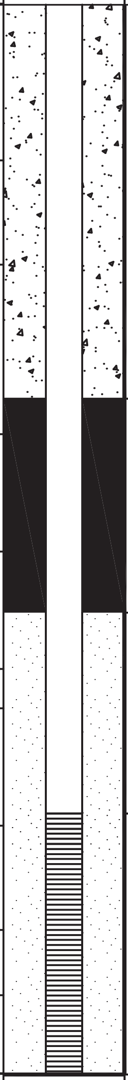
SUBSURFACE PROFILE

ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 585.8	DEPTH (FT)
530		Hard to Very Hard Gray SILTY CLAY with Little Gravel and Trace Sand (gravel content decreases with depth) (MH-CH)	60
520		519.8 66.0	
		ROCK FRAGMENTS 517.8 68.0	70
		Hard Light Gray SILTY CLAY with Trace Gravel (MH-CH) 511.8 74.0	
510		CLAY With LIMESTONE FRAGMENTS 509.8 76.0	
		LIMESTONE (reacted to HCL) 504.8 81.0	80
		CLAY Seam (MH-CH) 503.8 82.0	
500		LIMESTONE (reacted to HCL) 494.8 91.0	90
490			
480			

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #7	100	BS-9	>9000*
RUN #8	100	BS-10	>9000*
		BS-11	-
RUN #9	67	BS-12	-
		BS-13	-
		BS-14	-
RUN #10	100	BS-15	-
		BS-16	-
RUN #11	100	BS-17	-

INSTALLATION SCHEMATIC



DETAIL	TOP OF CASING ELEVATION: 588.7	DEPTH (FT)
	TREMIED CEMENT GROUT	60
	65.1	
	BENTONITE PELLETS	70
	73.3	
	FILTER SAND	
	81.0	80
	91.0	90
	END OF BORING	

Monitoring Well JRW MW-16003

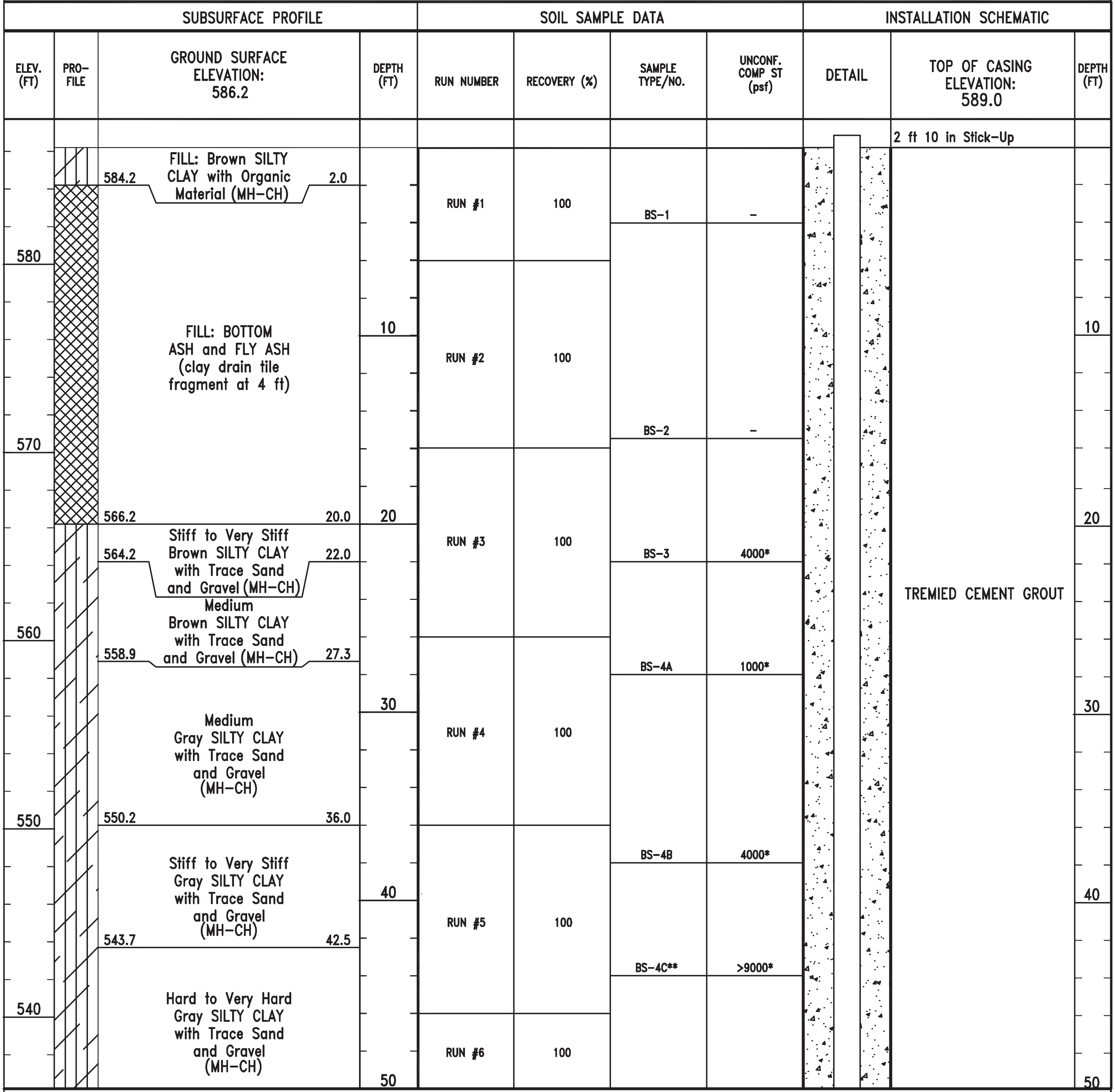
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 586.2

ELEV. (FT)	GROUND SURFACE ELEVATION: 586.2	DEPTH (FT)
584.2	FILL: Brown SILTY CLAY with Organic Material (MH-CH)	2.0
566.2	FILL: BOTTOM ASH and FLY ASH (clay drain tile fragment at 4 ft)	20.0
564.2	Stiff to Very Stiff Brown SILTY CLAY with Trace Sand and Gravel (MH-CH)	22.0
558.9	Medium Brown SILTY CLAY with Trace Sand and Gravel (MH-CH)	27.3
550.2	Medium Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)	36.0
543.7	Stiff to Very Stiff Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)	42.5
	Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)	

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #1	100	BS-1	-
RUN #2	100	BS-2	-
RUN #3	100	BS-3	4000*
RUN #4	100	BS-4A	1000*
RUN #5	100	BS-4B BS-4C**	4000* >9000*
RUN #6	100		

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 589.0

2 ft 10 in Stick-Up

TREMIED CEMENT GROUT

Total Depth: *85.0 ft*
Drilling Date: *10/23/2016*
Inspector: *J. Elsey*
Contractor: *Cascade Drilling*
Driller: *I. Young*
Equipment: *600T Truck-Mount*

Casing Diameter: *2 in*
Casing Length: *73 ft*
Casing Type: *PVC (SCH 40)*

Screen Diameter: *2 in*
Screen Length: *10 ft*
Screen Mesh: *2 in*
Screen Type: *0.01 in Slotted PVC*

Protective Casing: 2 ft 10 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-109687.92 Easting-13374452.98

FIGURE NO. 5

NO: JRW MW-16003

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 586.2

ELEV. (FT)	DESCRIPTION	DEPTH (FT)
533.7 532.9	Very Stiff Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)	52.5 53.3
522.2	Hard to Very Hard Gray SILTY CLAY with Trace Sand, Gravel (possible cobbles/boulders) (MH-CH)	64.0
520.2	Hard to Very Hard SANDY CLAY with Little Gravel (CH-SC)	66.0
516.2	Hard to Very Hard Gray SILTY CLAY with Little Gravel and (possible cobbles/boulders) (MH-CH)	70.0
503.2	LIMESTONE (sand seam at 82 ft) (odoriferous & reacted with HCL)	83.0

ELEV. (FT): 530, 520, 510, 500, 490, 480

DEPTH (FT): 60, 70, 80

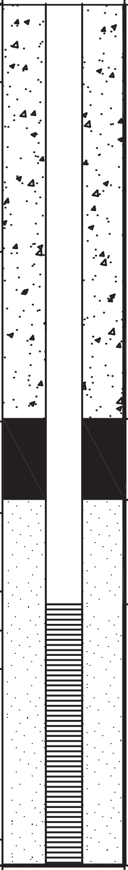
SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #6	100
RUN #7	100
RUN #8	100
RUN #9	40

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-5	7000*
BS-6A	>9000*
BS-6B	>9000*
BS-7	>9000*
BS-8	-
BS-9	-
BS-10	-
BS-11	-

INSTALLATION SCHEMATIC

DETAIL



TOP OF CASING ELEVATION: 589.0

DEPTH (FT)	
	TREMIED CEMENT GROUT
65.9	BENTONITE PELLETS
69.0	FILTER SAND
73.0	
83.0	END OF BORING

DEPTH (FT): 60, 70, 80

Monitoring Well JRW MW-16004

Project Name: J.R. Whiting Observation Wells

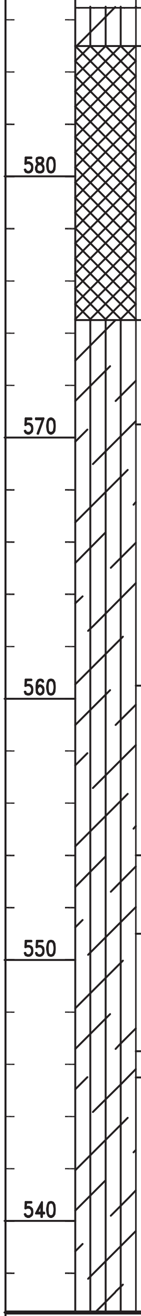
Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE



ELEV. (FT)	GROUND SURFACE ELEVATION: 586.5	DEPTH (FT)
585.0	FILL: Black SILTY CLAY with Organic Material (MH-CH)	1.5
574.5	FILL: Black FLY ASH	12.0
570.5	Very Stiff Brown SILTY CLAY with Tracce Sand and Gravel (MH-CH)	16.0
560.5	Stiff Brown SILTY CLAY with Trace Sand and Gravel (MH-CH)	26.0
554.0	Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	32.5
551.0	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	35.5
546.5	Hard to Very Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	40.0
545.5	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	41.0
	Hard to Very Hard Gray SILTY CLAY with Trace Gravel (possible cobbles/boulders below 54 ft) (MH-CH)	

DEPTH (FT): 10, 20, 30, 40, 50

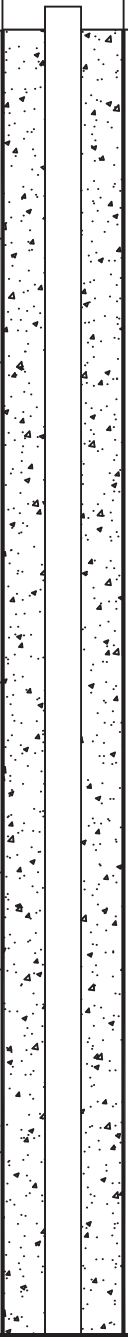
SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #1	100
RUN #2	100
RUN #3	100
RUN #4	100
RUN #5	100
RUN #6	100

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-1	-
BS-2	6000*
BS-3	3000*
BS-4**	3000*
BS-5	>9000*
BS-6	>9000*

INSTALLATION SCHEMATIC

DETAIL



TOP OF CASING ELEVATION: 589.4

2 ft 10 in Stick-Up

TREMIED CEMENT GROUT

DEPTH (FT): 10, 20, 30, 40, 50

Total Depth: *85.0 ft*
Drilling Date: *10/23/2016*
Inspector: *J. Elsey*
Contractor: *Cascade Drilling*
Driller: *I. Young*
Equipment: *600T Truck-Mount*

Casing Diameter: *2 in*
Casing Length: *75 ft*
Casing Type: *PVC (SCH 40)*

Screen Diameter: *2 in*
Screen Length: *10 ft*
Screen Mesh: *2 in*
Screen Type: *0.01 in Slotted PVC*

Protective Casing: 2 ft 10 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-108834.64 Easting-13374076.00

FIGURE NO. 6

NO: JRW MW-16004

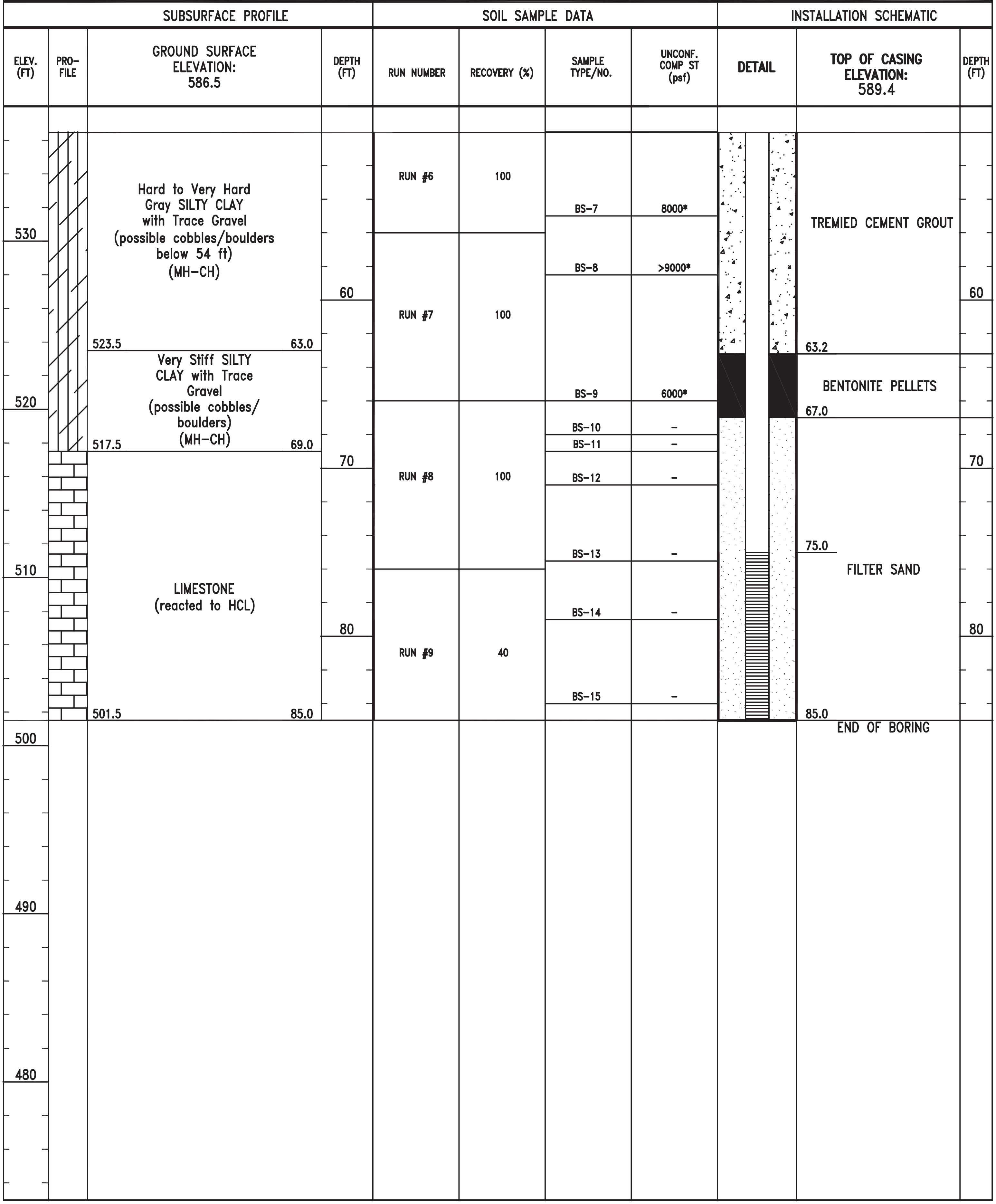
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



SUBSURFACE PROFILE

ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 586.5	DEPTH (FT)
		Hard to Very Hard Gray SILTY CLAY with Trace Gravel (possible cobbles/boulders below 54 ft) (MH-CH)	
523.5			63.0
		Very Stiff SILTY CLAY with Trace Gravel (possible cobbles/ boulders) (MH-CH)	
517.5			69.0
		LIMESTONE (reacted to HCL)	
501.5			85.0

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #6	100	BS-7	8000*
RUN #7	100	BS-8	>9000*
		BS-9	6000*
RUN #8	100	BS-10	–
		BS-11	–
		BS-12	–
		BS-13	–
RUN #9	40	BS-14	–
		BS-15	–

INSTALLATION SCHEMATIC

DETAIL	TOP OF CASING ELEVATION: 589.4	DEPTH (FT)
	TREMIED CEMENT GROUT	
	63.2	
	BENTONITE PELLETS	
	67.0	
	75.0	
	FILTER SAND	
	85.0	
	END OF BORING	

Monitoring Well JRW MW-16005

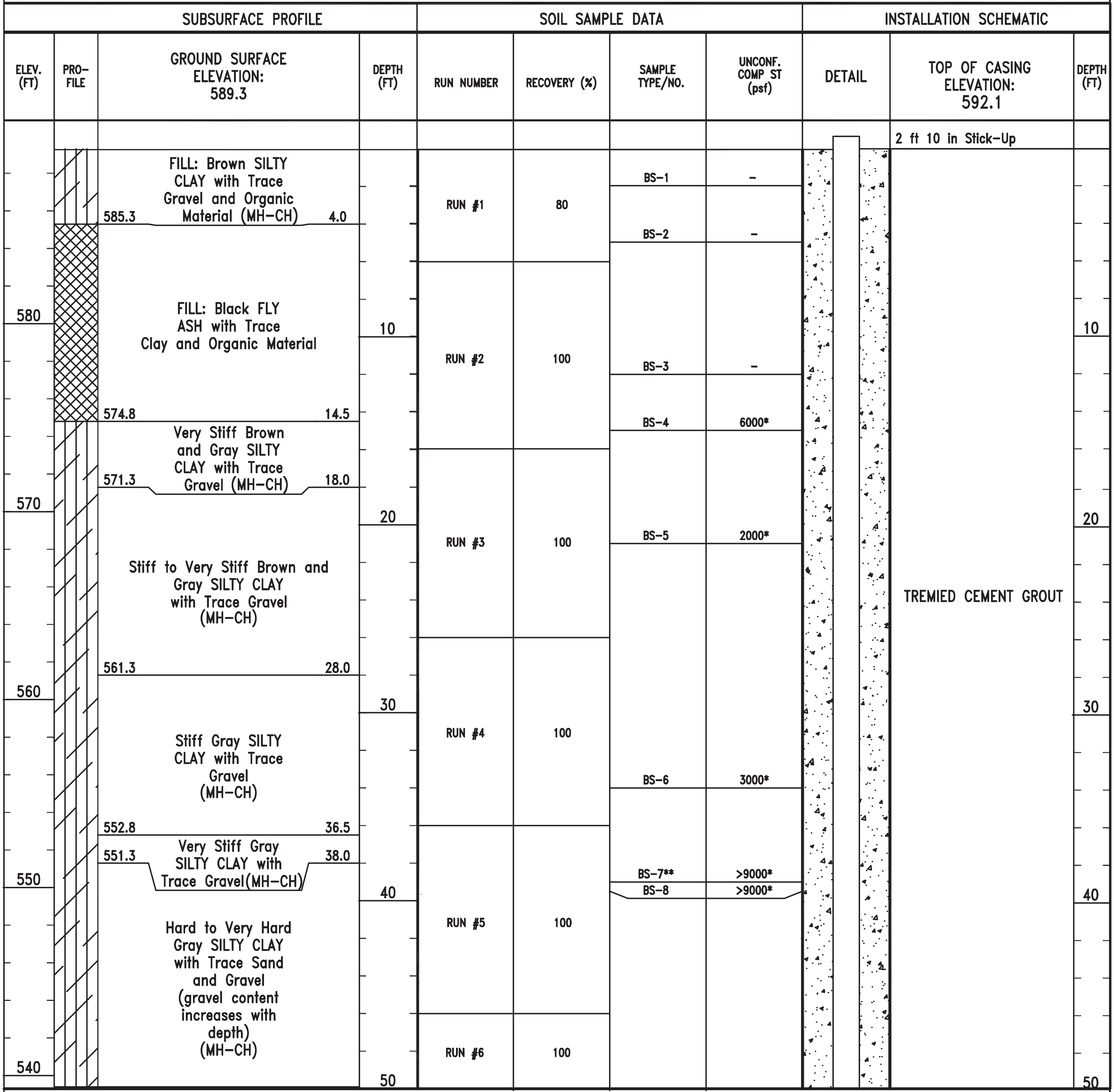
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 589.3

ELEV. (FT)	DESCRIPTION	DEPTH (FT)
585.3	FILL: Brown SILTY CLAY with Trace Gravel and Organic Material (MH-CH)	4.0
574.8	FILL: Black FLY ASH with Trace Clay and Organic Material	14.5
571.3	Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	18.0
561.3	Stiff to Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	28.0
552.8	Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	36.5
551.3	Very Stiff Gray SILTY CLAY with Trace Gravel(MH-CH)	38.0
	Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (gravel content increases with depth) (MH-CH)	

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #1	80
RUN #2	100
RUN #3	100
RUN #4	100
RUN #5	100
RUN #6	100

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-1	-
BS-2	-
BS-3	-
BS-4	6000*
BS-5	2000*
BS-6	3000*
BS-7**	>9000*
BS-8	>9000*

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 592.1

2 ft 10 in Stick-Up

TREMIED CEMENT GROUT

Total Depth:	*88.0 ft*
Drilling Date:	*10/25/2016*
Inspector:	*N. Bassett, P.E.*
Contractor:	*Cascade Drilling*
Driller:	*I. Young*
Equipment:	*600T Truck-Mount*
Casing Diameter:	*2 in*
Casing Length:	*78 ft*
Casing Type:	*PVC (SCH 40)*
Screen Diameter:	*2 in*
Screen Length:	*10 ft*
Screen Mesh:	*2 in*
Screen Type:	*0.01 in Slotted PVC*
Protective Casing:	2 ft 10 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-110509.27 Easting-13373630.27

FIGURE NO. 7

NO: JRW MW-16005

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 589.3

ELEV. (FT)	DESCRIPTION	DEPTH (FT)
	Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (gravel content increases with depth) (MH-CH) (At 56 ft 3-inch diameter cobble, did not react to HCL)	
522.3		67.0
	Very Hard SANDY CLAY/ CLAYEY SAND with Trace Gravel (CH-SC)	
520.8		68.5
	INTERFACE ZONE: FRAGMENTED ROCK with Clay (no recovery in this interval)	
516.3		73.0
	LIMESTONE (odoriferous & reacted with HCL)	
501.3		88.0

Elevation scale: 530, 520, 510, 500, 490, 480. Depth scale: 60, 70, 80.

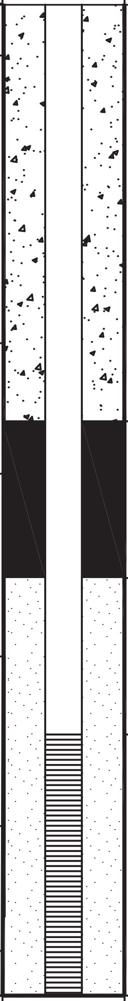
SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #6	100
RUN #7	100
RUN #8	50
RUN #9	50

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-9	>9000*
BS-10	-
BS-11	-
BS-12	-
BS-13	-
BS-14	-

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 592.1



DEPTH (FT)	MATERIAL
	TREMIED CEMENT GROUT
66.0	BENTONITE PELLETS
72.0	FILTER SAND
78.0	
88.0	END OF BORING

Monitoring Well JRW MW-16006

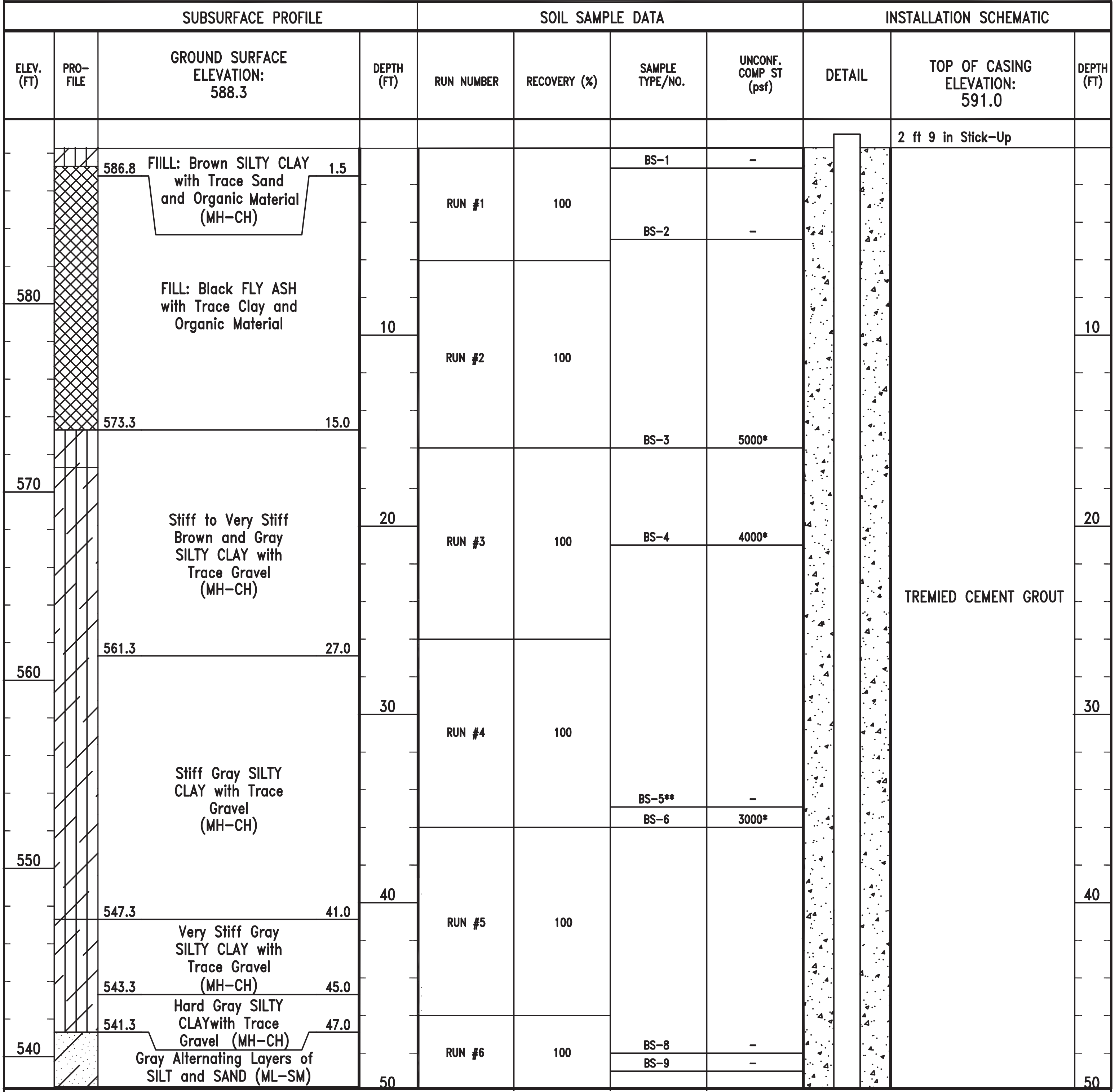
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



GROUND SURFACE ELEVATION: 588.3

TOP OF CASING ELEVATION: 591.0

Elev. (ft)	Description	Depth (ft)
586.8	FIILL: Brown SILTY CLAY with Trace Sand and Organic Material (MH-CH)	1.5
573.3	FILL: Black FLY ASH with Trace Clay and Organic Material	15.0
561.3	Stiff to Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	27.0
547.3	Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	41.0
543.3	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	45.0
541.3	Hard Gray SILTY CLAYwith Trace Gravel (MH-CH)	47.0
	Gray Alternating Layers of SILT and SAND (ML-SM)	

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #1	100	BS-1	-
		BS-2	-
RUN #2	100	BS-3	5000*
RUN #3	100	BS-4	4000*
RUN #4	100	BS-5**	-
		BS-6	3000*
RUN #5	100		
RUN #6	100	BS-8	-
		BS-9	-

Total Depth:	89.0 ft
Drilling Date:	10/19/2016
Inspector:	N. Bassett, P.E.
Contractor:	Cascade Drilling
Driller:	I. Young
Equipment:	600T Truck-Mount
Casing Diameter:	2 in
Casing Length:	79 ft
Casing Type:	PVC (SCH 40)
Screen Diameter:	2 in
Screen Length:	10 ft
Screen Mesh:	2 in
Screen Type:	0.01 in Slotted PVC
Protective Casing:	2 ft 9 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.

Coordinates: Northing-109719.88 Easting-13373640.49

FIGURE NO. 8

NO: JRW MW-16006

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

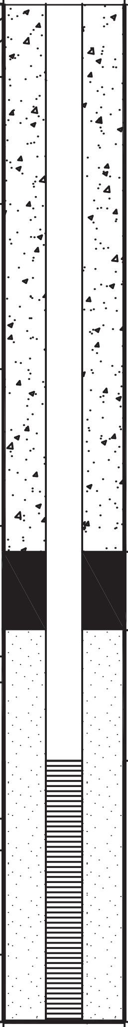
SUBSURFACE PROFILE

ELEV. (FT)	GROUND SURFACE ELEVATION: 588.3	DEPTH (FT)
535.3	Gray Alternating Layers of SILT and SAND (ML-SM)	53.0
530		
		60
519.3	Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	69.0
520		
		70
514.3	Very Hard Gray SANDY CLAY/ CLAYEY SAND (CH-SC)	74.0
513.3 512.3	INTERFACE ZONE: FRAGMENTED ROCK with Clay	76.0
510		
		80
499.3	LIMESTONE (reacted to HCL)	89.0
500		
490		
480		

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #6	100	BS-10	–
		BS-10A	–
		BS-11	>9000*
RUN #7	100	BS-12	>9000*
		BS-13	>9000*
RUN #8	100	BS-14	–
		BS-15	–
		BS-16	–
RUN #9	40	BS-17	–
		BS-18	–
		BS-19	–
RUN #10	67		

INSTALLATION SCHEMATIC



TOP OF CASING ELEVATION: 591.0	DEPTH (FT)
TREMIED CEMENT GROUT	60
71.0	70
BENTONITE PELLETS	
74.0	
79.0	80
FILTER SAND	
89.0	
END OF BORING	

Monitoring Well JRW MW-16007

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 579.5

ELEV. (FT)	DESCRIPTION	DEPTH (FT)
579.0	TOPSOIL	0.5
574.5	Stiff Brown SILTY CLAY with Trace Organic Material (MH-CH)	5.0
572.5	Brown SILTY SAND (SM)	7.0
563.5	Medium to Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	16.0
553.5	Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	26.0
546.5	Stiff to Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	33.0
543.5	Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	36.0
543.0	Gray SAND (SP)	36.5
535.0	Hard Gray SILTY CLAY with Trace Gravel (2 inch sand seam at 39.5') (MH-CH)	44.5
534.5	Gray SAND (SP)	45.0
	Hard Gray SILTY CLAY with Trace Gravel (sand and silt seams present) (MH-CH)	

ELEV. (FT): 570, 560, 550, 540, 530

DEPTH (FT): 10, 20, 30, 40, 50

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #1	100	BS-1	-
		BS-2	-
RUN #2	100	BS-3	3000*
RUN #3	100	BS-4	3000*
RUN #4	100	BS-5**	>9000*
		BS-6	-
RUN #5	100	BS-7	-
RUN #6	100	BS-8	-
		BS-9	-

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 582.3

2 ft 10 in Stick-Up

TREMIED CEMENT GROUT

DEPTH (FT): 10, 20, 30, 40, 50

Total Depth:	*78.3 ft*
Drilling Date:	*10/19/2016*
Inspector:	*N. Bassett, P.E.*
Contractor:	*Cascade Drilling*
Driller:	*I. Young*
Equipment:	*600T Truck-Mount*
Casing Diameter:	*2 in*
Casing Length:	*68 ft*
Casing Type:	*PVC (SCH 40)*
Screen Diameter:	*2 in*
Screen Length:	*10 ft*
Screen Mesh:	*2 in*
Screen Type:	*0.01 in Slotted PVC*
Protective Casing:	2 ft 10 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.
4) Driller noted continuous loss of drilling wash water during Run #8.

Coordinates: Northing-108397.13 Easting-13372561.93

FIGURE NO. 9

NO: JRW MW-16007

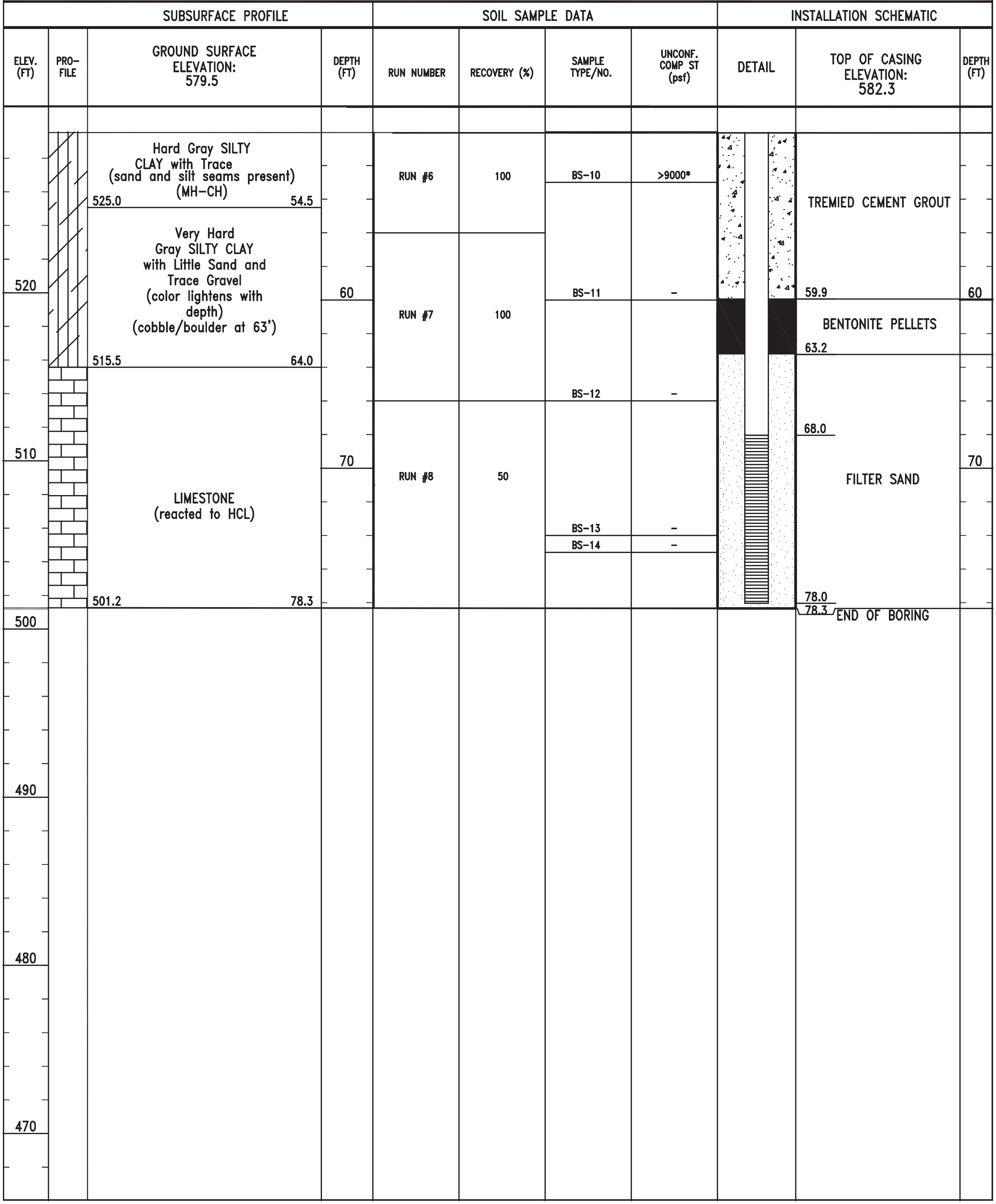
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



SUBSURFACE PROFILE

ELEV. (FT)	GROUND SURFACE ELEVATION: 579.5	DEPTH (FT)
525.0	Hard Gray SILTY CLAY with Trace (sand and silt seams present) (MH-CH)	54.5
515.5	Very Hard Gray SILTY CLAY with Little Sand and Trace Gravel (color lightens with depth) (cobble/boulder at 63')	64.0
501.2	LIMESTONE (reacted to HCL)	78.3

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #6	100	BS-10	>9000*
RUN #7	100	BS-11	-
		BS-12	-
RUN #8	50	BS-13	-
		BS-14	-

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 582.3	DEPTH (FT)
TREMIED CEMENT GROUT	59.9
BENTONITE PELLETS	63.2
FILTER SAND	68.0
	78.0
END OF BORING	78.3

Monitoring Well JRW MW-16008

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

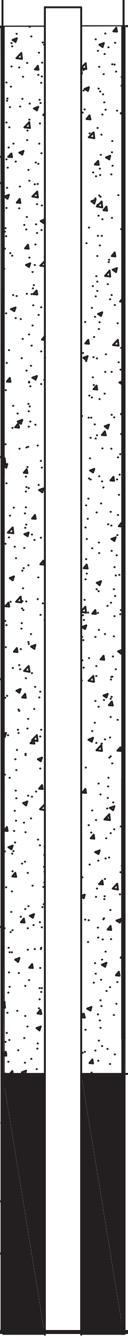
SUBSURFACE PROFILE

ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 580.0	DEPTH (FT)
580			
		579.0 FILL: GRAVEL Base Material 1.0	
		576.0 FILL: Very Stiff to Hard Brown SILTY CLAY with Trace Sand and Gravel (MH-CH) 4.0	
570		570.0 FILL: Medium Brown and Gray SILTY CLAY with Little Fly Ash and Trace Sand and Gravel (sand seam at 9 ft) (MH-CH) 10.0	10
560		Soft to Meduim Mottled Brown and Gray SILTY CLAY (gravel seam at 16.5 ft) 559.5 (MH-CH) 20.5	20
550		Medium Gray SILTY CLAY with Trace Sand and Gravel (MH-CH) 550.0 30.0	30
		Stiff Gray SILTY CLAY with Trace Sand and Gravel (MH-CH) 545.0 35.0	
		543.5 Very Stiff Gray SILTY CLAY with Trace Sand and Gravel (MH-CH) 36.5	
540			40
530		Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (MH-CH) 530.0 50.0	50

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #1	90	BS-1A BS-1B	500* 500*
RUN #2	100	BS-2	500*
RUN #3	100	BS-3	1000*
RUN #4	100	BS-4	2000*
RUN #5	100	BS-5 BS-6	>9000* >9000*

INSTALLATION SCHEMATIC



DETAIL	TOP OF CASING ELEVATION: 582.8	DEPTH (FT)
	2 ft 10 in Stick-Up	
		10
		20
	TREMIED CEMENT GROUT	
		30
	40.0	40
	BENTONITE CHIPS	
		50

Total Depth: *75.0 ft*
Drilling Date: *10/27/2016*
Inspector: *J. Elsey*
Contractor: *Cascade Drilling*
Driller: *R. Adkison*
Equipment: *200C Compact Size Track-Mount*

Casing Diameter: *2 in*
Casing Length: *68 ft*
Casing Type: *PVC (SCH 40)*

Screen Diameter: *2 in*
Screen Length: *5 ft*
Screen Mesh: *2 in*
Screen Type: *0.01 in Slotted PVC*

Protective Casing: 2 ft 10 in Stick-Up

Notes:

1) * -Denotes Pocket Penetrometer Value
2) ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.
4) During well construction, first bentonite chips added up to 57 ft bgs, then approx. 60 gallons of grout was added. Grout was lost around well casing, so additional Bentonite chips were added to 40 ft bgs followed by cement grout up to grade.

Coordinates: Northing-108021.97 Easting-13372562.48

FIGURE NO. 10

NO: JRW MW-16008

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

SUBSURFACE PROFILE				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 580.0	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 582.8	DEPTH (FT)
530										
		Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (MH-CH) 525.0 55.0		RUN #6	100	BS-7	-		BENTONITE CHIPS	
		Very Hard Gray SANDY CLAY/CLAYEY SAND (CH-SC) 521.5 58.5								
520			60						61.0	60
		INTERFACE ZONE: FRAGMENTED ROCK with Silty Clay and Sand (odoriferous) 517.5 62.5		RUN #7	80	BS-8	-		FILTER SAND	
		LIMESTONE (reacted to HCL)							68.0	
510			70							70
				RUN #8	30	BS-9	-		73.0	
		505.0 75.0							Caved-In Material 75.0 END OF BORING	
500										
490										
480										
470										

Monitoring Well JRW MW-16009

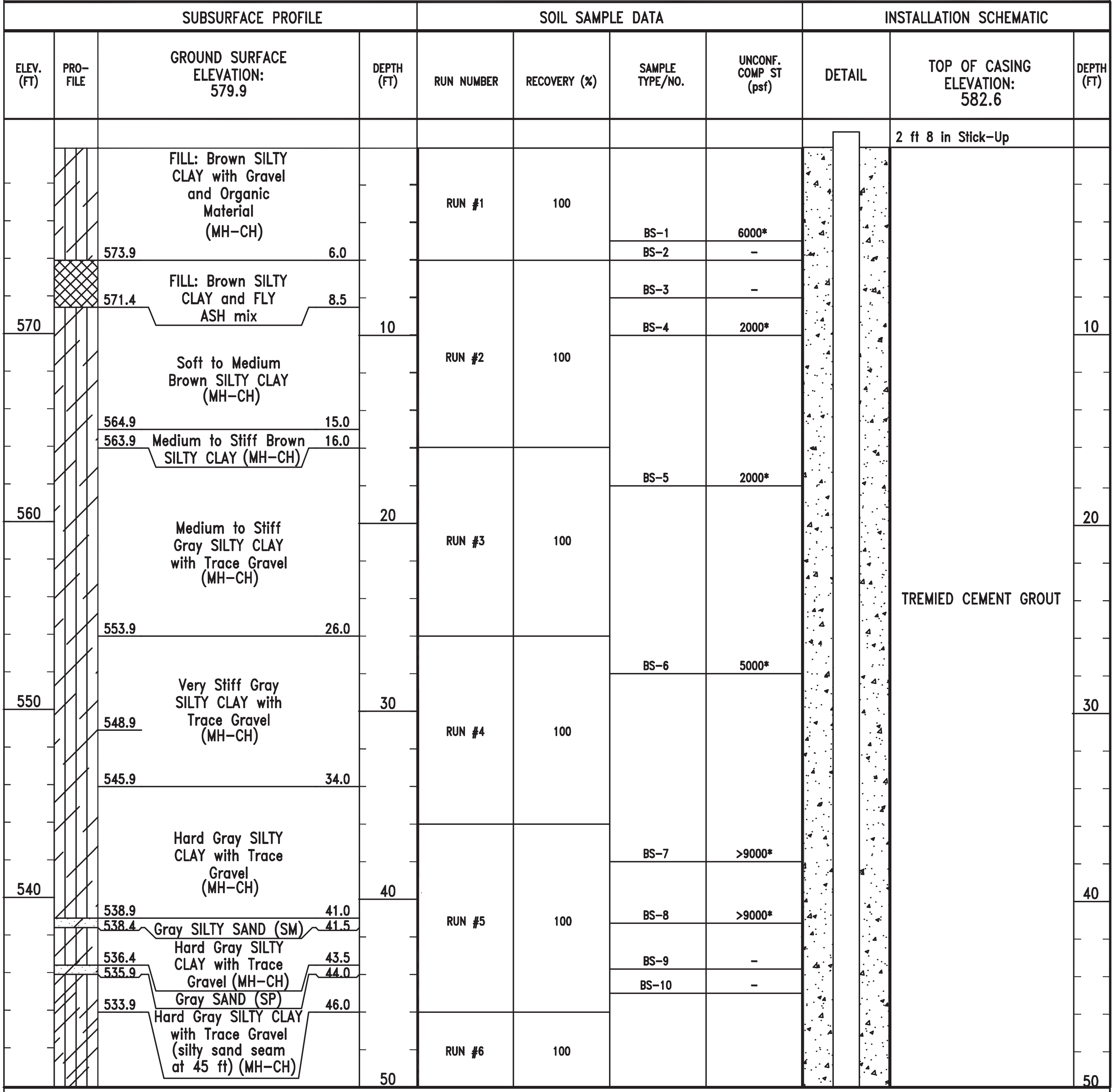
Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 579.9

ELEV. (FT)	GROUND SURFACE ELEVATION: 579.9	DEPTH (FT)
573.9	FILL: Brown SILTY CLAY with Gravel and Organic Material (MH-CH)	6.0
571.4	FILL: Brown SILTY CLAY and FLY ASH mix	8.5
564.9	Soft to Medium Brown SILTY CLAY (MH-CH)	15.0
563.9	Medium to Stiff Brown SILTY CLAY (MH-CH)	16.0
553.9	Medium to Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	26.0
548.9	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	
545.9		34.0
538.9	Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	41.0
538.4	Gray SILTY SAND (SM)	41.5
536.4	Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	43.5
535.9		44.0
533.9	Gray SAND (SP)	46.0
	Hard Gray SILTY CLAY with Trace Gravel (silty sand seam at 45 ft) (MH-CH)	

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)
RUN #1	100
RUN #2	100
RUN #3	100
RUN #4	100
RUN #5	100
RUN #6	100

SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
BS-1	6000*
BS-2	–
BS-3	–
BS-4	2000*
BS-5	2000*
BS-6	5000*
BS-7	>9000*
BS-8	>9000*
BS-9	–
BS-10	–

INSTALLATION SCHEMATIC

TOP OF CASING ELEVATION: 582.6

2 ft 8 in Stick-Up

TREMIED CEMENT GROUT

Total Depth:	*79.0 ft*
Drilling Date:	*10/18/2016*
Inspector:	*N. Bassett, P.E.*
Contractor:	*Cascade Drilling*
Driller:	*I. Young*
Equipment:	*600T Truck-Mount*
Casing Diameter:	*2 in*
Casing Length:	*69 ft*
Casing Type:	*PVC (SCH 40)*
Screen Diameter:	*2 in*
Screen Length:	*10 ft*
Screen Mesh:	*2 in*
Screen Type:	*0.01 in Slotted PVC*
Protective Casing:	2 ft 8 in Stick-Up

Notes:

1) * –Denotes Pocket Penetrometer Value
2) ** –Indicates Clay rich sample packaged for hydraulic permeability testing.
3) No groundwater observations made during or upon completion of drilling due to water added during drilling.
4) Driller advanced Run #9 without water due to plugging issues.

Coordinates: Northing–107653.55 Easting–13372573.73

FIGURE NO. 11

NO: JRW MW-16009

Project Name: J.R. Whiting Observation Wells

Project Location: J.R. Whiting Generating Facility, Erie, MI

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.

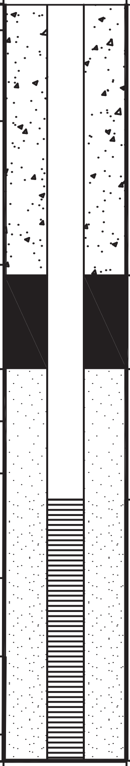
SUBSURFACE PROFILE

ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 579.9	DEPTH (FT)
		Hard Gray SILTY CLAY with Trace Gravel with Sand and Silt Seams (MH-CH)	
		523.9 56.0	
520		INTERFACE ZONE: FRAGMENTED ROCK with Silty Clay	60
		514.4 65.5	
510		LIMESTONE (clay infilling at 73 ft and 76 ft) (reacted to HCL)	70
		500.9 79.0	
500			
490			
480			
470			

SOIL SAMPLE DATA

RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)
RUN #6	100	BS-11	>9000*
RUN #7	75	BS-12	6000*
RUN #8	100	BS-13	-
		BS-14	-
		BS-15	-
RUN #9	100	BS-16	-
		BS-17	-
		BS-18	-
RUN #10	100	BS-19	-

INSTALLATION SCHEMATIC



DETAIL	TOP OF CASING ELEVATION: 582.6	DEPTH (FT)
	TREMIED CEMENT GROUT	
	60.4	60
	BENTONITE PELLETS	
	64.0	
	69.0	70
	FILTER SAND	
	79.0	
	END OF BORING	

LOG OF HAND AUGER BORING NO: HAB-1

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 589.2	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
589	▨	FILL: Brown SILTY CLAY with Trace Organic Material		BS-1	-	-	-	-
588	▨		1	BS-2	-	-	-	-
		587.8	1.4					
587	▩	FILL: Gray FLY ASH	2	BS-3	-	-	-	-
586	▩		3					
585	▩		4					
		584.2	5.0 5	BS-4	-	-	-	-
584		END OF BORING	6					

Total Depth: *5 FT*
Drilling Date: *10/19/16*
Inspector: *J. Elsey*

Drilling Method:
4-inch diameter bucket-type hand auger.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16001.

GPS Coordinates:

Figure No. 12

LOG OF HAND AUGER BORING NO: HAB-2

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO- FILE	GROUND SURFACE ELEVATION: 585.8	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
585	▨	FILL: Brown SILTY CLAY with Trace Organic Material						
		584.8 1.0	1					
584	▩							
			2					
583	▩	FILL: Gray BOTTOM/ FLY ASH with Ocasional Clay Seams	3					
582	▩							
			4					
581	▩							
		580.8 5.0	5					
		END OF BORING						
580								
			6					

Total Depth: *5 FT*
Drilling Date: *10/21/16*
Inspector: *N. Bassett, P.E.*

Drilling Method:
4-inch diameter bucket-type hand auger.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16002.

GPS Coordinates:

Figure No. 13

LOG OF HAND AUGER BORING NO: HAB-3

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 586.2	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
586								
		FILL: Brown SILTY CLAY with Trace Organic Material						
		585.2 1.0	1	BS-1	-	-	-	-
585								
		FILL: Brown SILTY CLAY with Little Fly Ash						
		584.4 1.8		BS-2	-	-	-	-
			2	BS-3	-	-	-	-
584								
			3					
583								
		FILL: Gray FLY ASH and BOTTOM ASH (bottom ash increases with depth)						
			4	BS-4	-	-	-	-
582								
		581.2 5.0	5	BS-5	-	-	-	-
		END OF BORING						
581								
			6					

Total Depth: *5 FT*
Drilling Date: *10/19/16*
Inspector: *J. Elsey*

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Drilling Method:
4-inch diameter bucket-type hand auger.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16003.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

GPS Coordinates:

Figure No. 14

LOG OF HAND AUGER BORING NO: HAB-4

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 586.5	DEPTH (ft)
585.3	▧	FILL: Dark Brown to Black SILTY CLAY with Trace Organic Material	1.3
583.5	▦	FILL: Gray FLY ASH	3.0
581.5	▦	FILL: Gray FLY ASH and BOTTOM ASH (bottom ash increases with depth)	5.0
		END OF BORING	

SOIL SAMPLE DATA

SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
BS-1	-	-	-	-
BS-2	-	-	-	-
BS-3	-	-	-	-
BS-4	-	-	-	-
BS-5	-	-	-	-

Total Depth: *5 FT*
Drilling Date: *10/19/16*
Inspector: *J. Elsey*

Drilling Method:
4-inch diameter bucket-type hand auger.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16004.

GPS Coordinates:

Figure No. 15

LOG OF HAND AUGER BORING NO: HAB-5

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 589.3

ELEV. (ft)	DESCRIPTION	DEPTH (ft)
589.3 – 586.6	FILL: Brown SILTY CLAY with Trace Gravel and Organic Material	0 – 2.7
586.6 – 585.4	FILL: Brown SILTY CLAY with Trace Fly Ash	2.7 – 3.9
585.4 – 584.3	FILL: Gray FLY ASH	3.9 – 5.0
584.3	END OF BORING	5.0

SOIL SAMPLE DATA

SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMPST (PSF)
BS-1	-	-	-	-
BS-2	-	-	-	-
BS-3	-	-	-	-
BS-4	-	-	-	-
BS-5	-	-	-	-

Total Depth: *5 FT*
Drilling Date: *10/19/16*
Inspector: *J. Elsey*

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Drilling Method:
4-inch diameter bucket-type hand auger.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16005.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

GPS Coordinates:

Figure No. 16

LOG OF HAND AUGER BORING HAND AUGERS.GPJ 12/8/16

LOG OF HAND AUGER BORING NO: HAB-6

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 588.3	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
587.3		FILL: Brown SILTY CLAY with Trace Organic Material	1.0	BS-1	-	-	-	-
				BS-2	-	-	-	-
		FILL: Gray/Black FLY ASH (clay seams from 2ft to 3ft)		BS-3	-	-	-	-
583.3			5.0	BS-4	-	-	-	-
		END OF BORING						

Total Depth: *5 FT*
Drilling Date: *10/19/16*
Inspector: *J. Elsey*

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Drilling Method:
4-inch diameter bucket-type hand auger.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16006.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

GPS Coordinates:

Figure No. 17

LOG OF HAND AUGER BORING NO: HAB-7

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE | SOIL SAMPLE DATA

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 579.5	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
579		FILL: Brown SAND with Little Gravel and Asphalt Debris		BS-1	-	-	-	-
		578.5 1.0	1	BS-2	-	-	-	-
		ASPHALT						
		578.3 1.2						
578								
			2	BS-3	-	-	-	-
		FILL: Dark Brown SAND with Trace Clay and Organic Material						
577				BS-4	-	-	-	-
		576.5 3.0	3					
576				BS-5	-	-	-	-
		Dark Brown SILTY CLAY						
			4					
575								
		574.8 4.7						
		Brown SAND with Trace Silt						
		574.5 5.0	5	BS-6	-	-	-	-
		END OF BORING						
574								
			6					

Total Depth: *5 FT*
Drilling Date: *10/18/16*
Inspector: *J. Elsey*

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Drilling Method:
4-inch diameter bucket-type hand auger.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16007.
2) Used chisel to penetrate asphalt encouneterd at 1ft.

GPS Coordinates:

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

Figure No. 18

LOG OF HAND AUGER BORING NO: HAB-8

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE | SOIL SAMPLE DATA

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 580.0	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMPST (PSF)
580								
		FILL: GRAVEL BASE MATERIAL						
579.5			0.5					
		ASPHALT						
579.3			0.7					
579			1					
		FILL: GRAVEL BASE MATERIAL						
578.5			1.5					
578			2					
		FILL: Brown SILTY CLAY with Trace Sand and Gravel						
577			3					
576.0			4.0					
576			4					
		FILL: Brown and Gray SILTY CLAY with Little Black Fly Ash and Trace Sand and Gravel						
575.2			4.8					
		Brown SAND						
575.0			5.0					
575		END OF BORING	5					
574			6					

Total Depth: *5 FT*
Drilling Date: *10/27/16*
Inspector: *J. Elsey*

Drilling Method:
4-inch diameter bucket-type hand auger.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

Water Level Observation:
Groundwater observed at 4.8 ft during drilling and 4.2 ft upon completion of drilling.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16008.
2) Used chisel to penetrate asphalt encouneterd at 0.5ft.

GPS Coordinates:

LOG OF HAND AUGER BORING NO: HAB-9

Project Name: *J.R. Whiting Well Installation*

Project Location: *J. R. Whiting Generating Facility, Erie, Michigan*

FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 579.9	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMPST (PSF)
				BS-1	-	-	-	-
579		FILL: Gray SAND with Little Gravel and Trace Fly Ash	1					
				BS-2	-	-	-	-
578		577.9 2.0	2	BS-3	-	-	-	-
577			3					
		FILL: Brown SILTY CLAY						
576			4	BS-4	-	-	-	-
575		574.9 5.0	5	BS-5	-	-	-	-
		END OF BORING						
574			6					

Total Depth: *5 FT*
Drilling Date: *10/18/16*
Inspector: *J. Elsey*

Water Level Observation:
No groundwater encountered during or upon completion of drilling.

Drilling Method:
4-inch diameter bucket-type hand auger.

Notes:
1) Drilled to clear boring location for the sonic drilling of JRW MW-16009.

Plugging Procedure:
Borehole backfilled with soil cuttings to prevailing grade.

GPS Coordinates:

Appendix B
Photographic Log

Photographs of Clay to Bedrock Transition (individual well locations)

Photograph of clay to bedrock transitions at JRW MW-16001:

JRW MW-16001 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16002:

10/24/2016 12:42

JRW MW-16002 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16003:

JRW MW-16003 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16004:

JRW MW-16004 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16005:

JRW MW-16005 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16006:

JRW MW-16006 66-76 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16007:

JRW MW-16007 56-66 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16008:

JRW MW-16008 50-60 feet bgs – Run 6

Photograph of clay to bedrock transitions at JRW MW-16008:

JRW MW-16008 60-70 feet bgs – Run 7

Photograph of clay to bedrock transitions at JRW MW-16009:

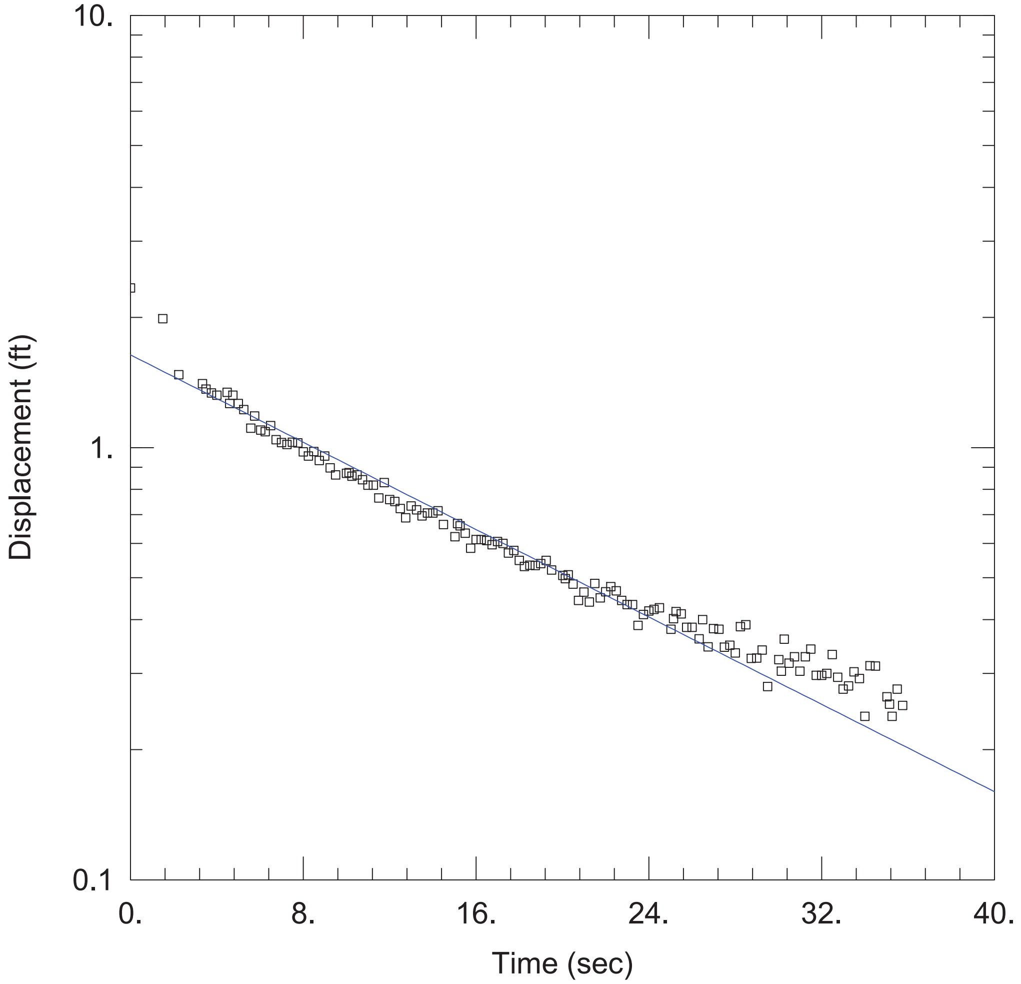
JRW MW-16009 66-70 feet bgs

Photograph of clay to bedrock transitions at JRW MW-16009:

JRW MW-16009 66-76 feet bgs

Appendix C
Hydraulic Test Results

Individual Well Locations



JR MW-16001 SLUG IN 1

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16
Time: 08:38:58

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

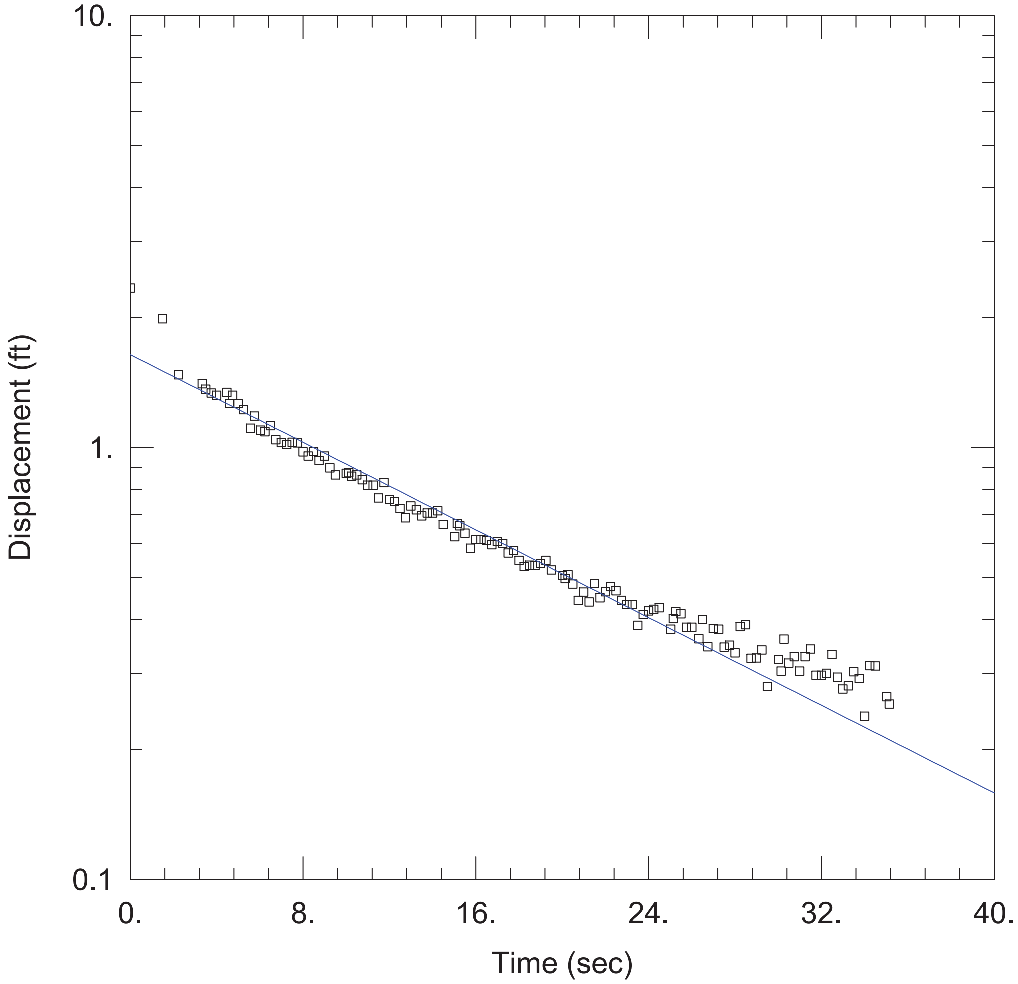
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.161 ft/day
y0 = 1.638 ft



JR MW-16001 SLUG IN 1

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:46:48

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

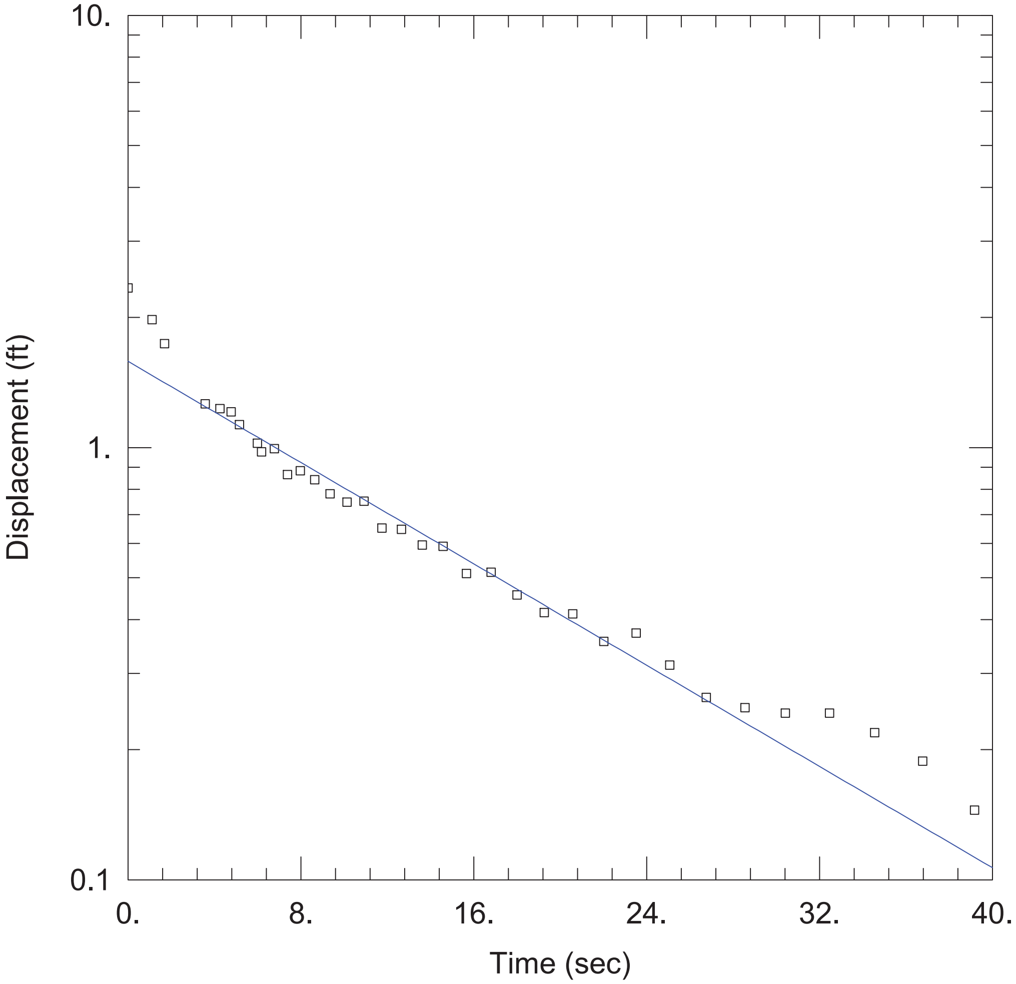
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.672 ft/day
y0 = 1.642 ft



JR MW-16001 SLUG IN 2

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:42:55

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

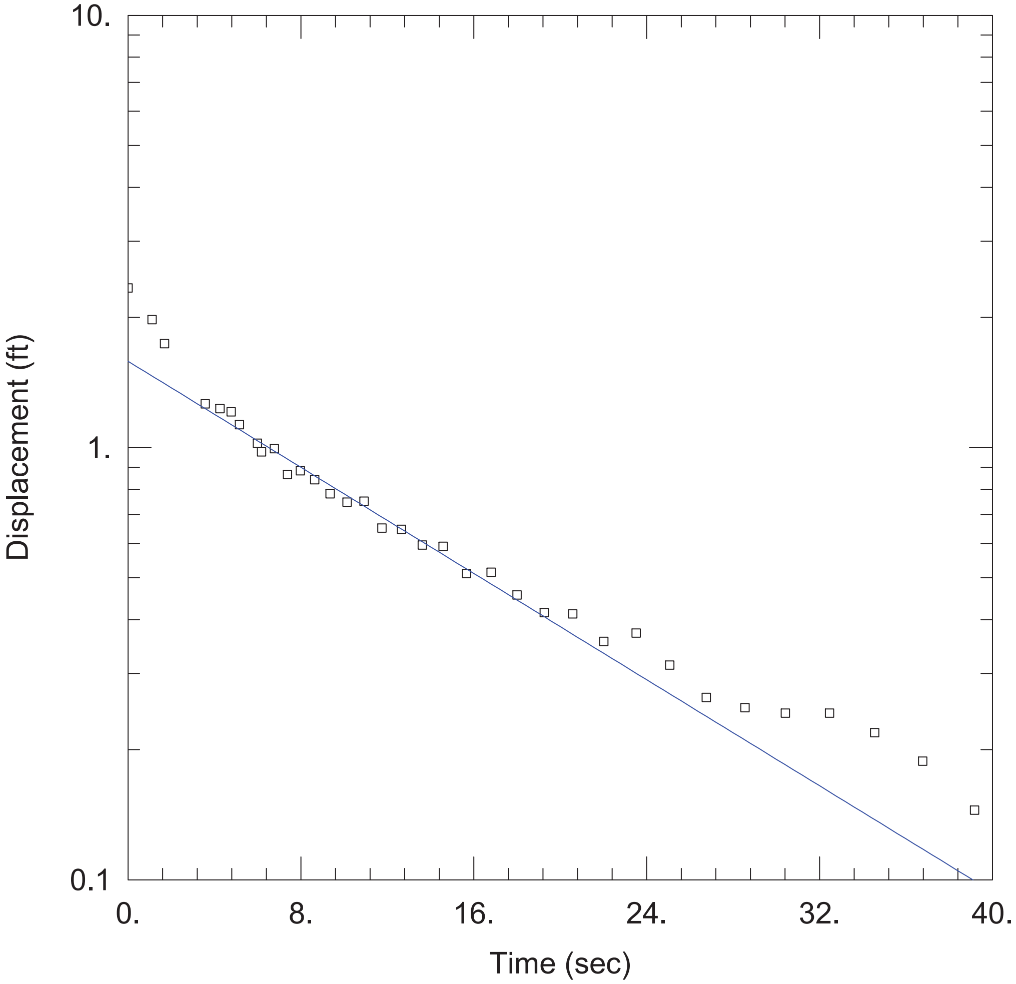
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 66.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.666 ft/day
y0 = 1.583 ft



JR MW-16001 SLUG IN 2

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:44:25

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

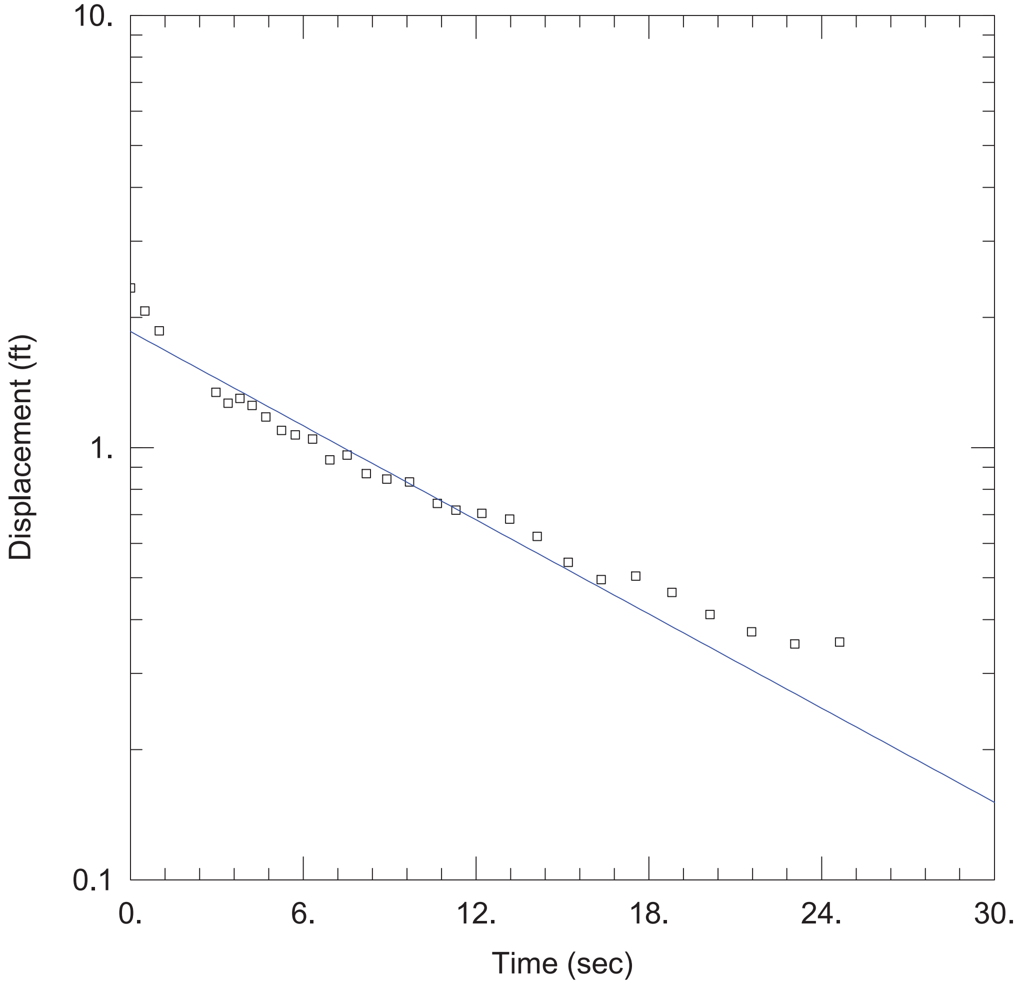
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.652 ft/day
y0 = 1.583 ft



JR MW-16001 SLUG IN 3

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16
Time: 08:50:31

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

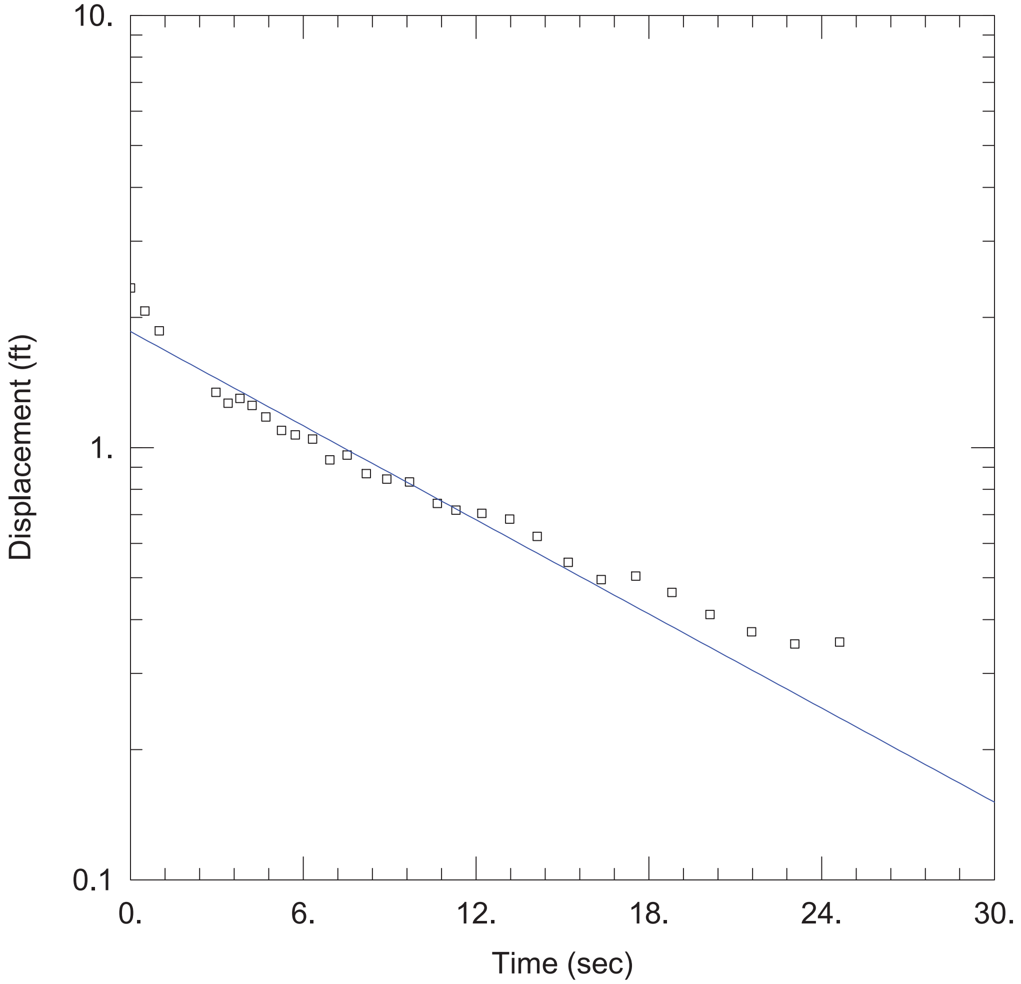
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.545 ft/day
y0 = 1.855 ft



JR MW-16001 SLUG IN 3

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:49:31

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

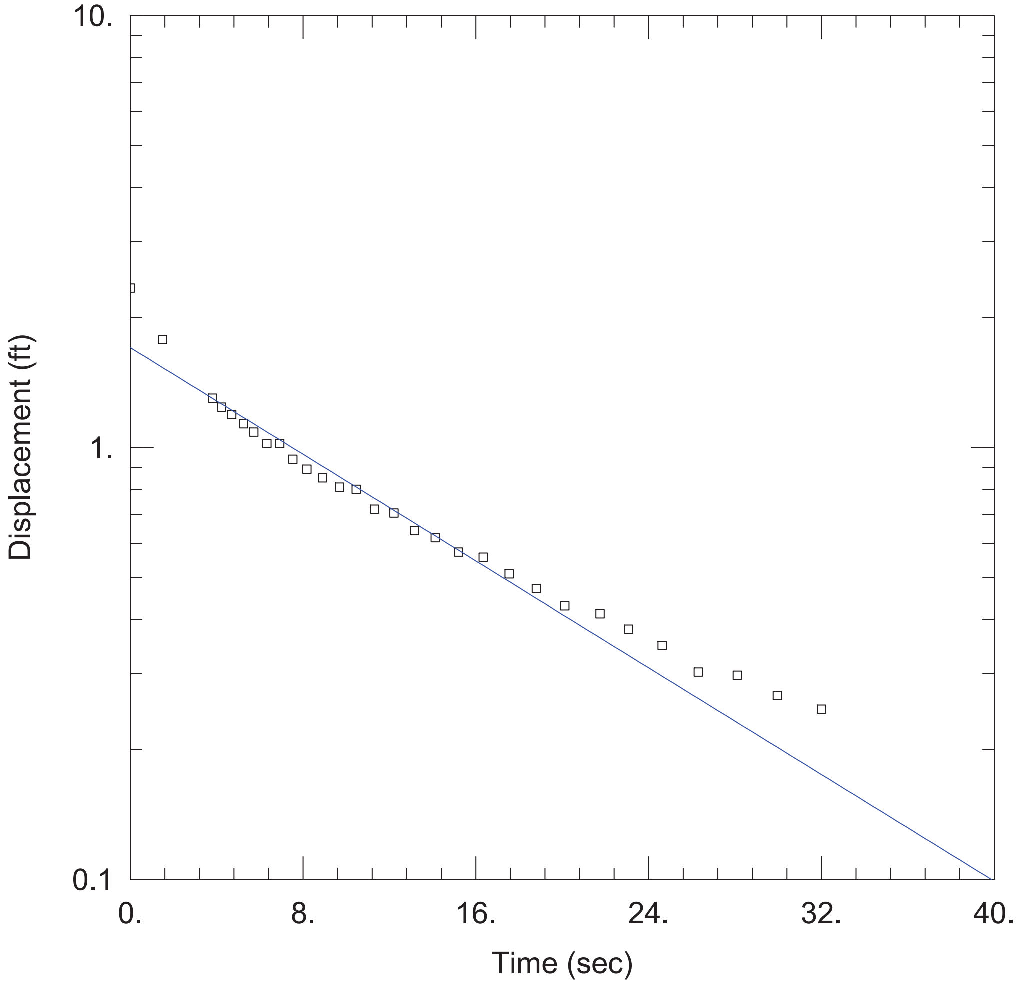
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 6.686 ft/day
y0 = 1.854 ft



JR MW-16001 SLUG IN 4

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:53:50

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

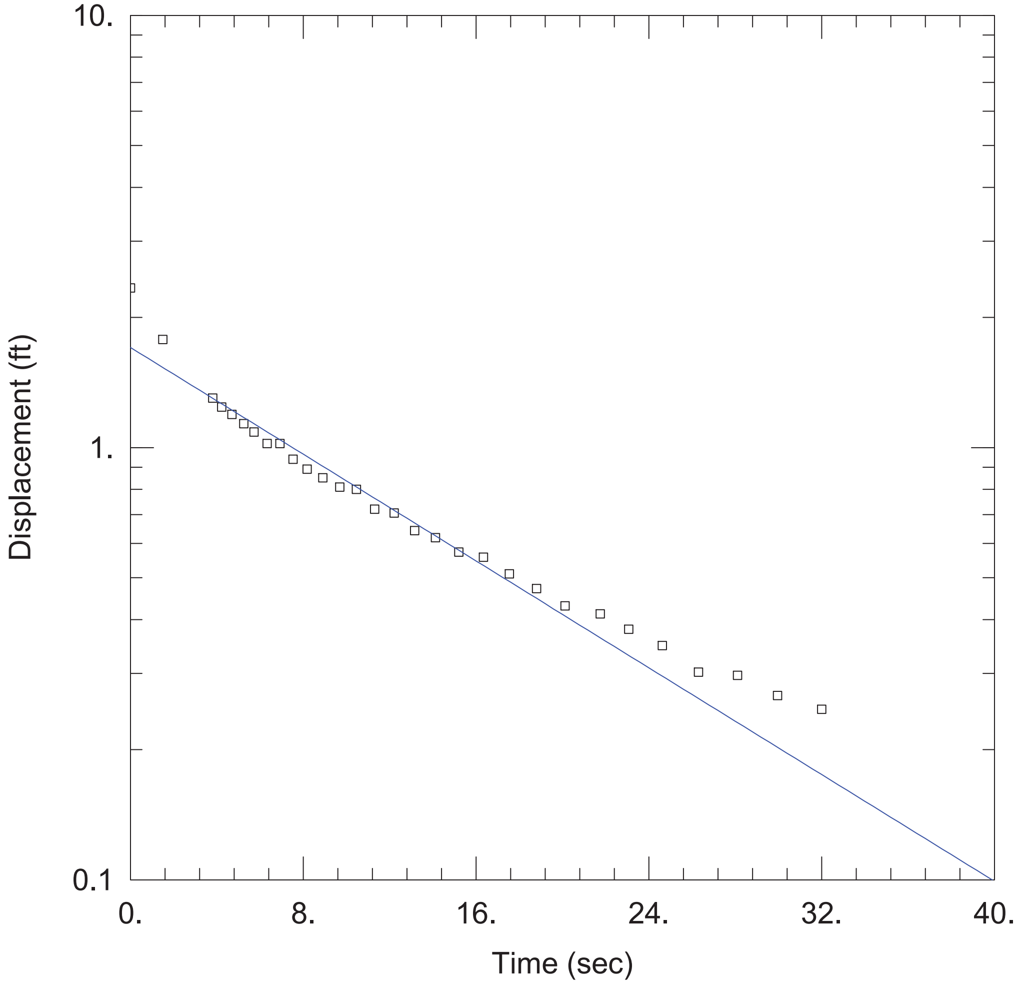
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Static Water Column Height: 66.3 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.865 ft/day
y0 = 1.704 ft



JR MW-16001 SLUG IN 4

Data Set: S:\...\MW-16001 Slug in 1.aqt
Date: 11/08/16 Time: 08:54:39

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16001
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

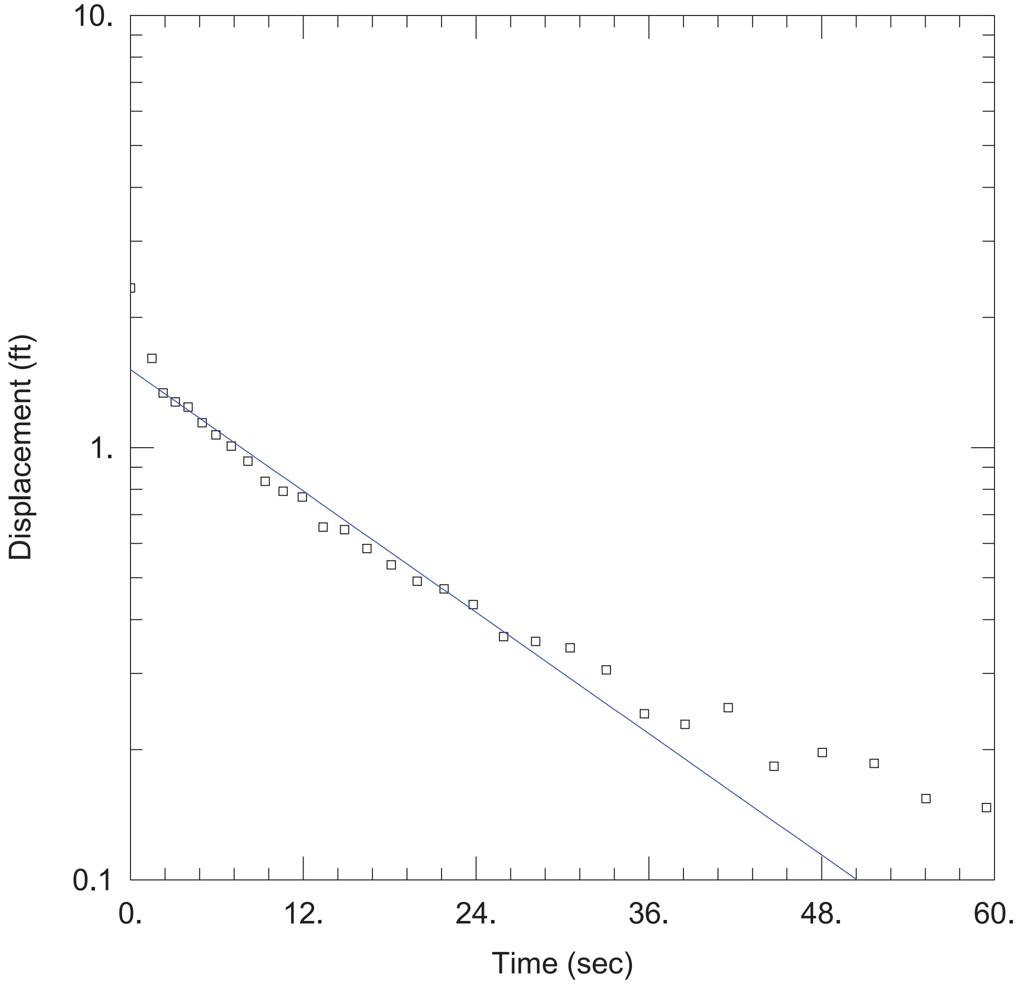
WELL DATA (JR MW-16001)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 66.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.686 ft/day
y0 = 1.704 ft



JR MW-16002 SLUG IN 1

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16 Time: 08:57:00

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

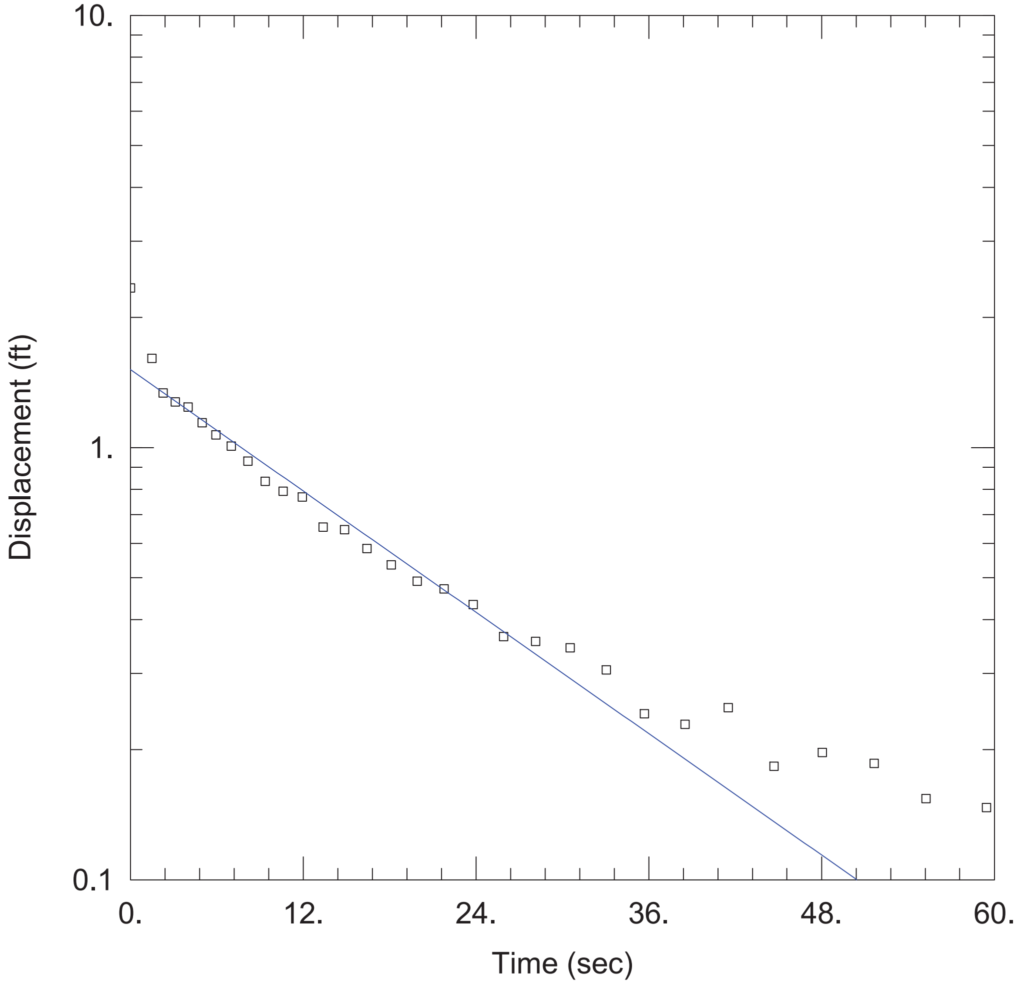
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Static Water Column Height: 79.5 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.016 ft/day
y0 = 1.514 ft



JR MW-16002 SLUG IN 1

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16
Time: 08:58:55

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

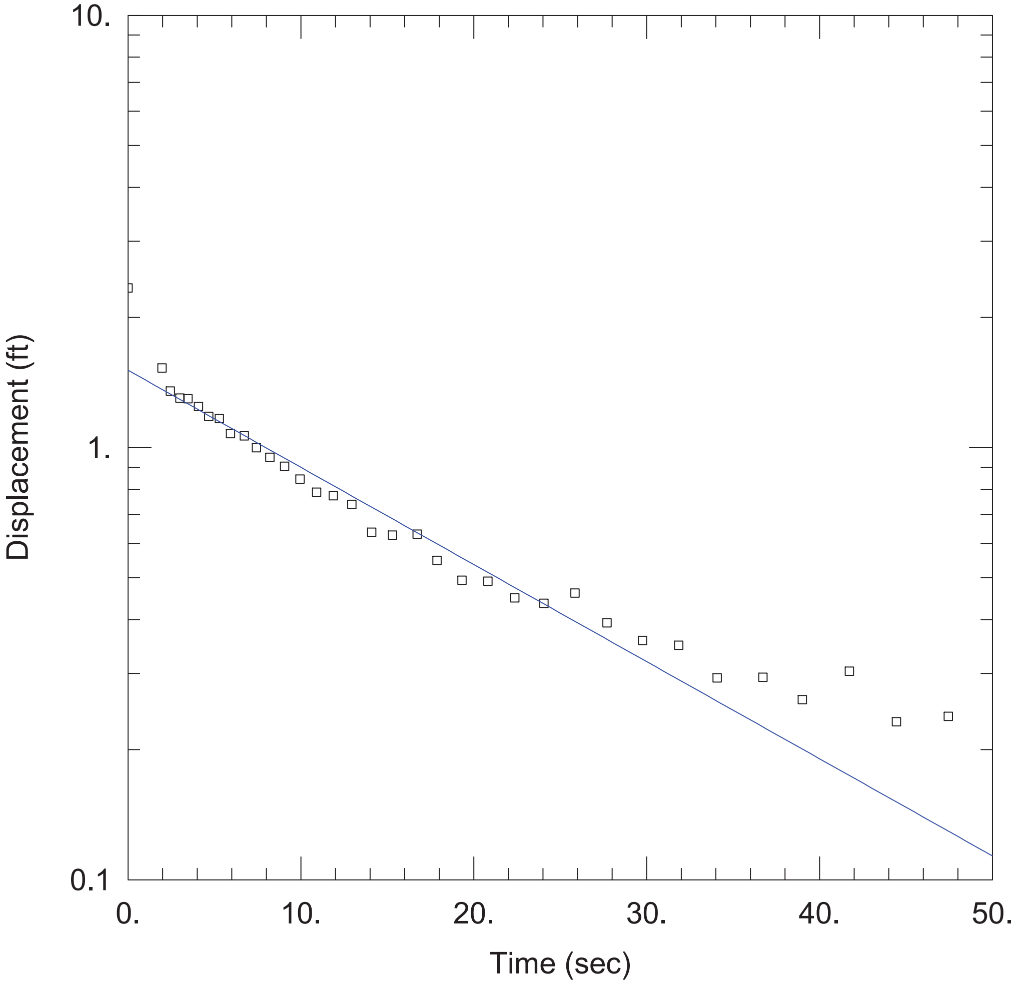
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Static Water Column Height: 79.5 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.31 ft/day
y0 = 1.514 ft



JR MW-16002 SLUG IN 2

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16
Time: 09:04:11

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

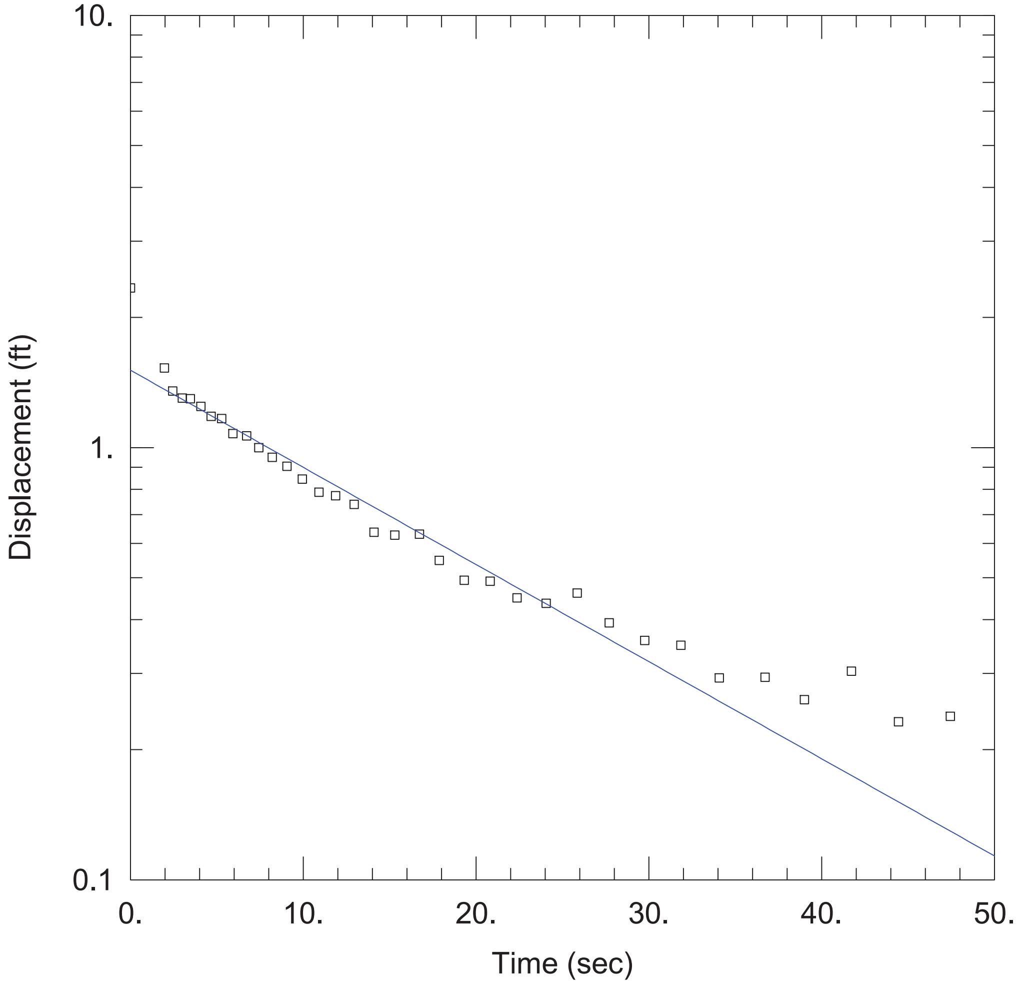
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 79.5 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.897 ft/day
y0 = 1.509 ft



JR MW-16002 SLUG IN 2

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16
Time: 09:00:47

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

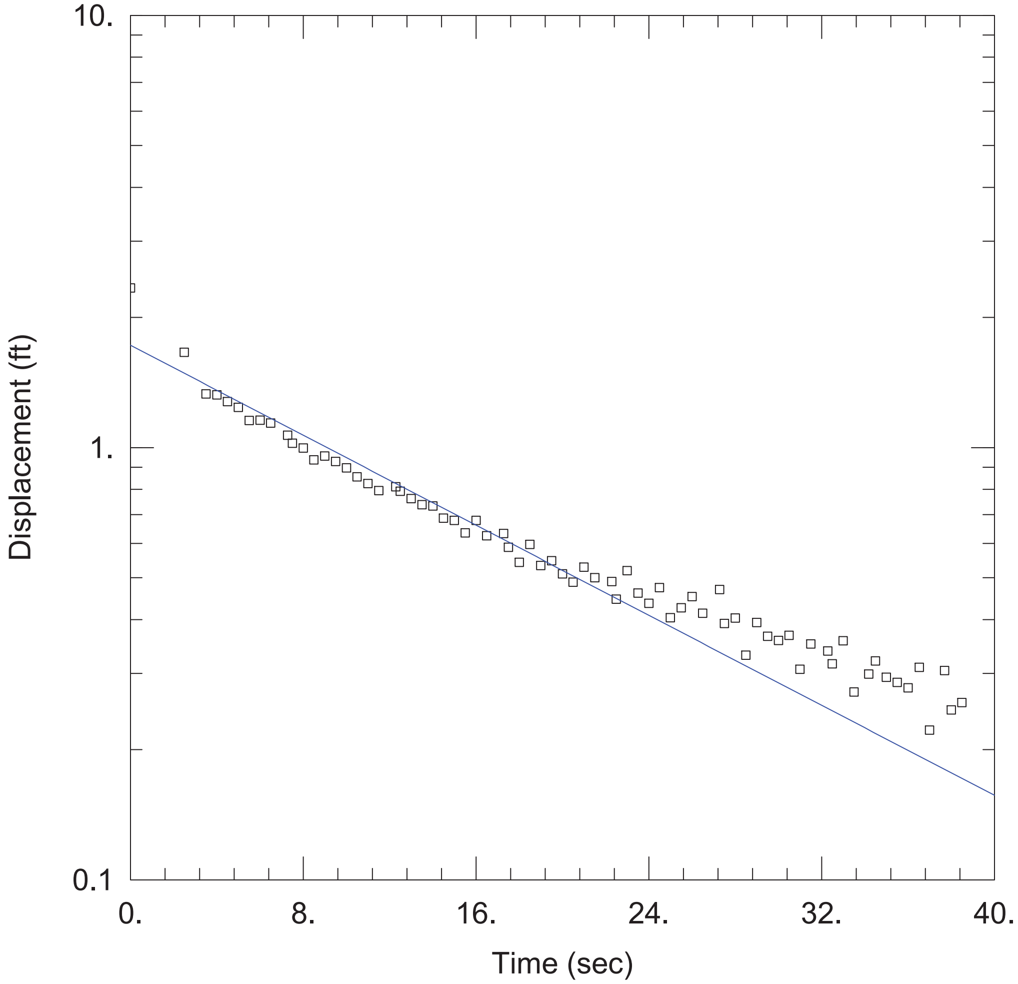
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Static Water Column Height: 79.5 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.14 ft/day
y0 = 1.509 ft



JR MW-16002 SLUG IN 3

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16
Time: 09:06:33

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

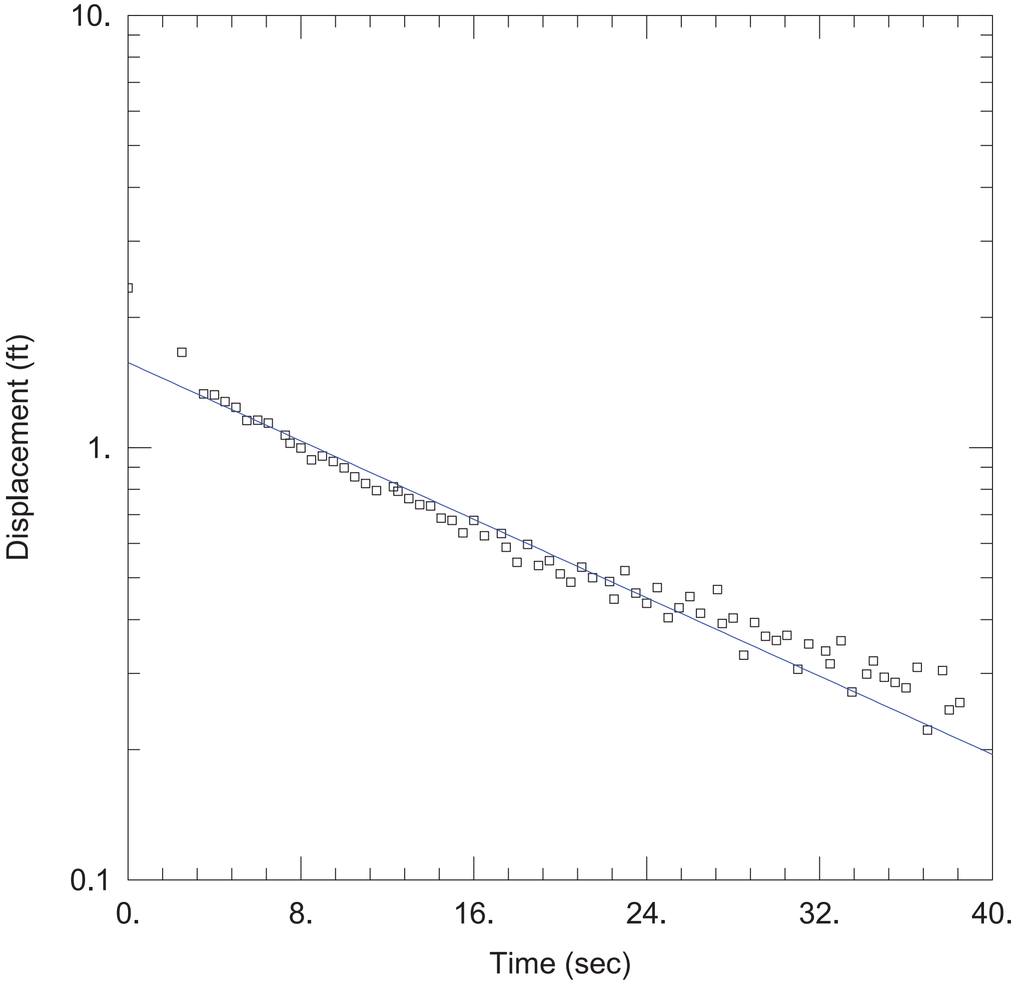
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 79.5 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.355 ft/day
y0 = 1.724 ft



JR MW-16002 SLUG IN 3

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16 Time: 09:08:20

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

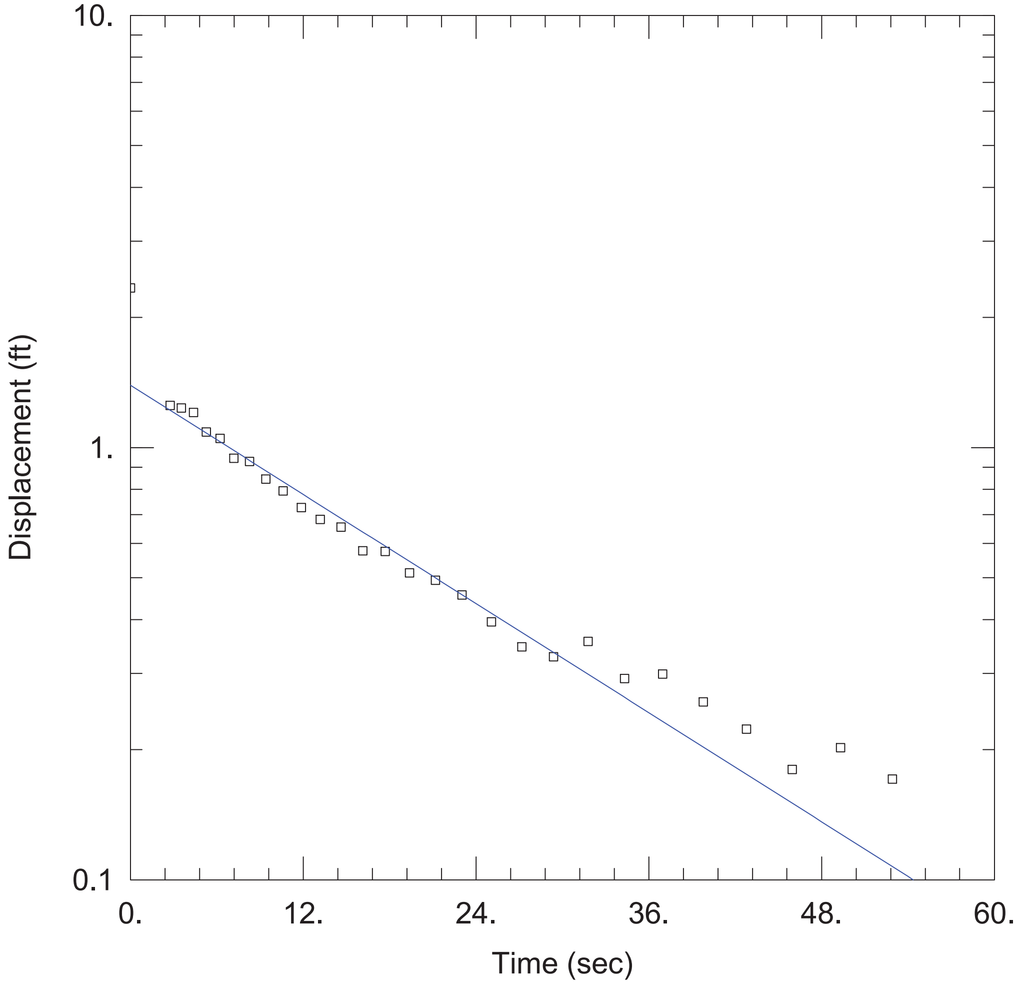
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Static Water Column Height: 79.5 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.174 ft/day
y0 = 1.572 ft



JR MW-16002 SLUG IN 4

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16 Time: 09:12:31

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

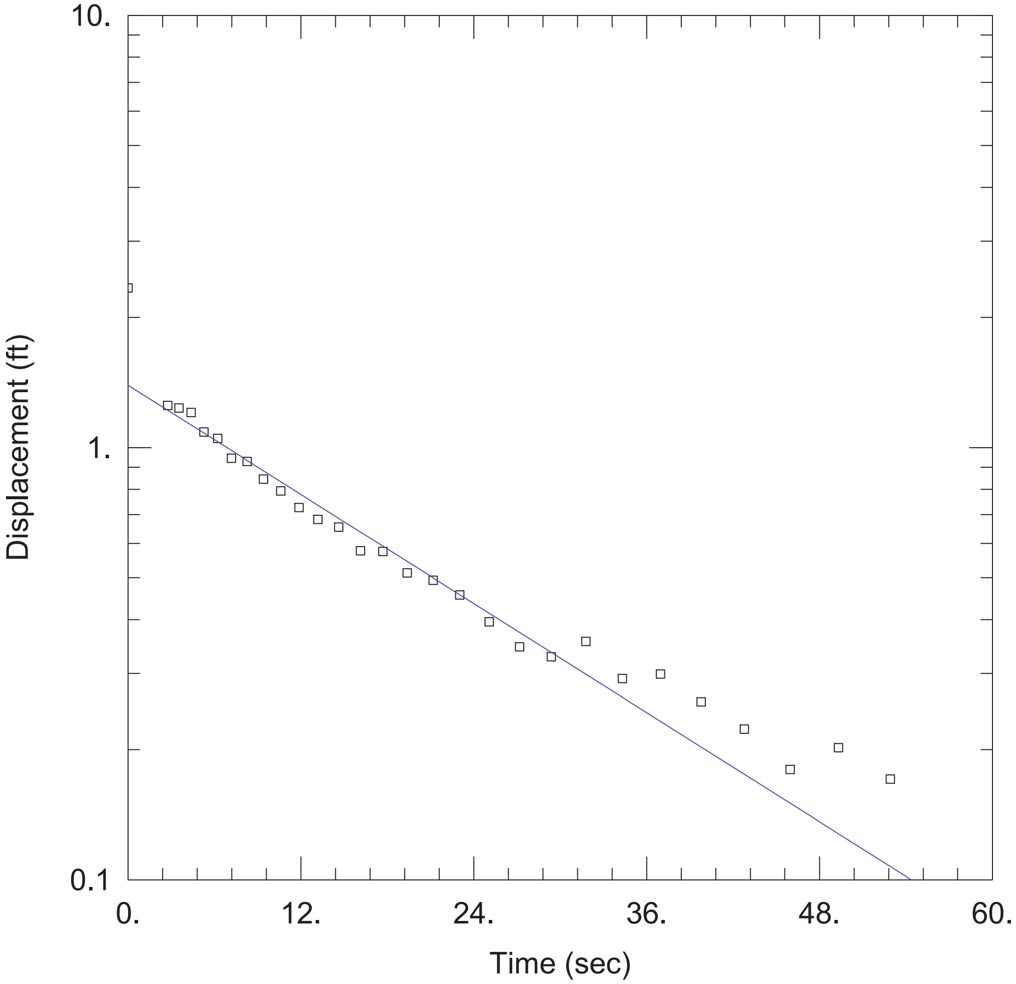
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 79.5 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.713 ft/day y0 = 1.394 ft



JR MW-16002 SLUG IN 4

Data Set: S:\...\MW-16002.aqt
Date: 11/08/16 Time: 09:11:17

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16002
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

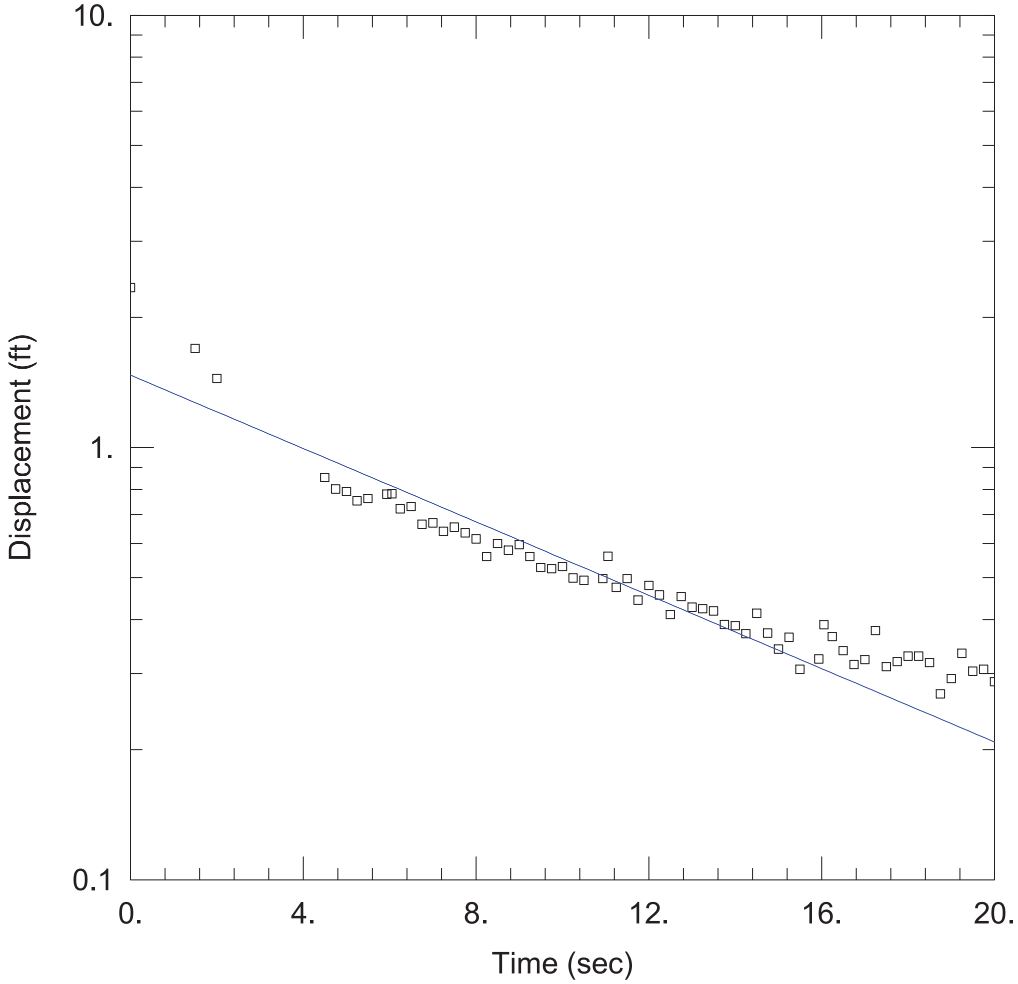
WELL DATA (JR MW-16002)

Initial Displacement: 2.34 ft
Static Water Column Height: 79.5 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.877 ft/day
y0 = 1.394 ft



JR MW-16003 SLUG IN 1

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:18:52

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft Anisotropy Ratio (Kz/Kr): 1.

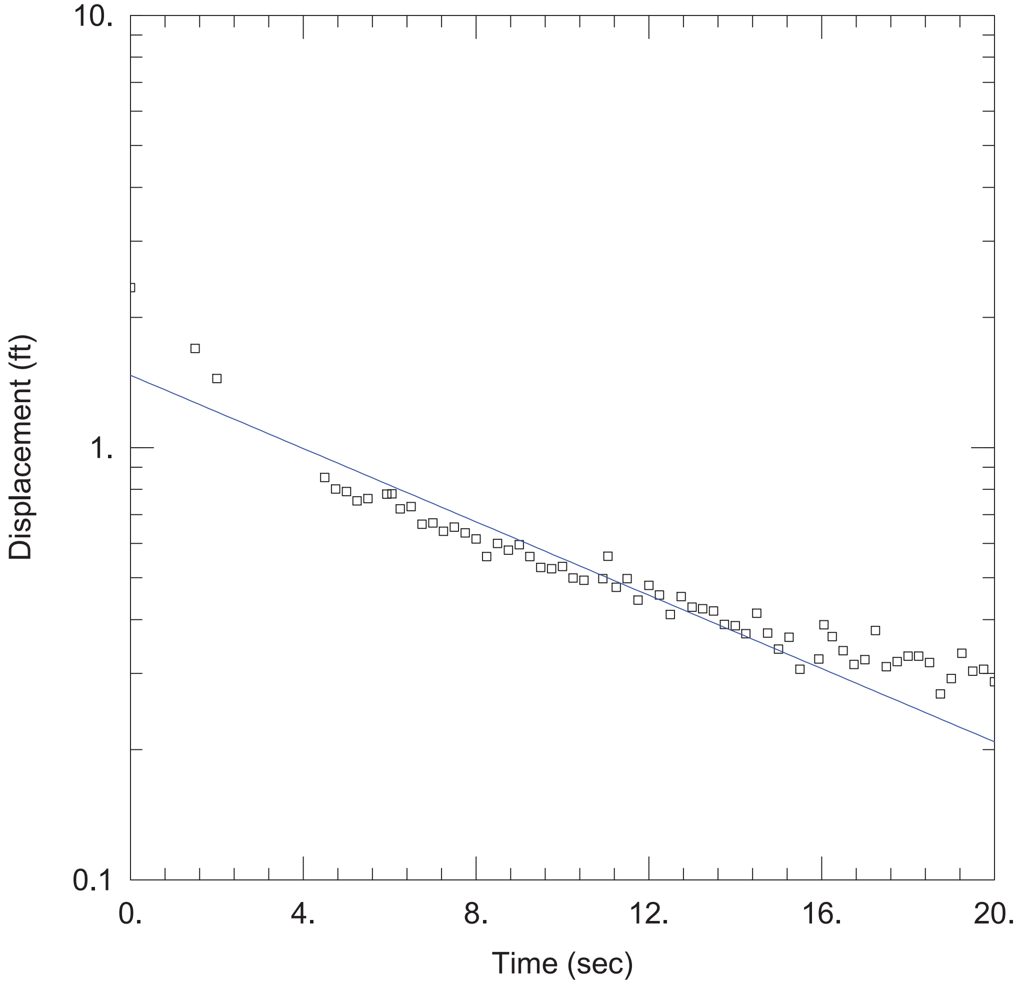
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 71.1 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 5.31 ft/day y0 = 1.47 ft



JR MW-16003 SLUG IN 1

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16
Time: 09:18:07

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

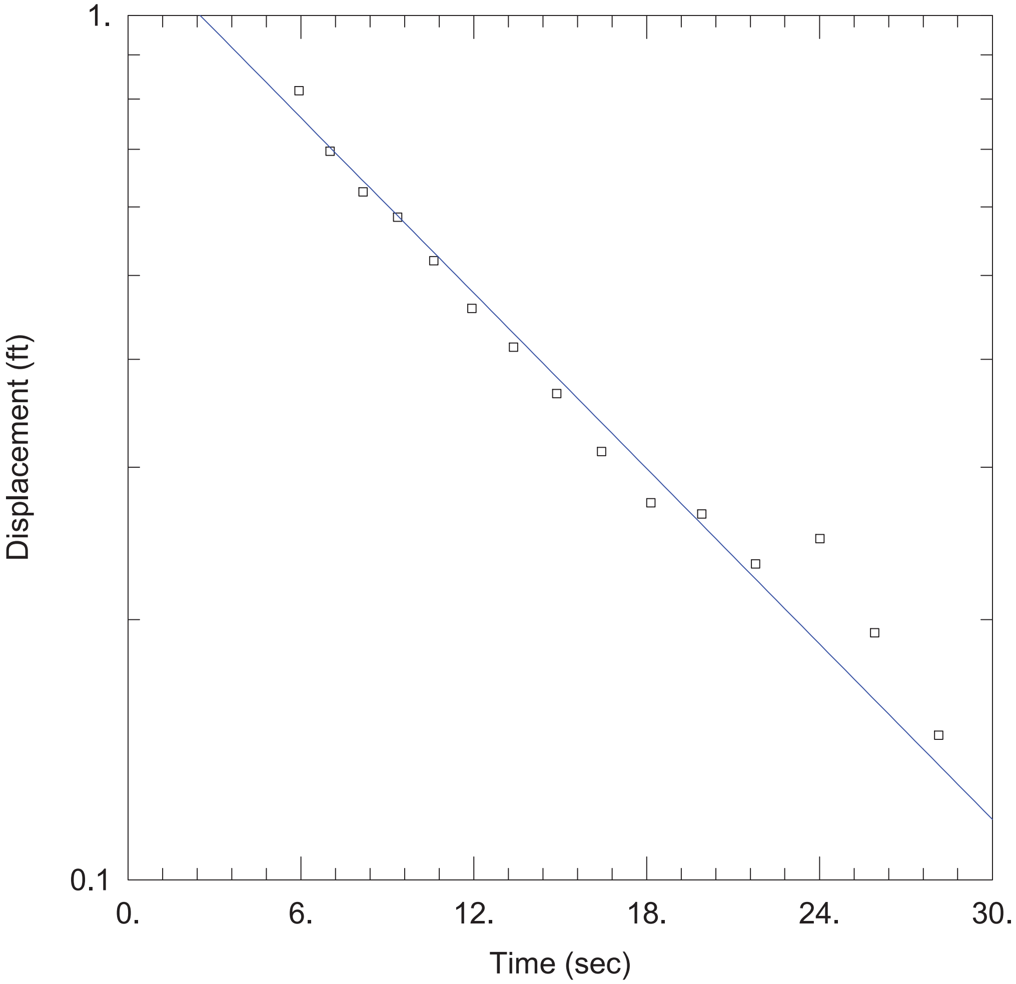
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Static Water Column Height: 71.1 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 7.811 ft/day
y0 = 1.47 ft



JR MW-16003 SLUG IN 2

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:22:16

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

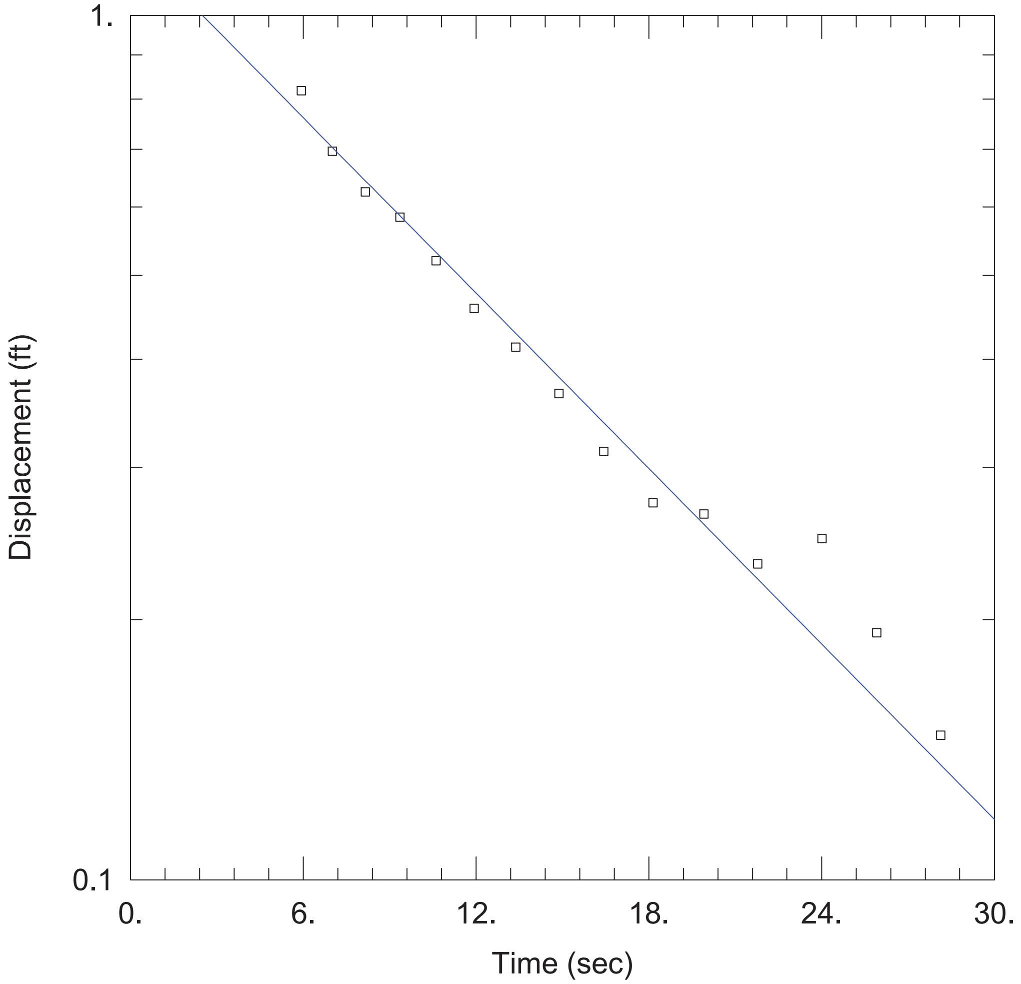
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Static Water Column Height: 71.1 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.235 ft/day
y0 = 1.215 ft



JR MW-16003 SLUG IN 2

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:23:11

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

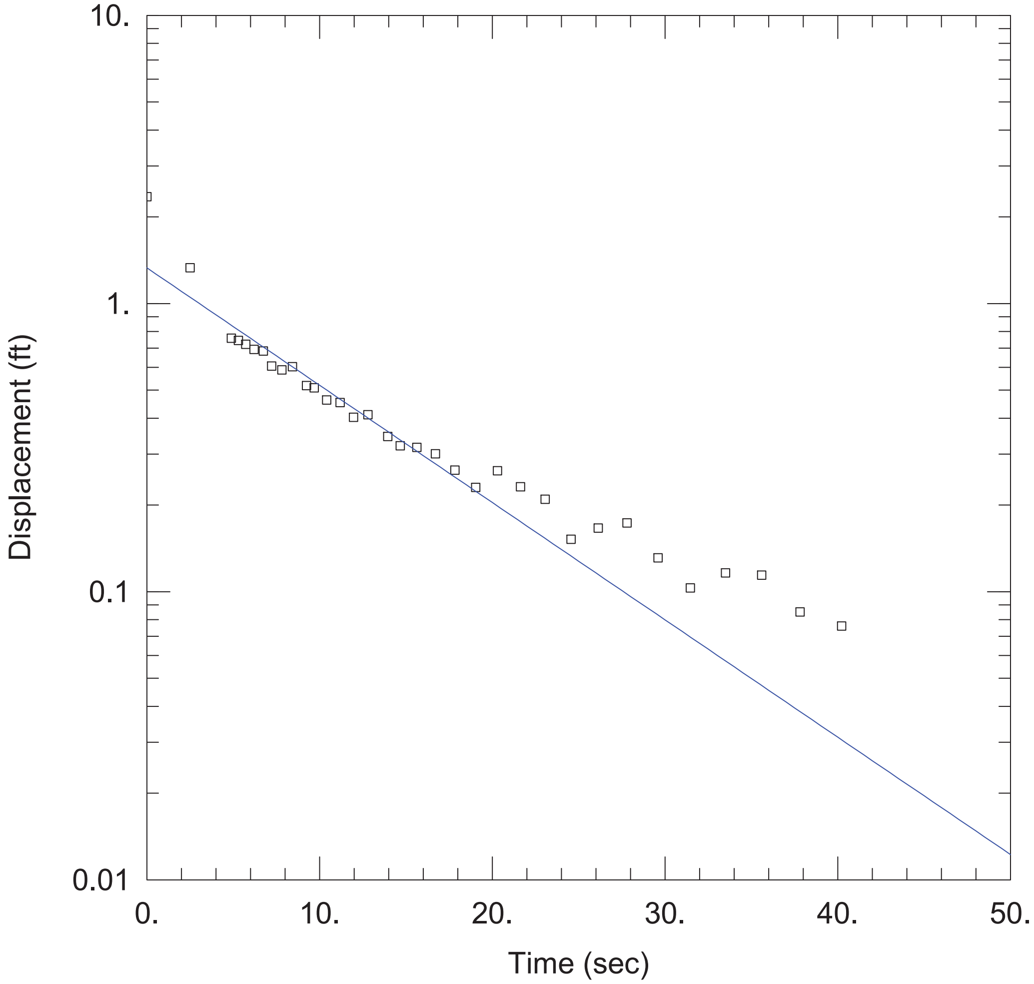
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 71.1 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 6.232 ft/day
y0 = 1.215 ft



JR MW-16003 SLUG IN 3

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:26:04

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

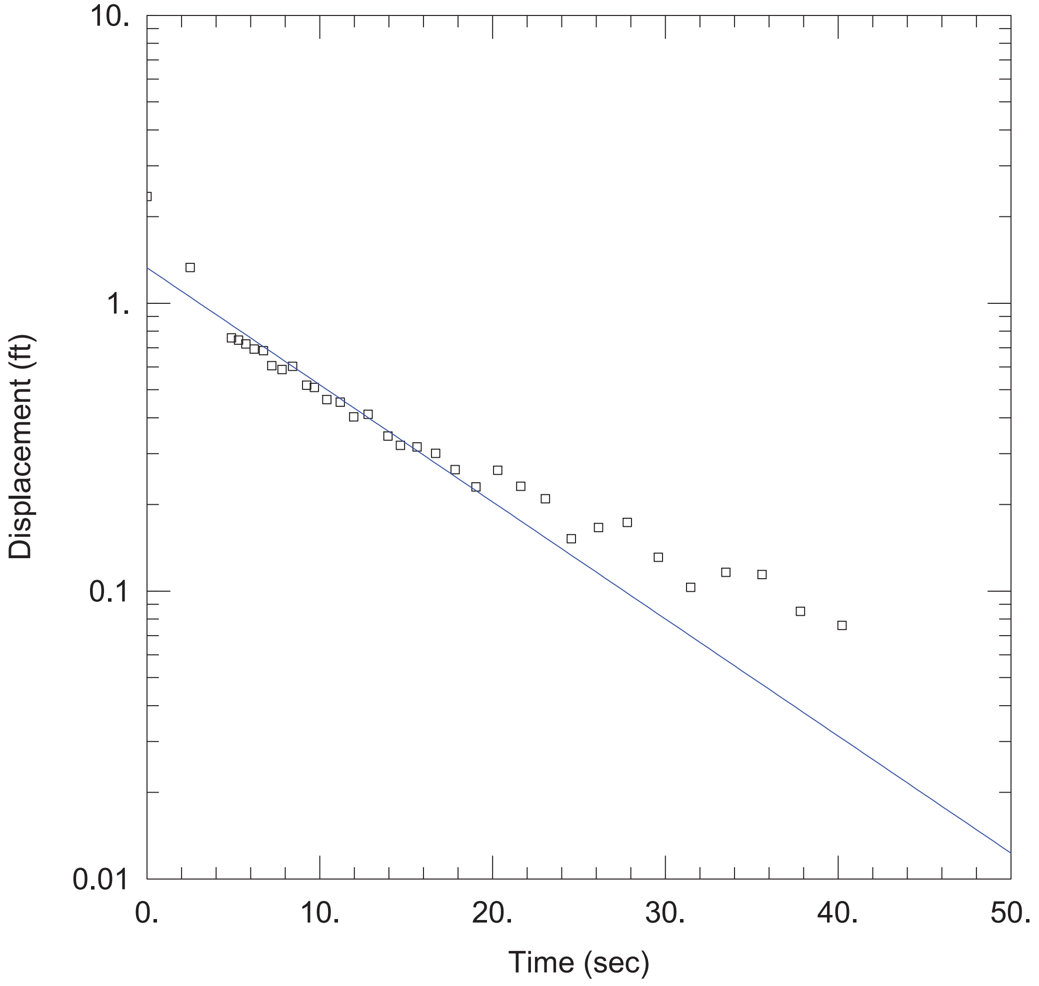
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Static Water Column Height: 71.1 ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 5.097 ft/day
y0 = 1.329 ft



JR MW-16003 SLUG IN 3

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:25:24

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

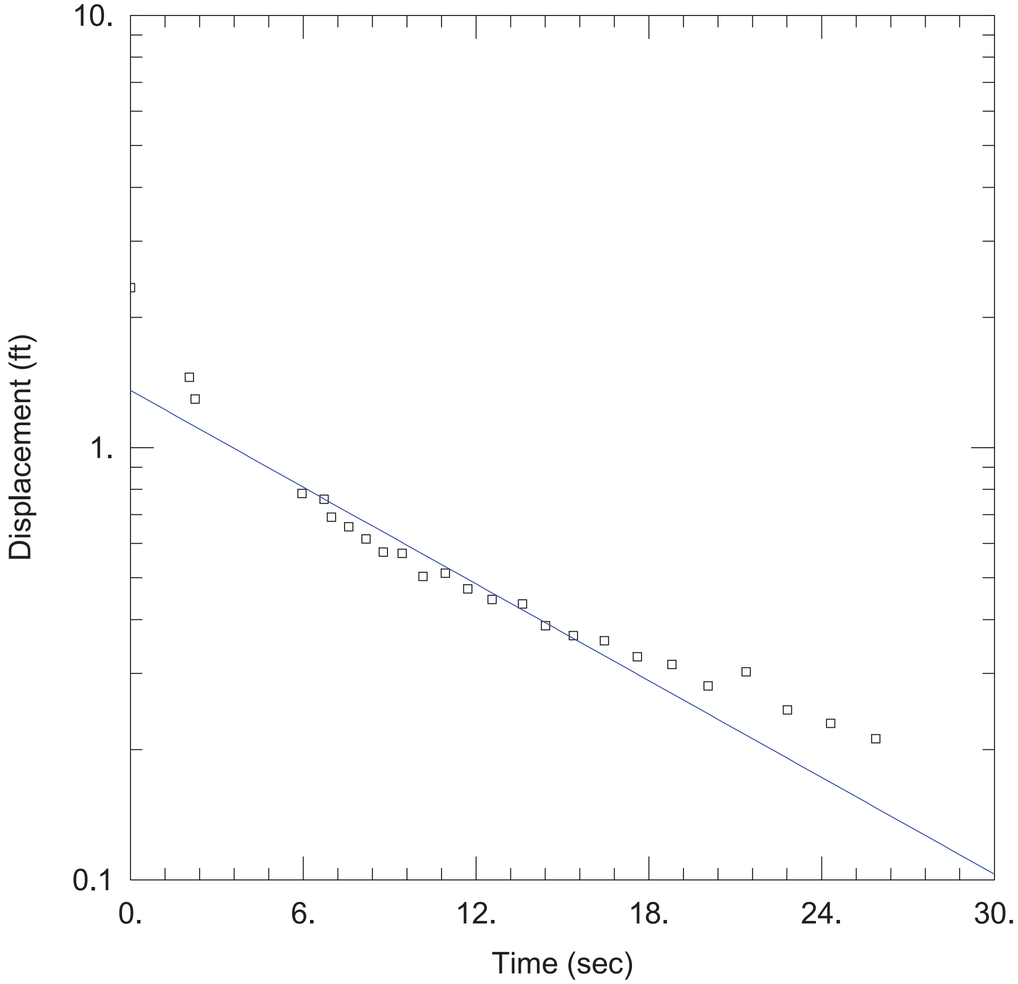
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 71.1 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 7.493 ft/day
y0 = 1.328 ft



JR MW-16003 SLUG IN 4

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:28:45

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

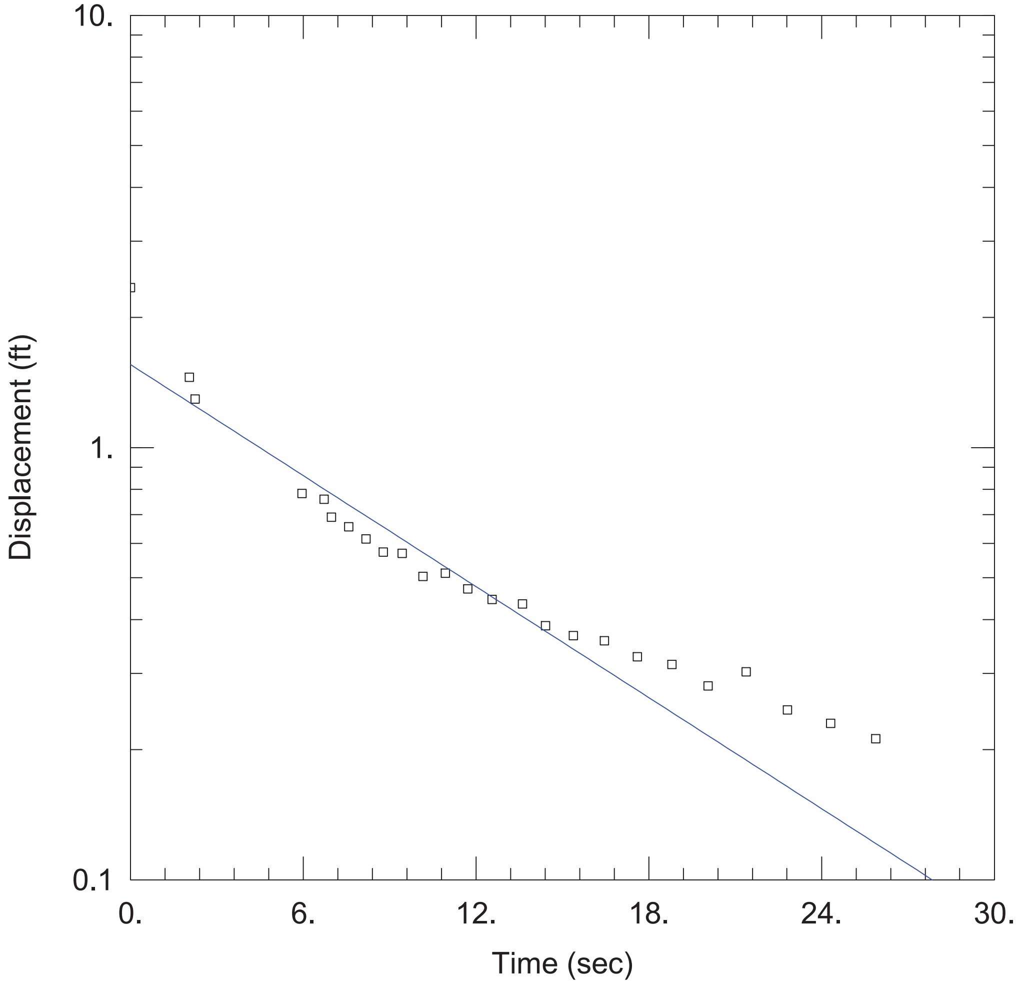
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 71.1 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.671 ft/day
y0 = 1.356 ft



JR MW-16003 SLUG IN 4

Data Set: S:\...\MW-16003.aqt
Date: 11/08/16 Time: 09:29:28

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16003
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

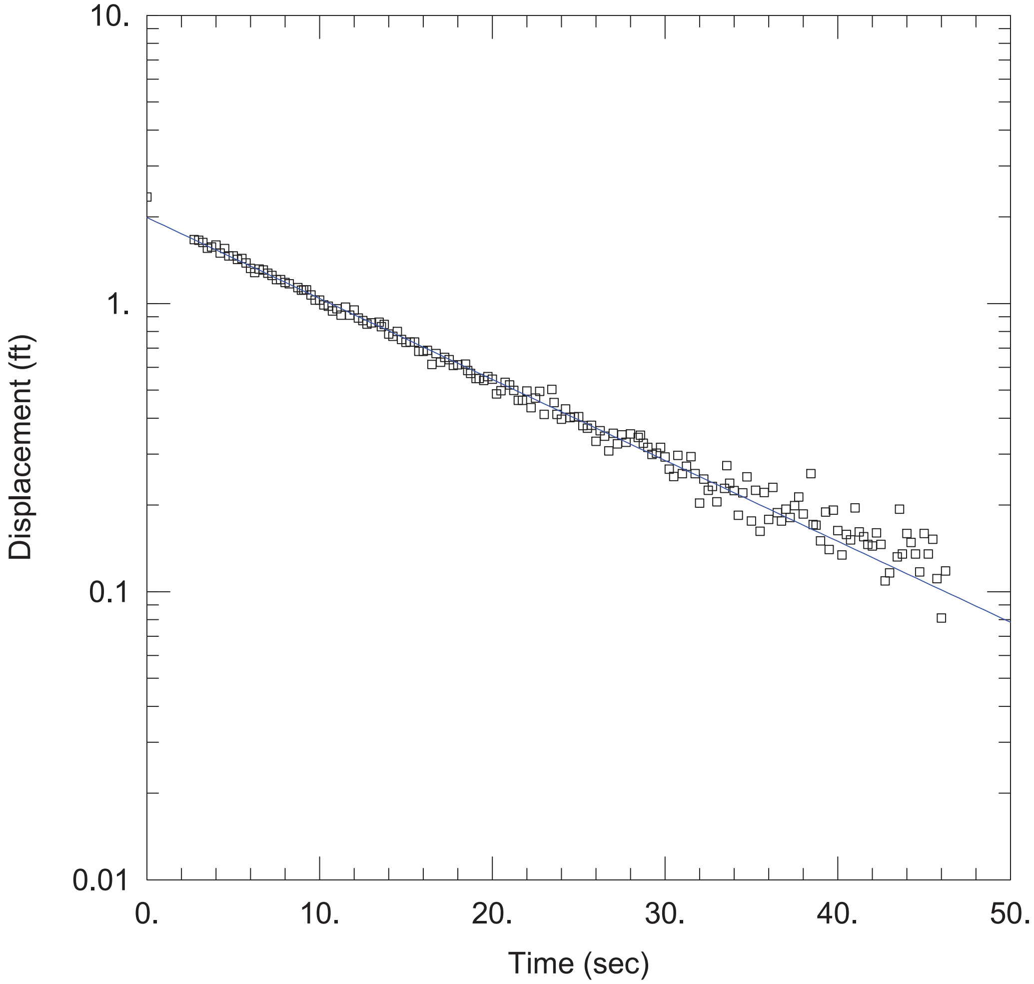
WELL DATA (JR MW-16003)

Initial Displacement: 2.345 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 71.1 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 7.888 ft/day
y0 = 1.556 ft



JR MW-16004 SLUG IN 1

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 15:52:17

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

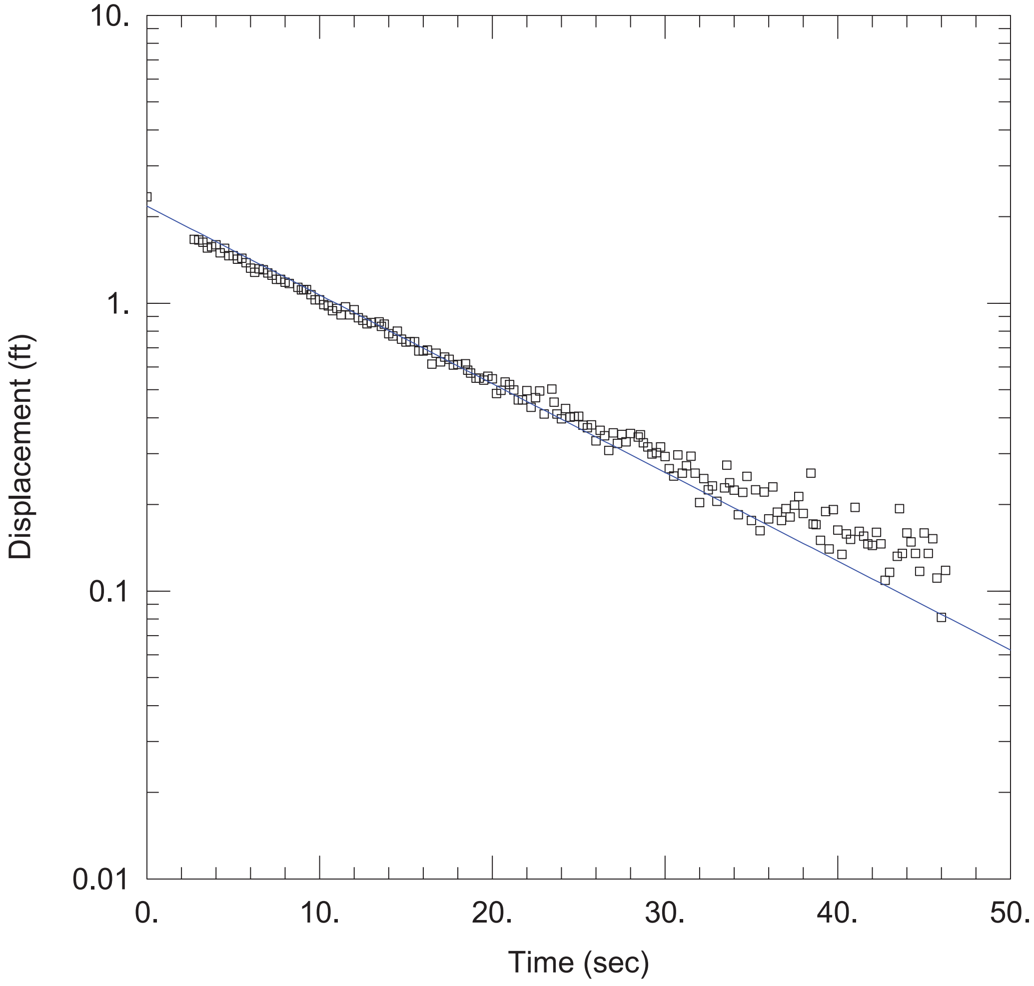
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 16. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.669 ft/day
y0 = 1.987 ft



JR MW-16004 SLUG IN 1

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 15:51:30

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

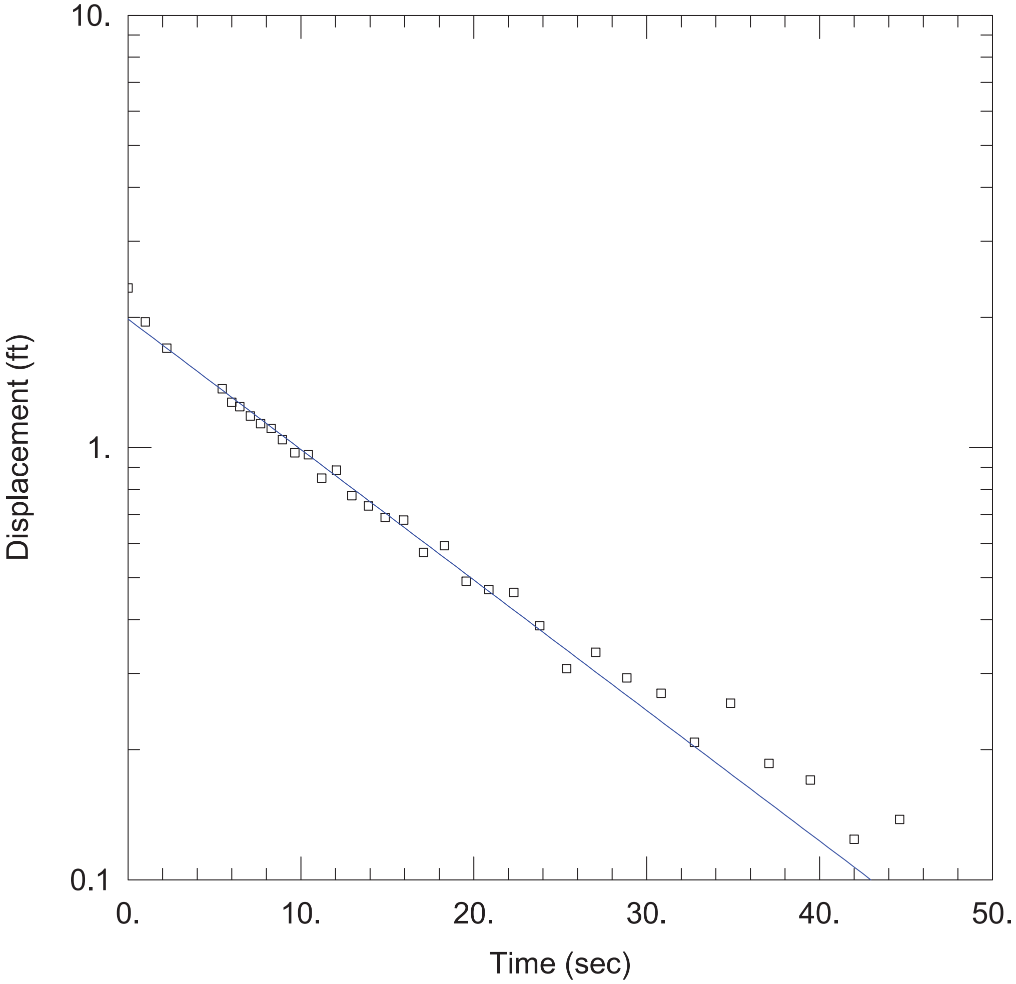
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 16. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.68 ft/day
y0 = 2.173 ft



JR MW-16004 SLUG IN 2

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 15:55:38

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

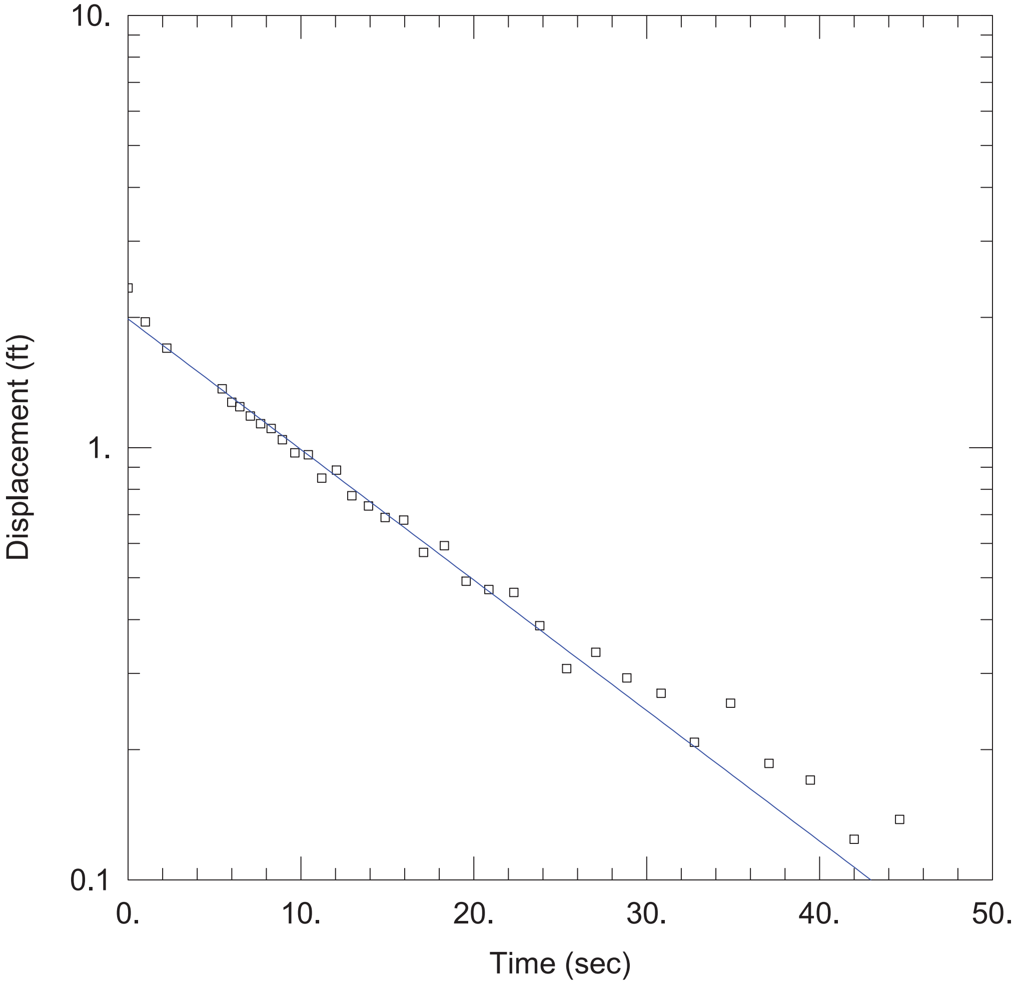
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 16. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.942 ft/day
y0 = 1.983 ft



JR MW-16004 SLUG IN 2

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 15:56:33

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

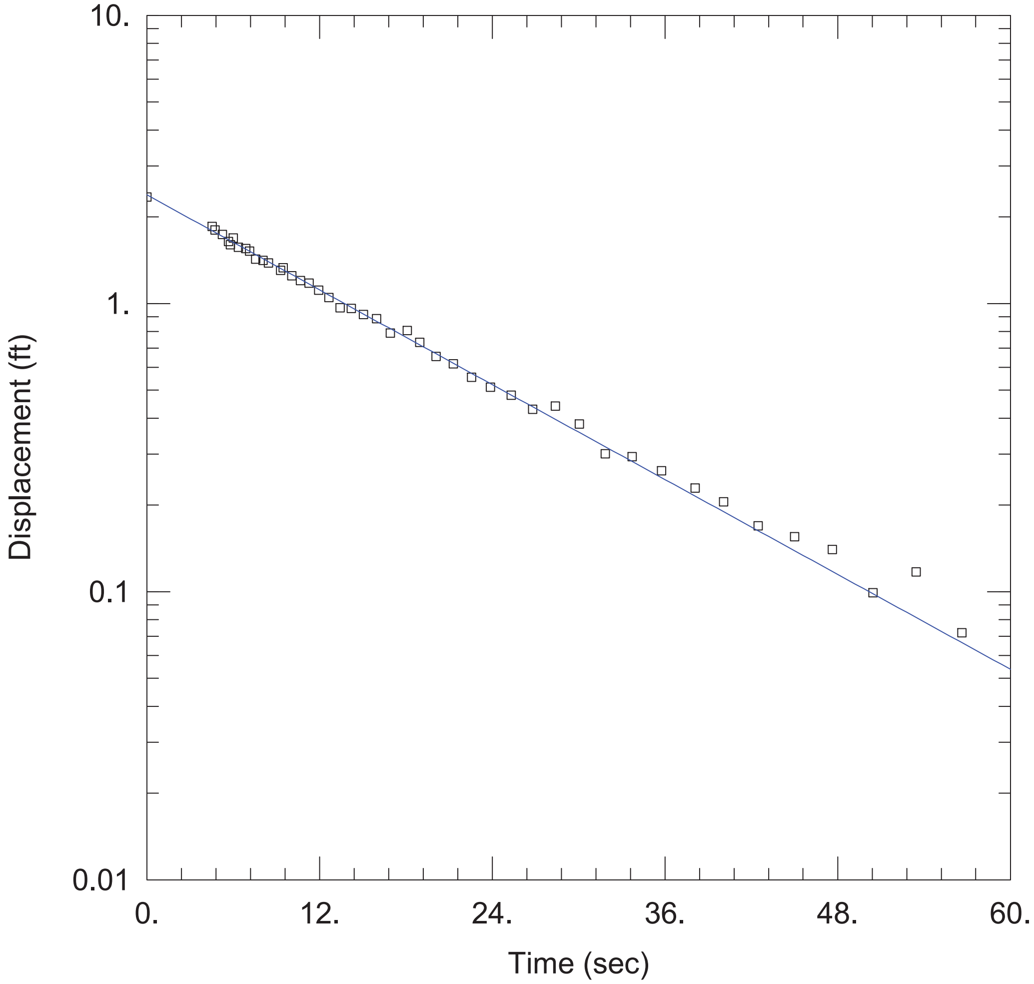
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 16. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.563 ft/day
y0 = 1.983 ft



JR MW-16004 SLUG IN 3

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 16:00:29

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

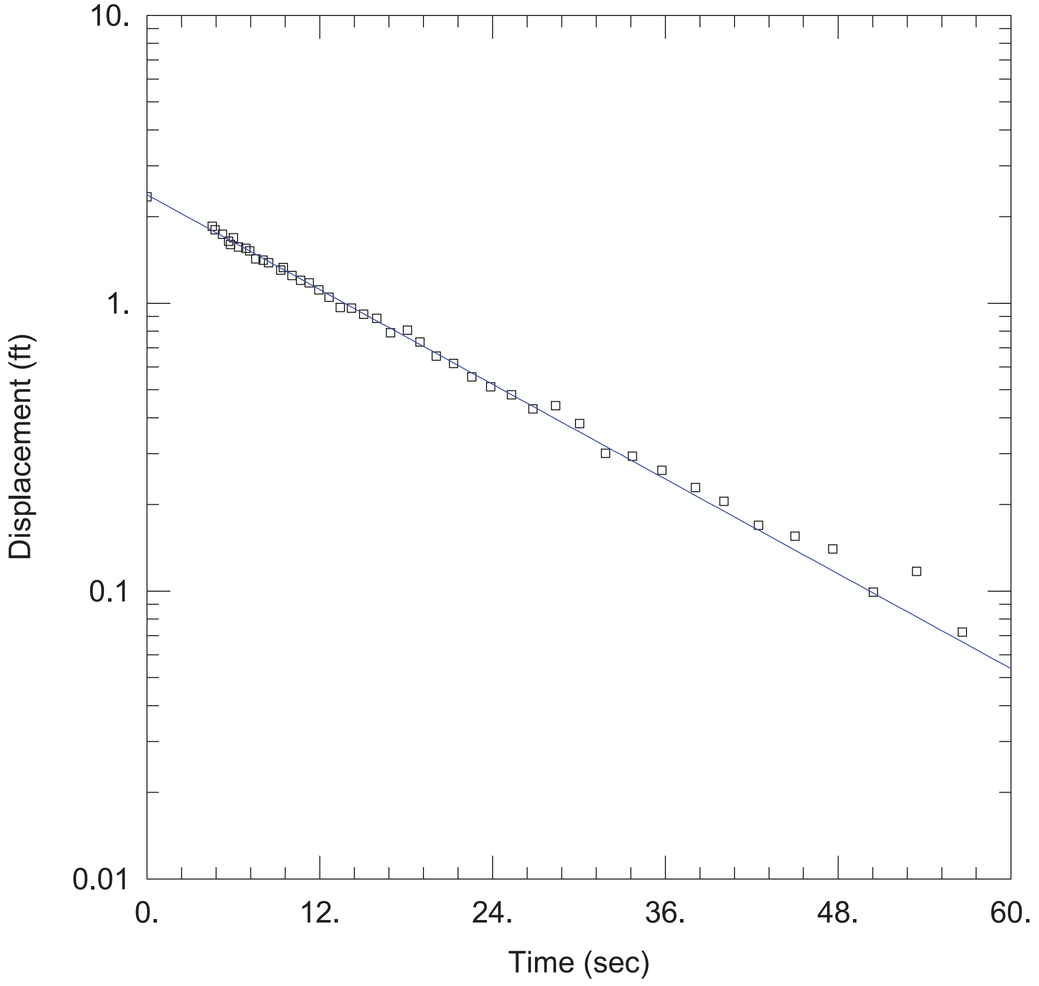
Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 16. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 3.583 ft/day
y0 = 2.381 ft



JR MW-16004 SLUG IN 3

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 15:59:39

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

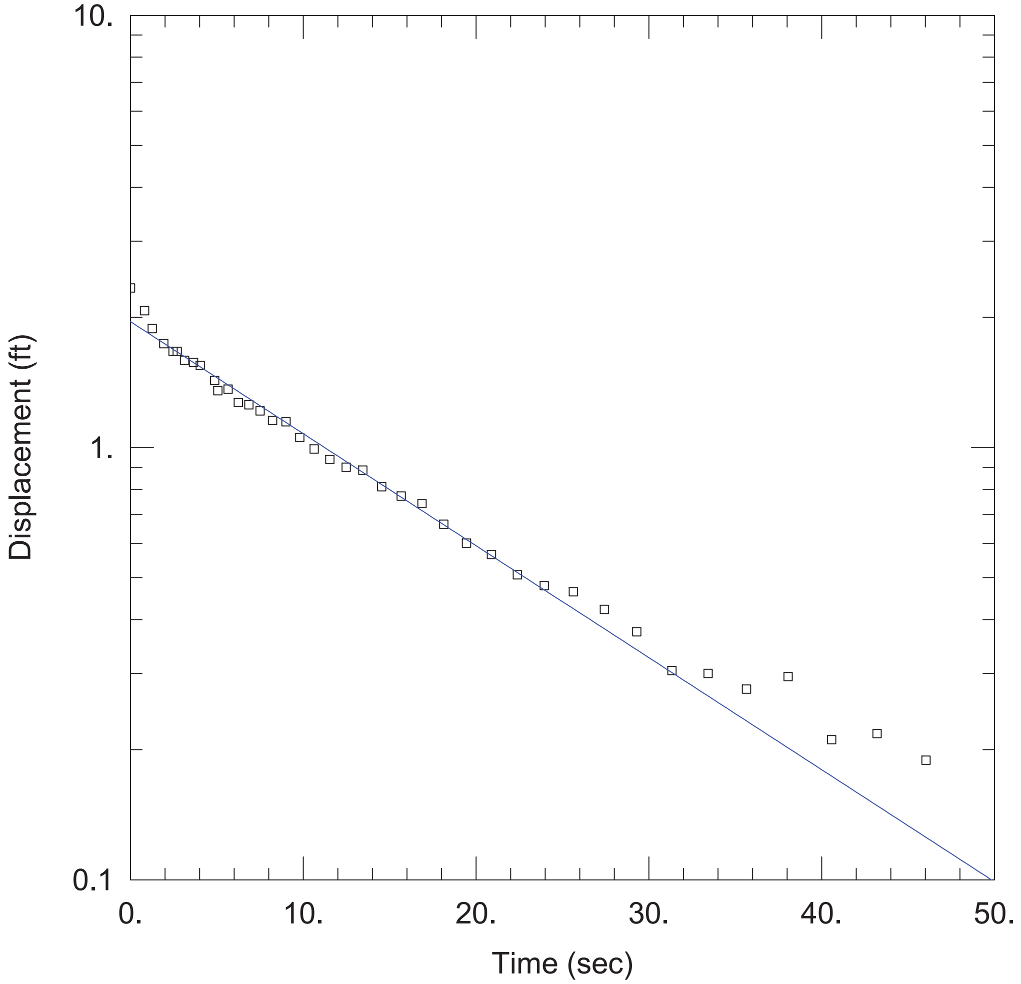
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 16. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.055 ft/day
y0 = 2.38 ft



JR MW-16004 SLUG IN 4

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 16:04:38

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft Anisotropy Ratio (Kz/Kr): 1.

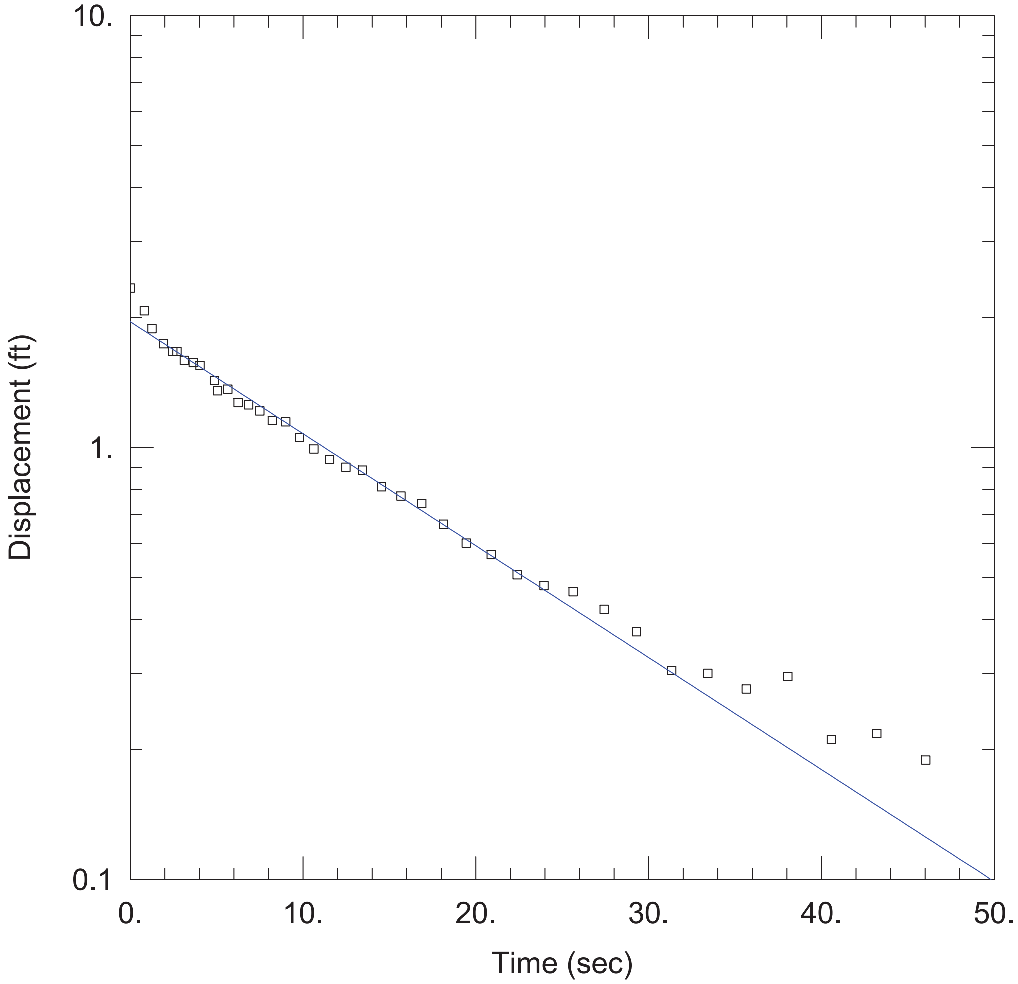
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft Static Water Column Height: 73. ft
Total Well Penetration Depth: 16. ft Screen Length: 10. ft
Casing Radius: 0.0833 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 3.384 ft/day y0 = 1.955 ft



JR MW-16004 SLUG IN 4

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 16:05:24

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

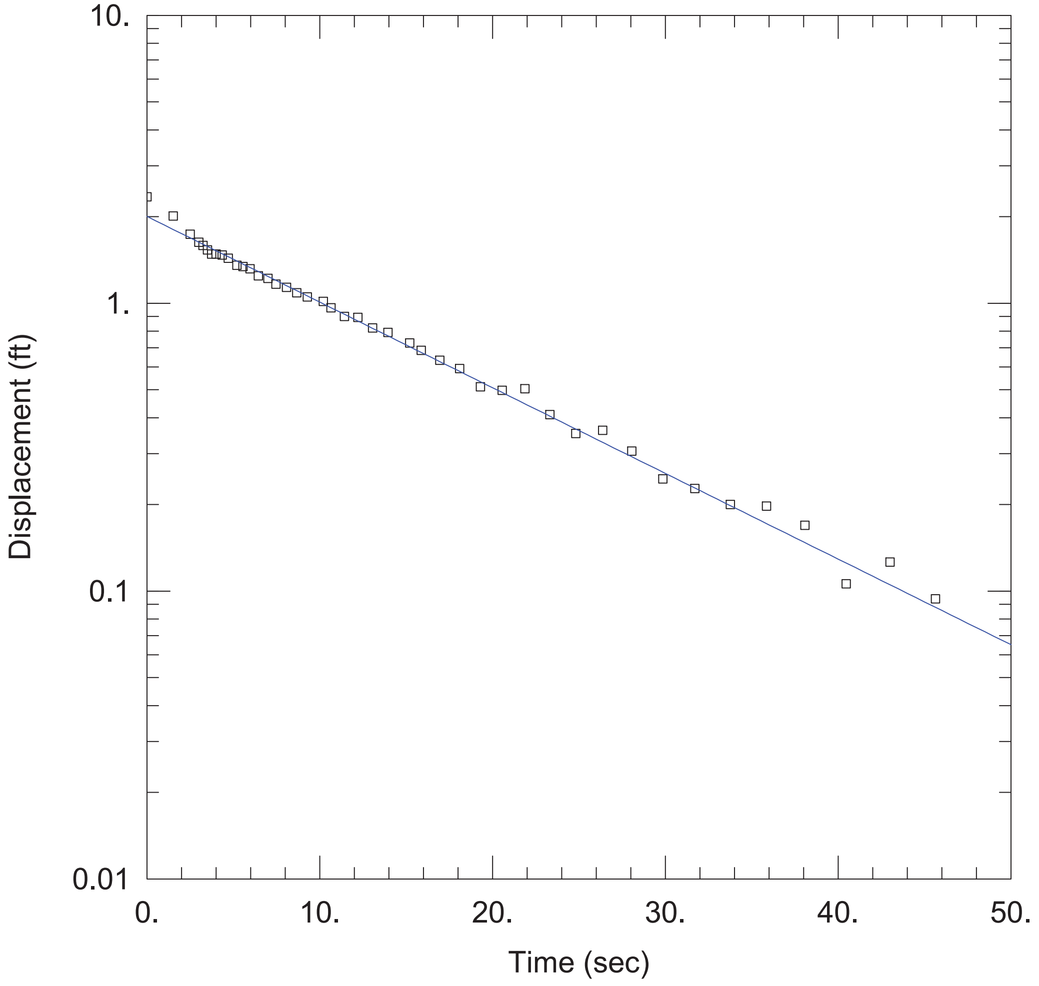
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 16. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.774 ft/day
y0 = 1.955 ft



JR MW-16004 SLUG IN 5

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 16:08:03

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

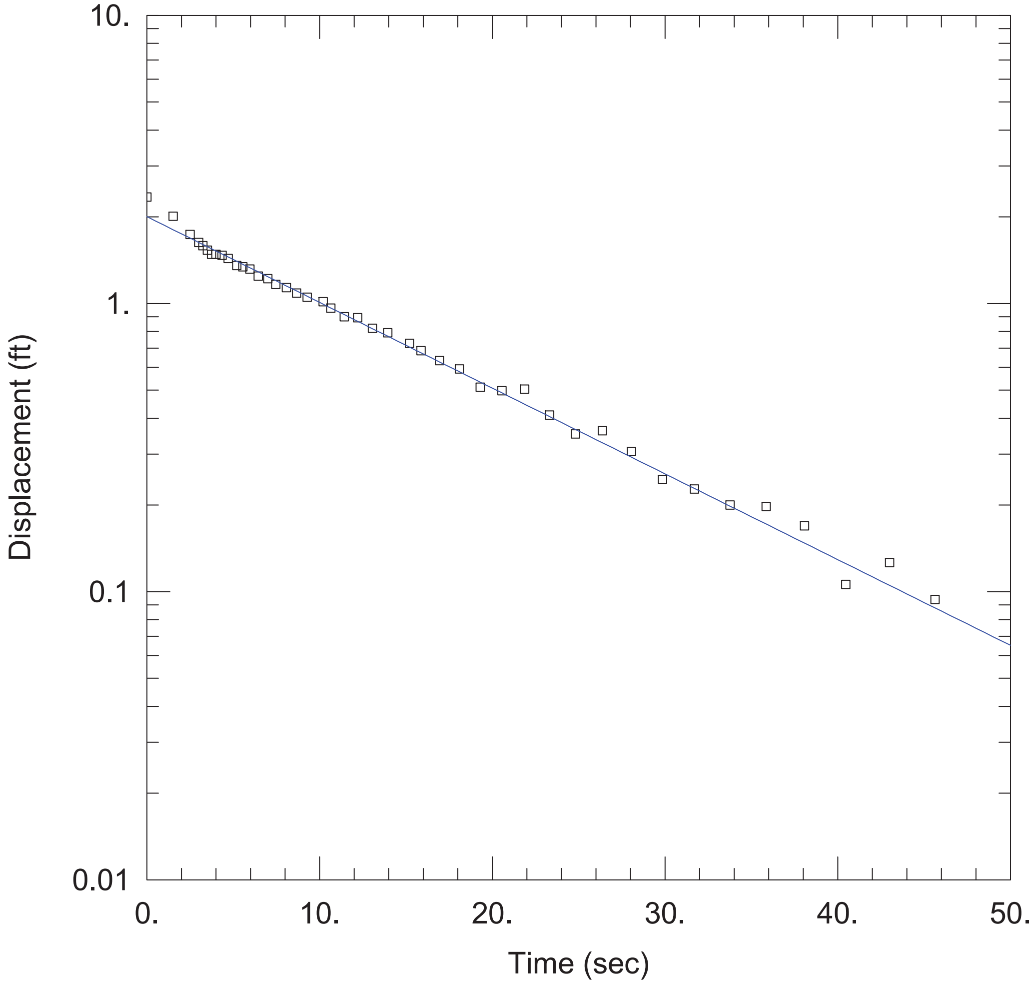
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 16. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.886 ft/day
y0 = 2.001 ft



JR MW-16004 SLUG IN 5

Data Set: S:\...\MW-16004.aqt
Date: 11/07/16 Time: 16:07:33

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16004
Test Date: 11/1/16

AQUIFER DATA

Saturated Thickness: 16. ft
Anisotropy Ratio (Kz/Kr): 1.

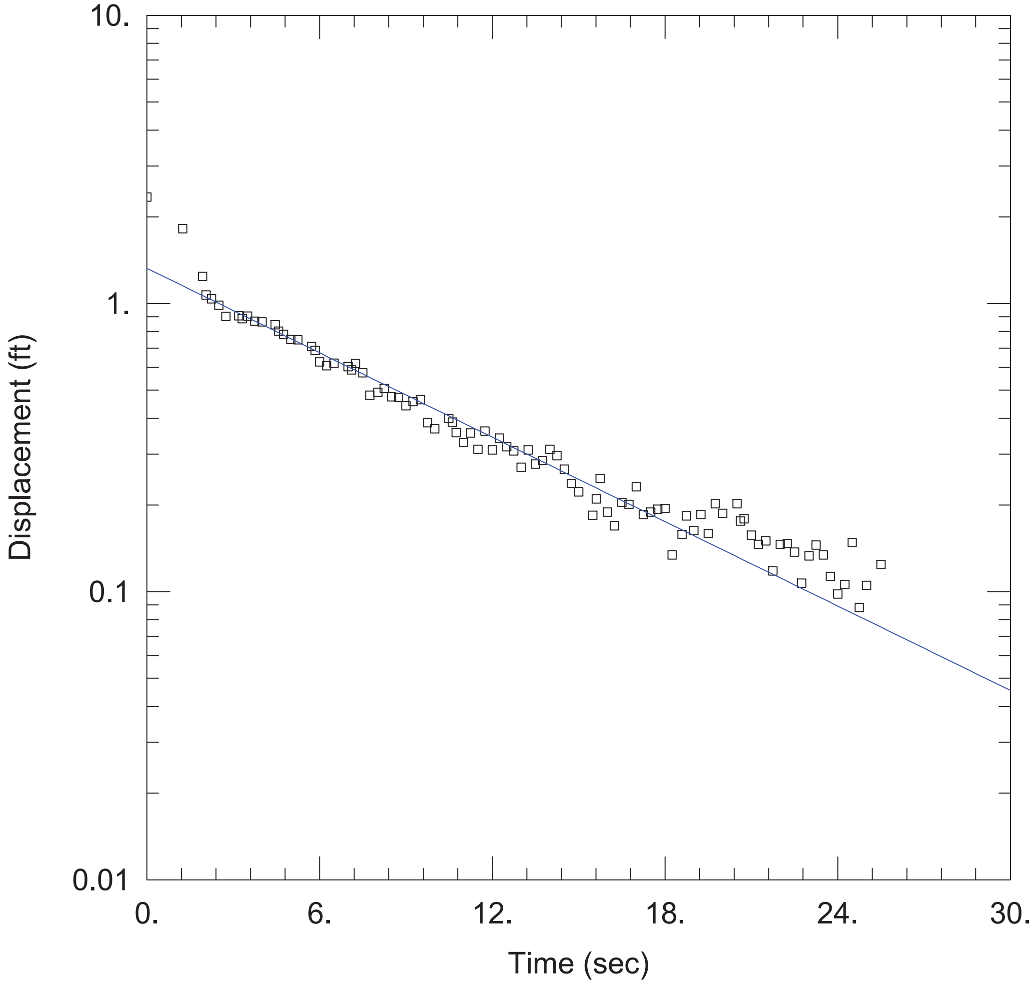
WELL DATA (JR MW-16004)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 16. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.482 ft/day
y0 = 2.001 ft



JR MW-16005 SLUG IN 1

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:15:32

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

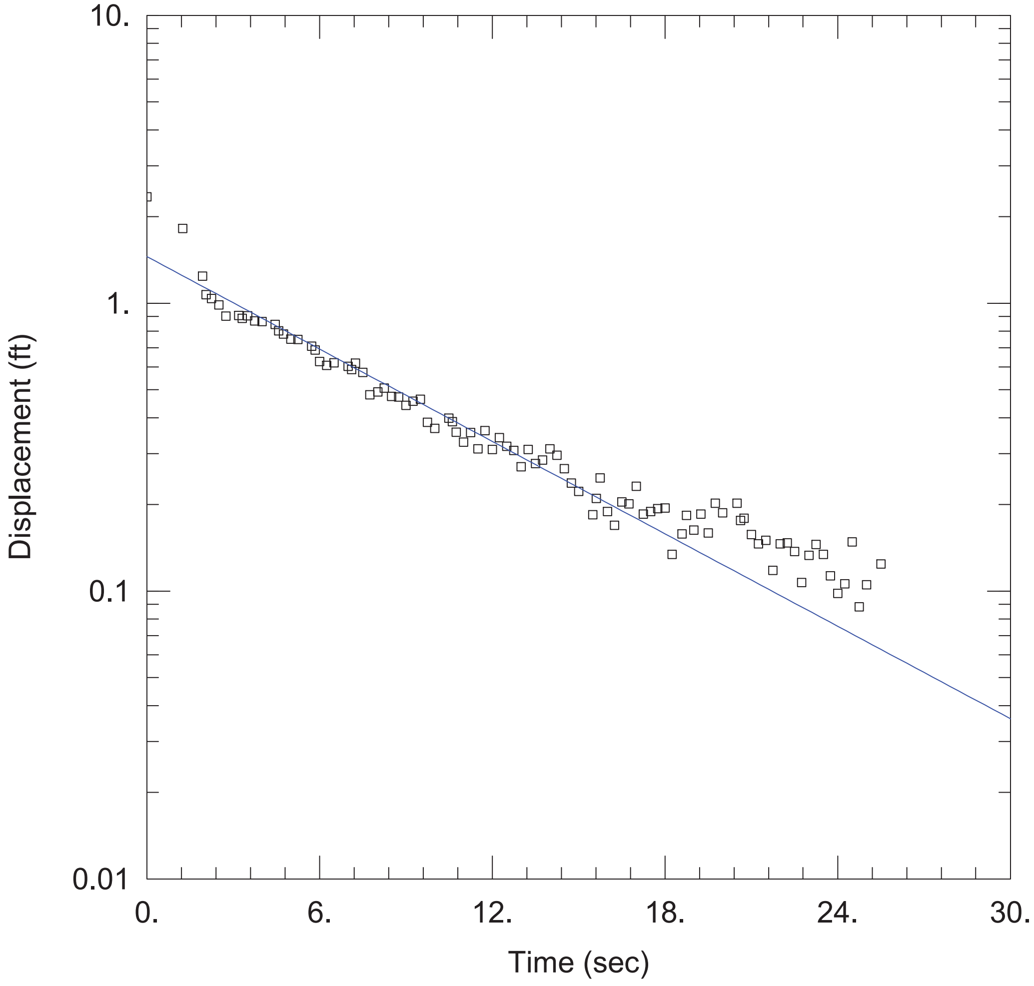
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 6.296 ft/day y0 = 1.324 ft



JR MW-16005 SLUG IN 1

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:14:24

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

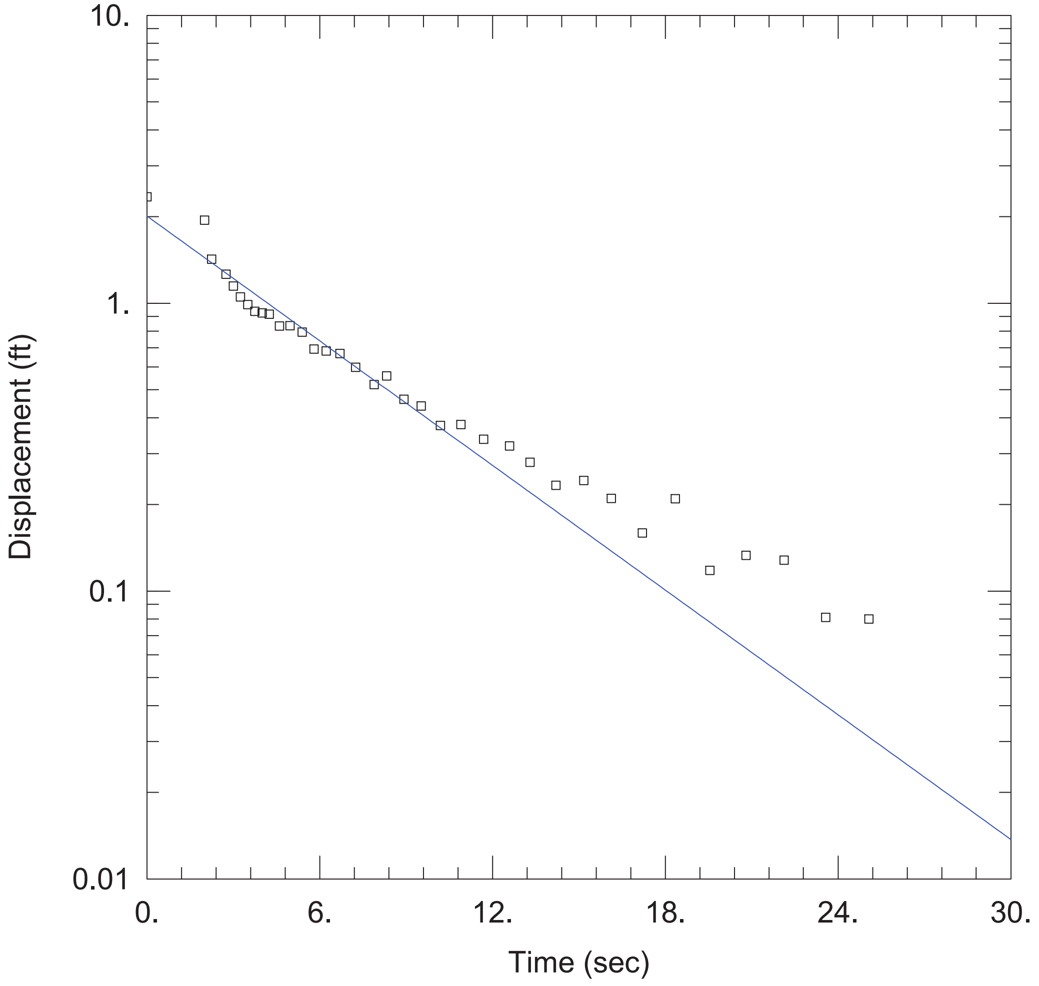
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 9.859 ft/day y0 = 1.452 ft



JR MW-16005 SLUG IN 2

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16
Time: 16:17:55

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

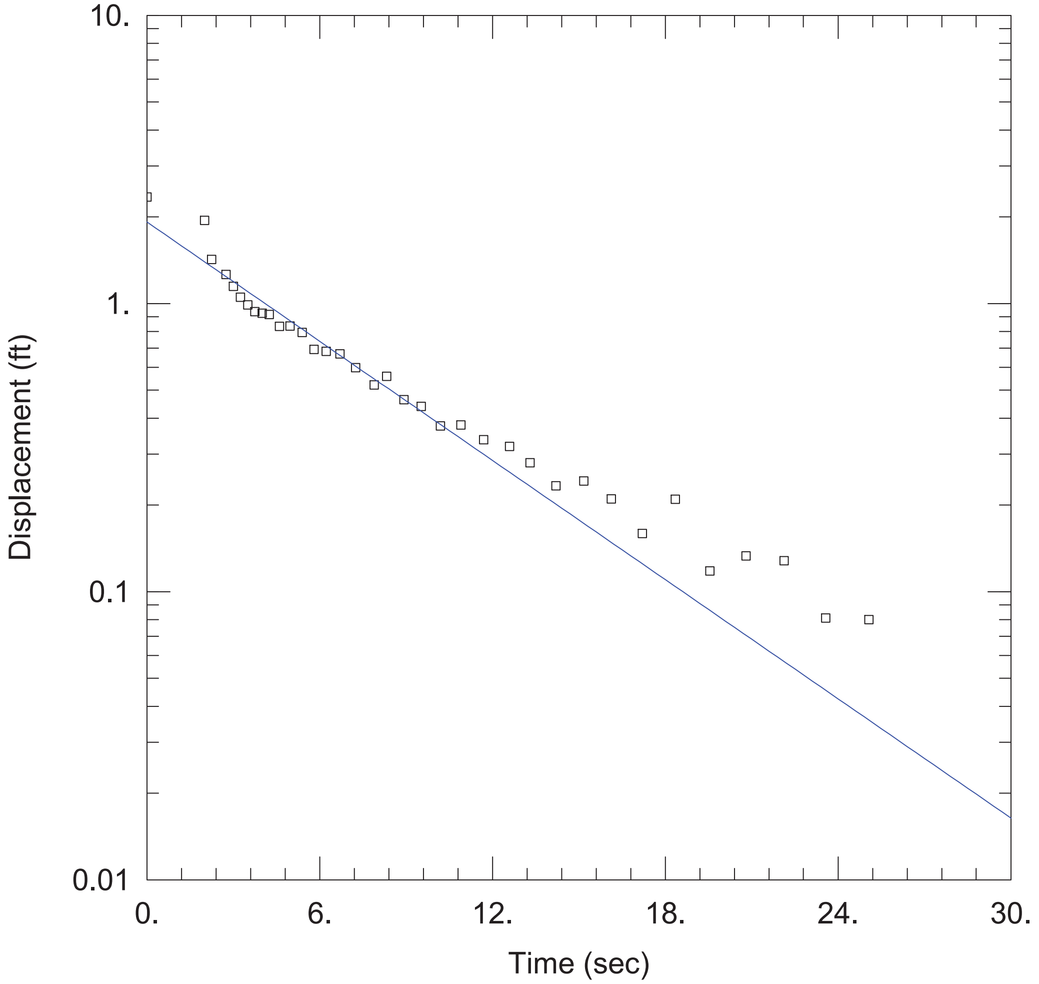
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Static Water Column Height: 73.2 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.309 ft/day
y0 = 2.007 ft



JR MW-16005 SLUG IN 2

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:19:41

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

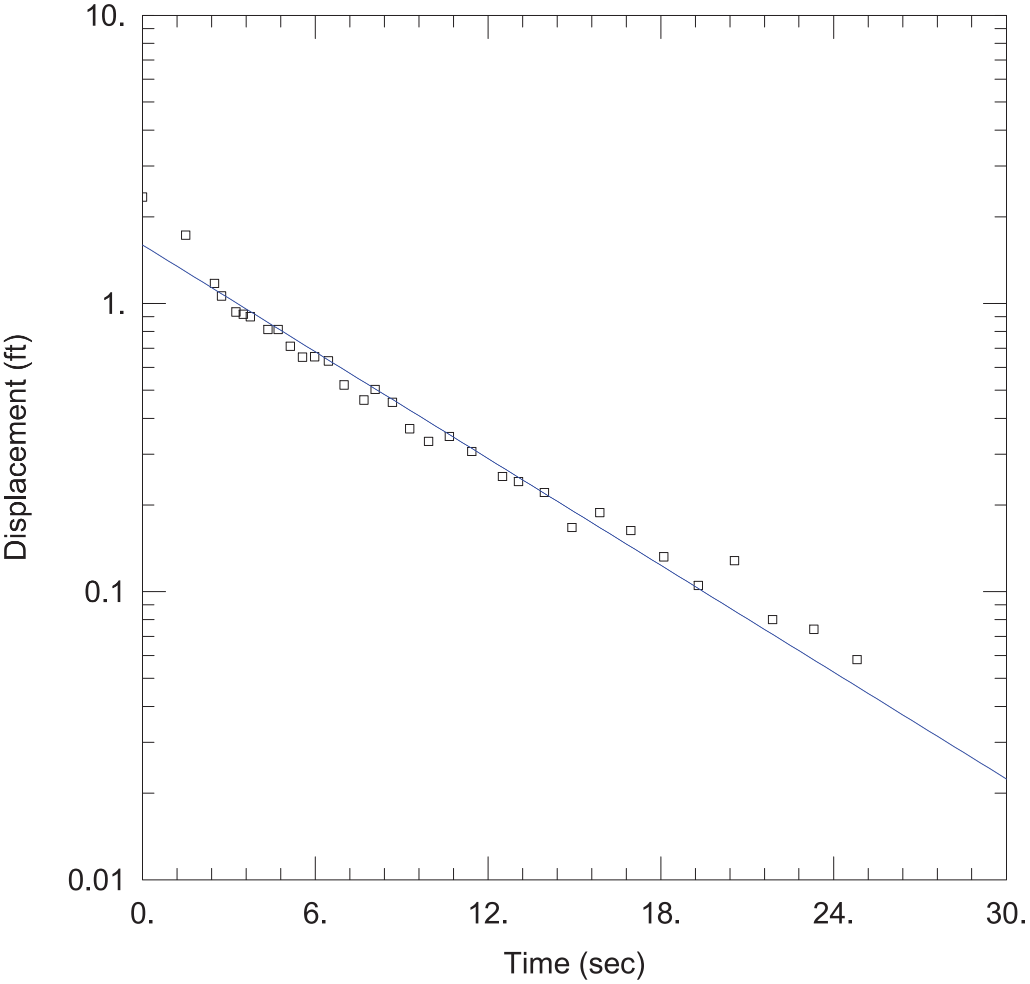
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 12.7 ft/day
y0 = 1.917 ft



JR MW-16005 SLUG IN 3

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:24:41

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

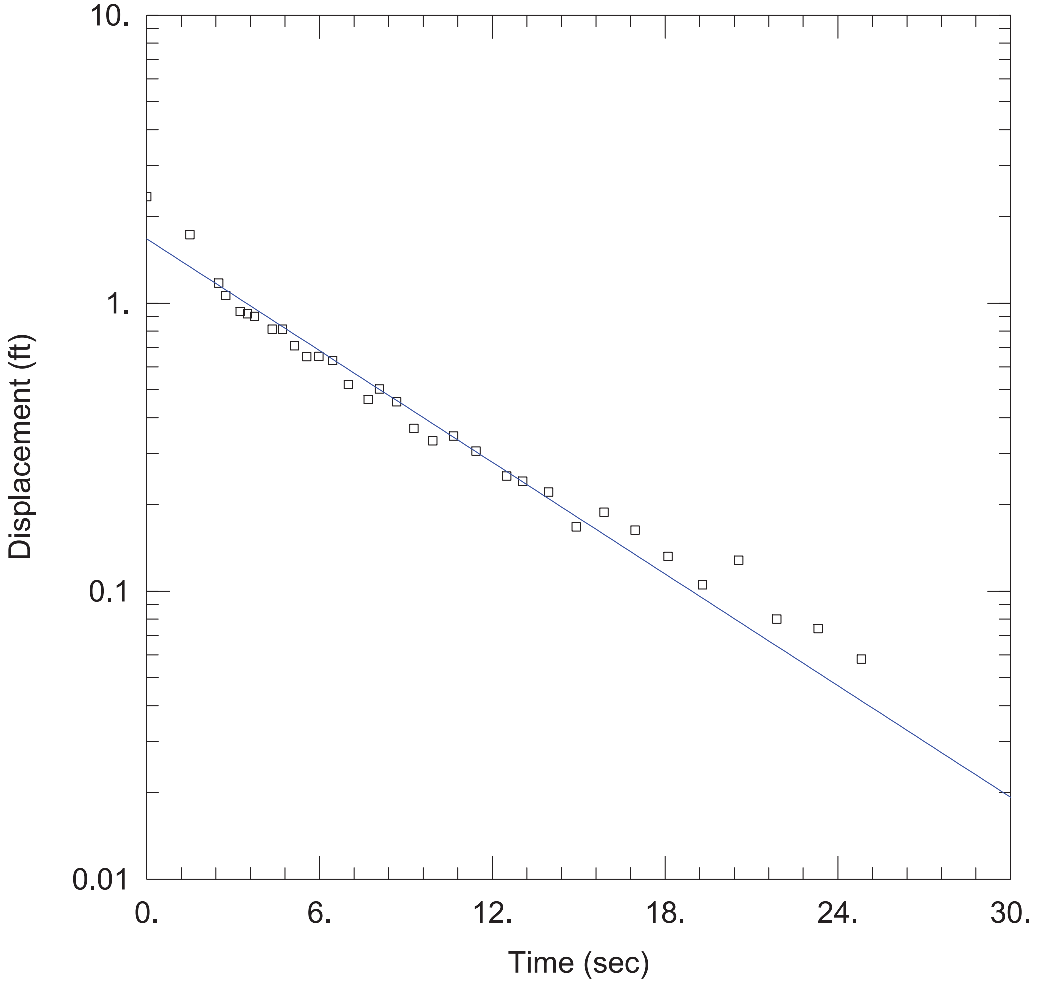
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 15. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 7.965 ft/day
y0 = 1.597 ft



JR MW-16005 SLUG IN 3

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:23:23

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

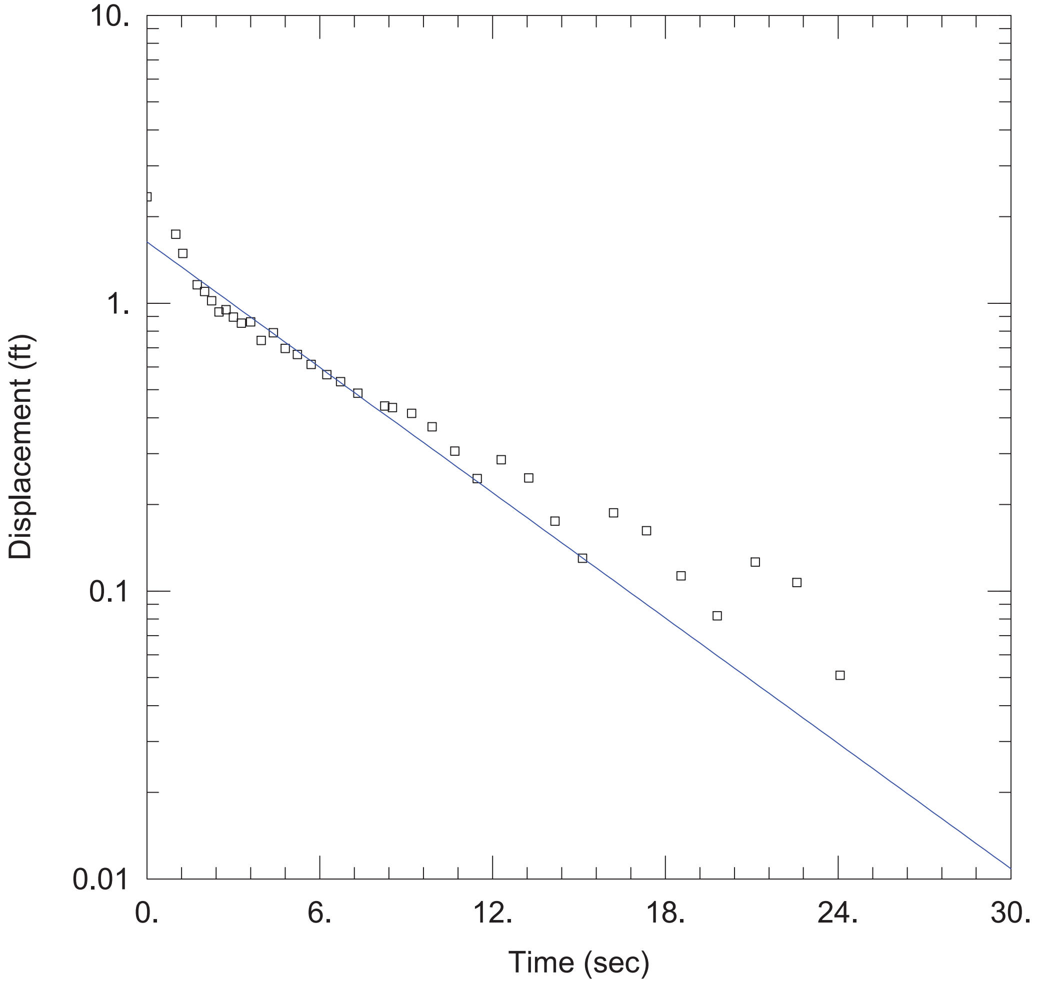
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft Static Water Column Height: 73.2 ft
Total Well Penetration Depth: 15. ft Screen Length: 10. ft
Casing Radius: 0.0833 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 11.91 ft/day y0 = 1.671 ft



JR MW-16005 SLUG IN 4

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:26:45

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

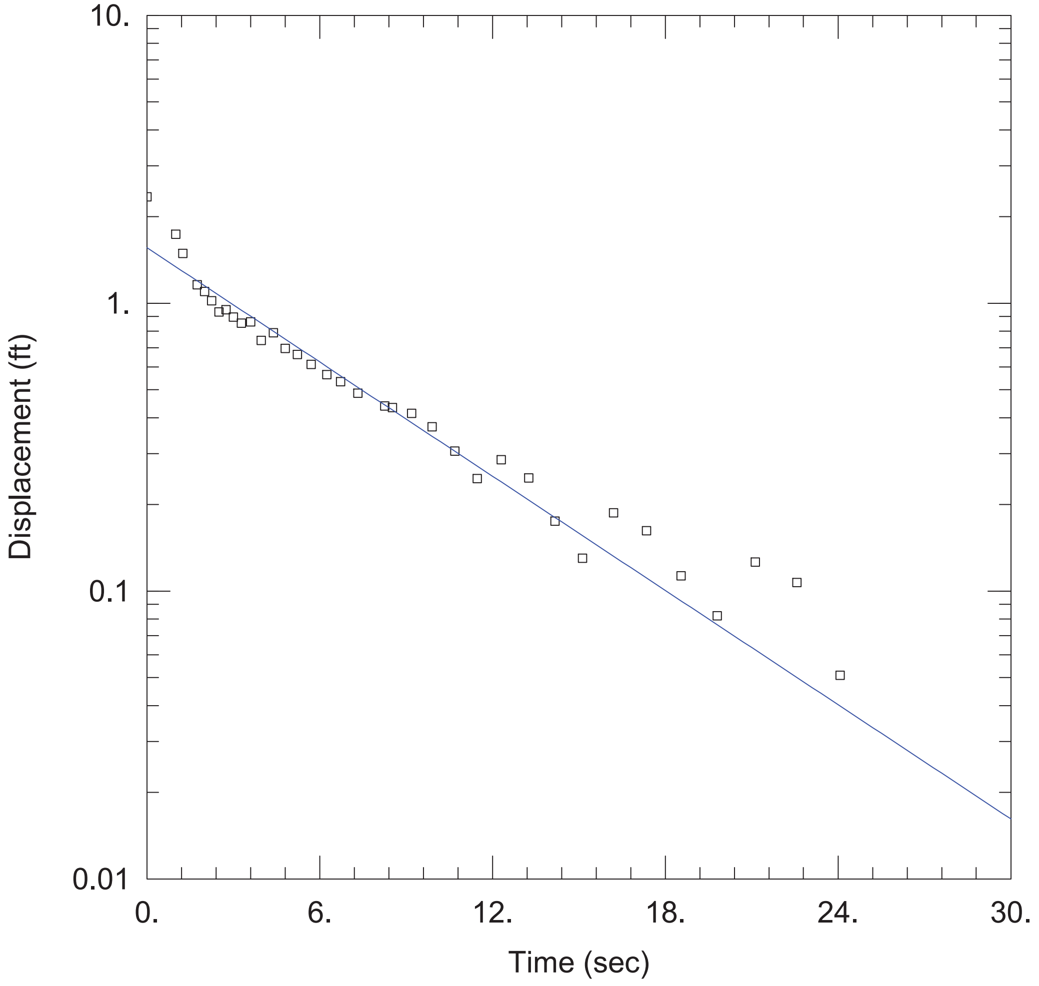
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft Static Water Column Height: 73.2 ft
Total Well Penetration Depth: 15. ft Screen Length: 10. ft
Casing Radius: 0.0833 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 9.359 ft/day y0 = 1.633 ft



JR MW-16005 SLUG IN 4

Data Set: S:\...\MW-16005.aqt
Date: 11/07/16 Time: 16:28:15

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16005
Test Date: 11/3/16

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

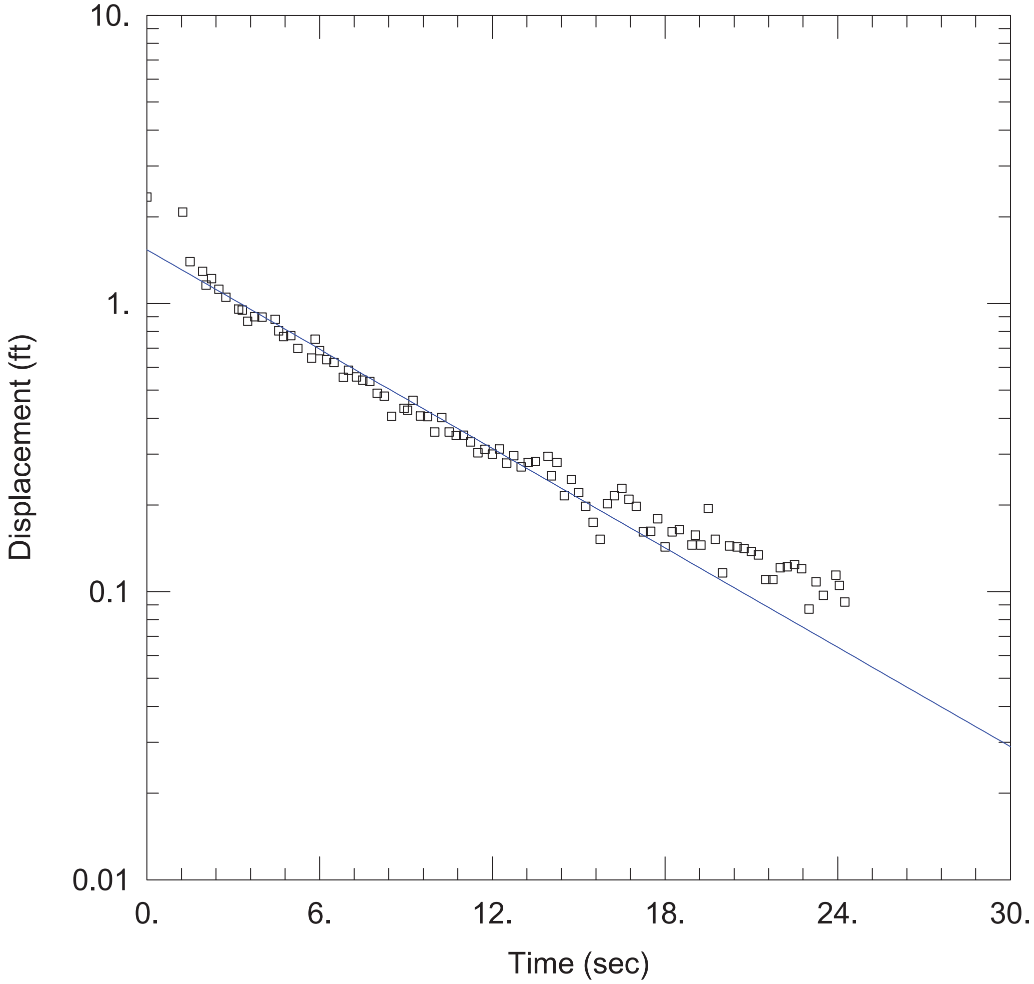
WELL DATA (JR MW-16005)

Initial Displacement: 2.34 ft
Static Water Column Height: 73.2 ft
Total Well Penetration Depth: 15. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 12.19 ft/day
y0 = 1.559 ft



JR MW-16006 SLUG IN 1

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:35:42

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

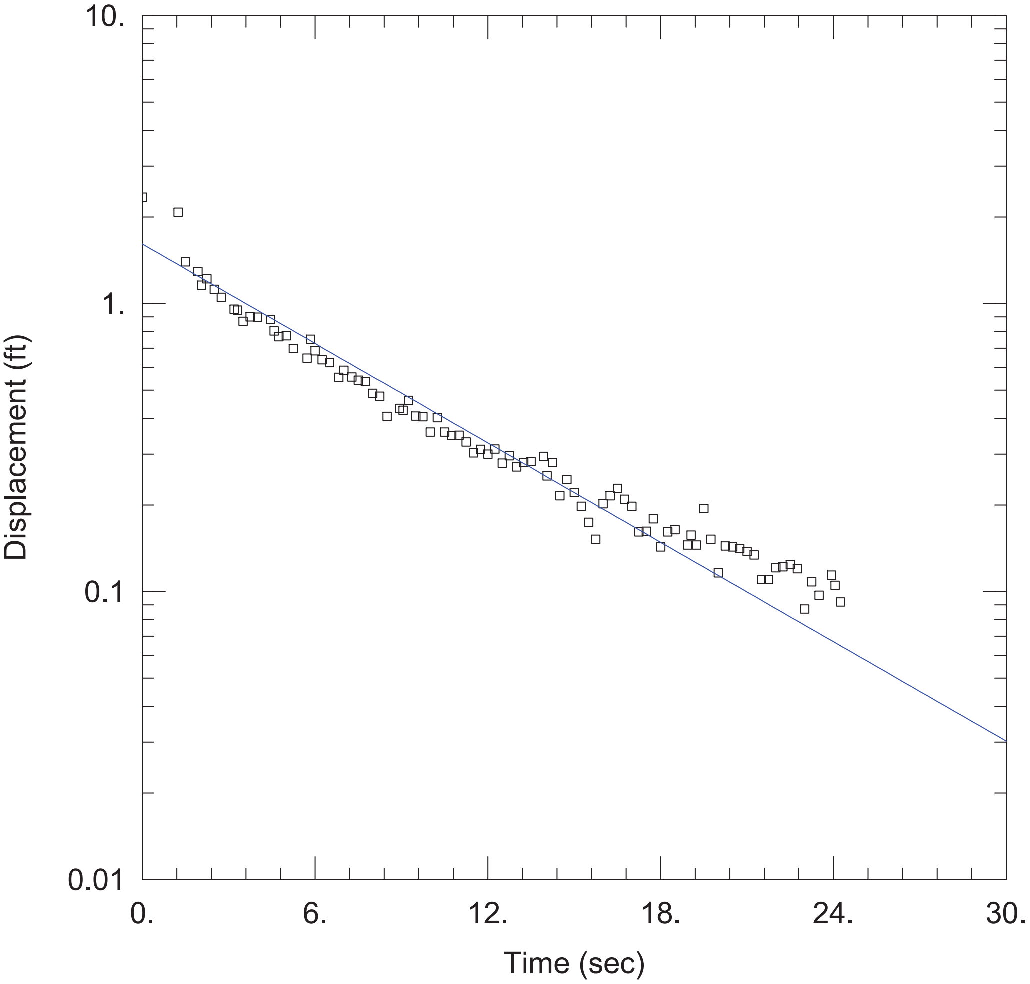
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 7.198 ft/day
y0 = 1.537 ft



JR MW-16006 SLUG IN 1

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16
Time: 16:33:13

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

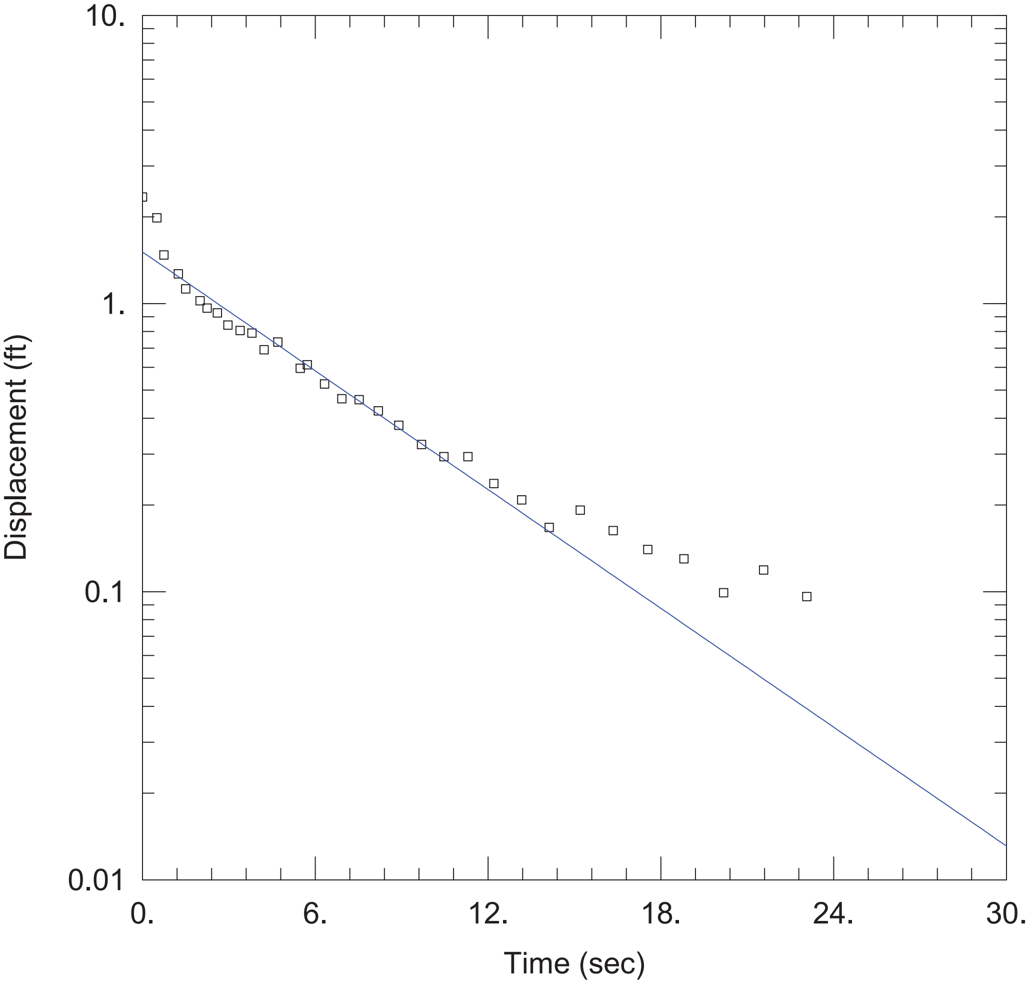
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 75. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 10.6 ft/day
y0 = 1.61 ft



JR MW-16006 SLUG IN 2

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:44:16

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

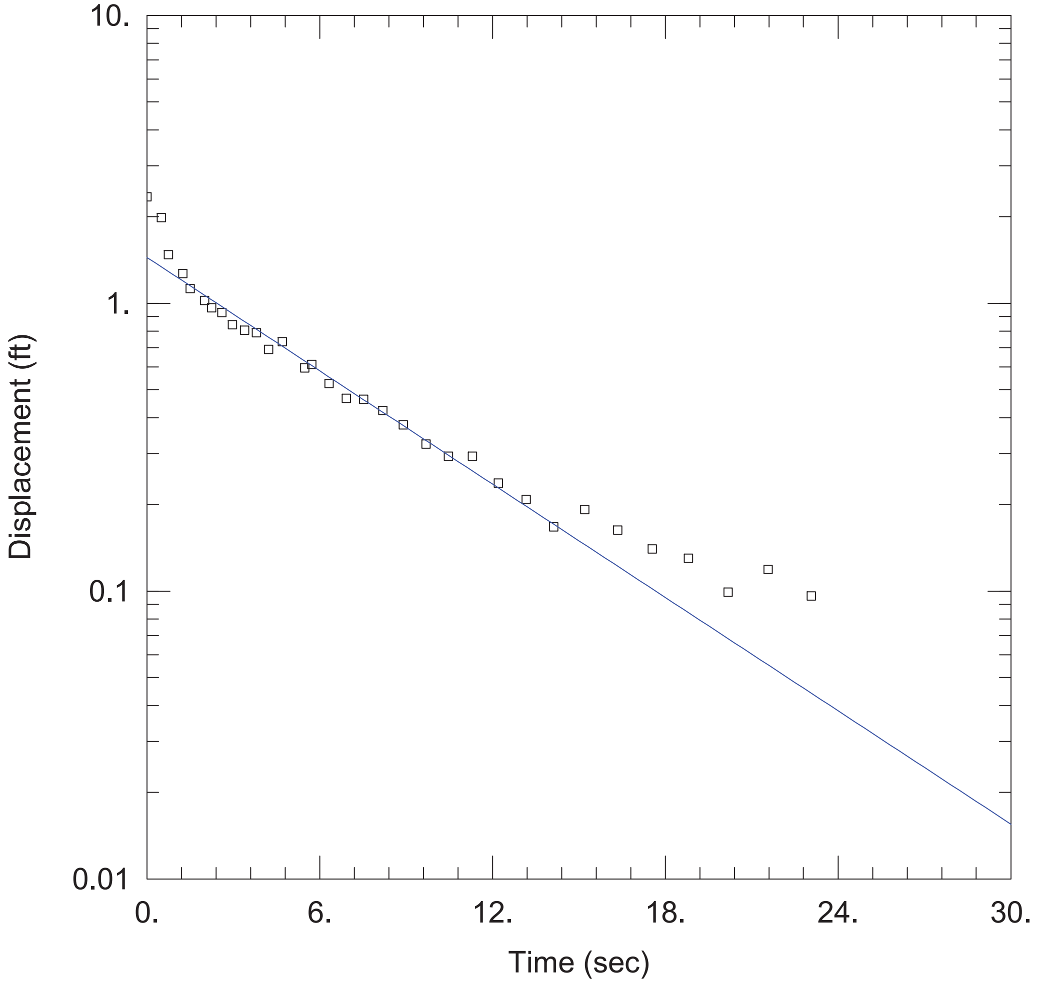
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 8.603 ft/day
y0 = 1.509 ft



JR MW-16006 SLUG IN 2

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:45:46

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

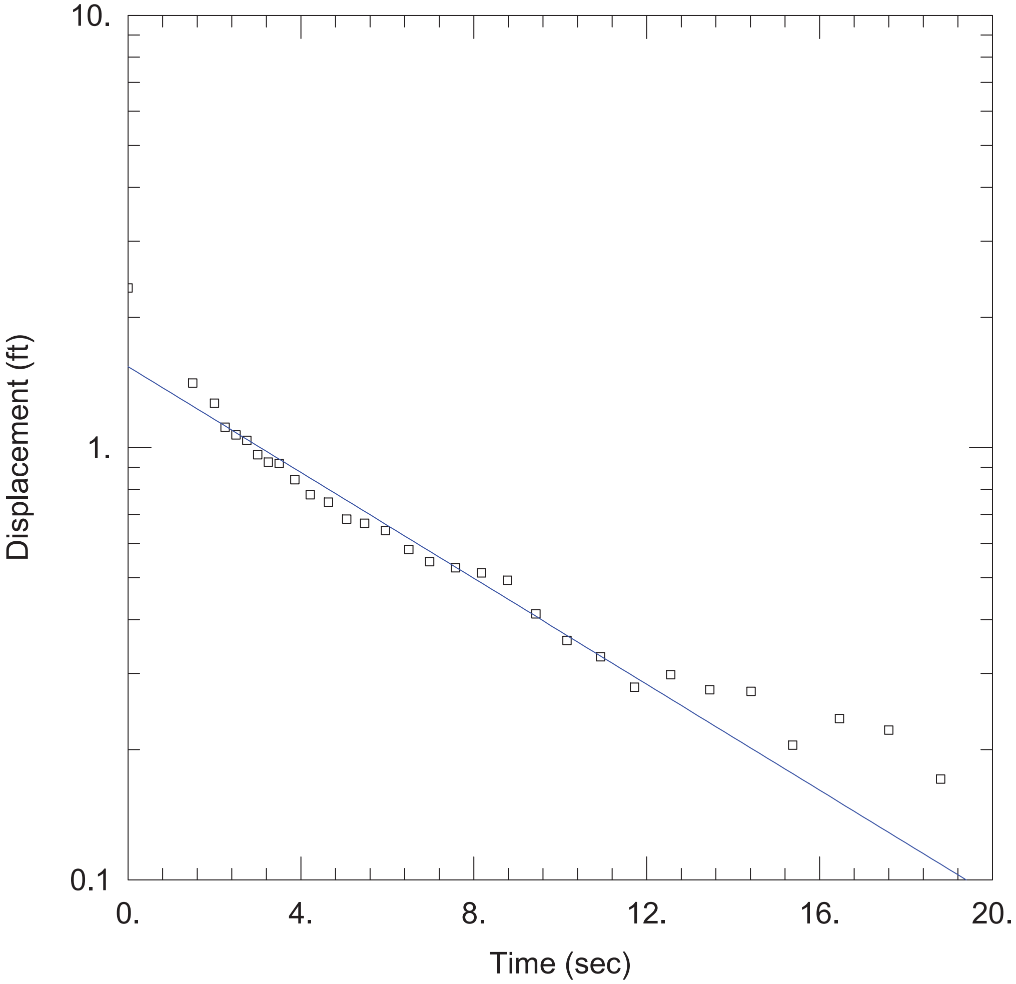
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 75. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 12.09 ft/day
y0 = 1.441 ft



JR MW-16006 SLUG IN 3

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16
Time: 16:48:54

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

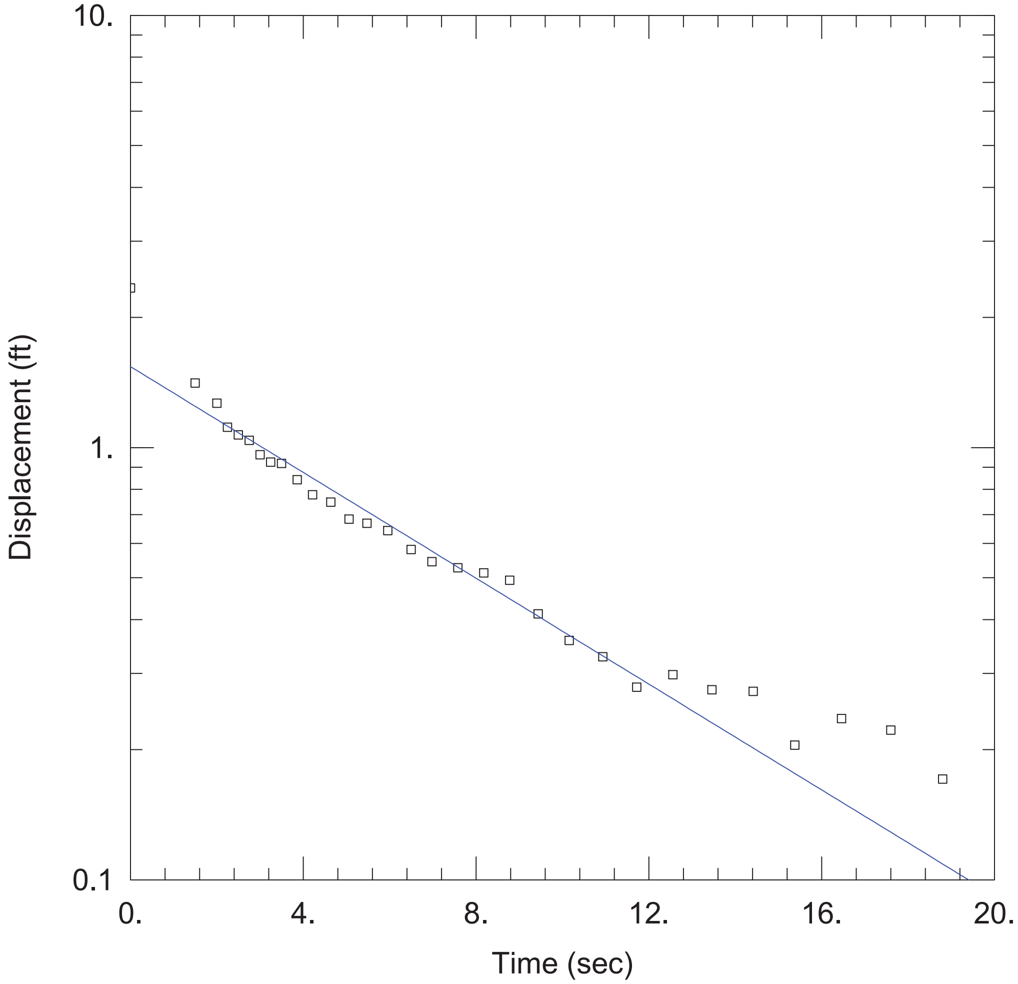
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 7.663 ft/day
y0 = 1.539 ft



JR MW-16006 SLUG IN 3

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:48:08

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

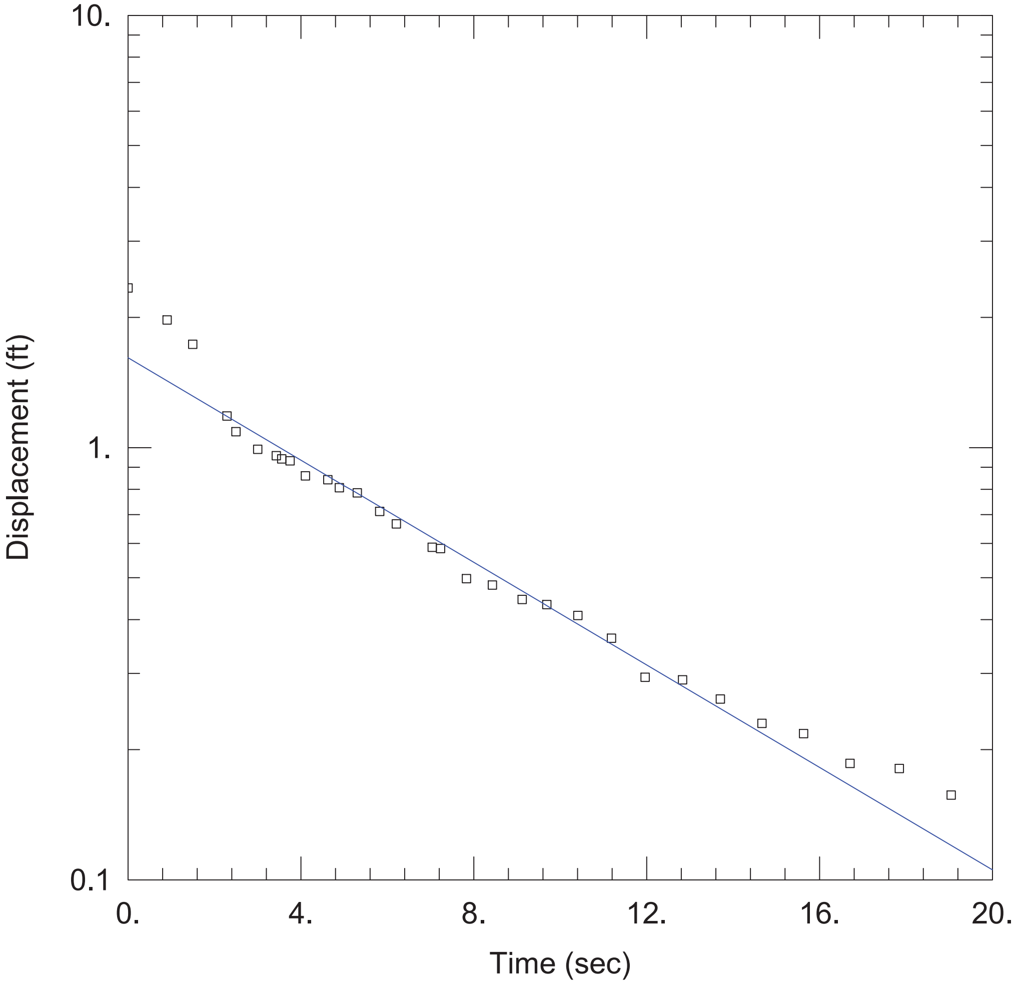
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 11.27 ft/day
y0 = 1.539 ft



JR MW-16006 SLUG IN 4

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:51:25

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

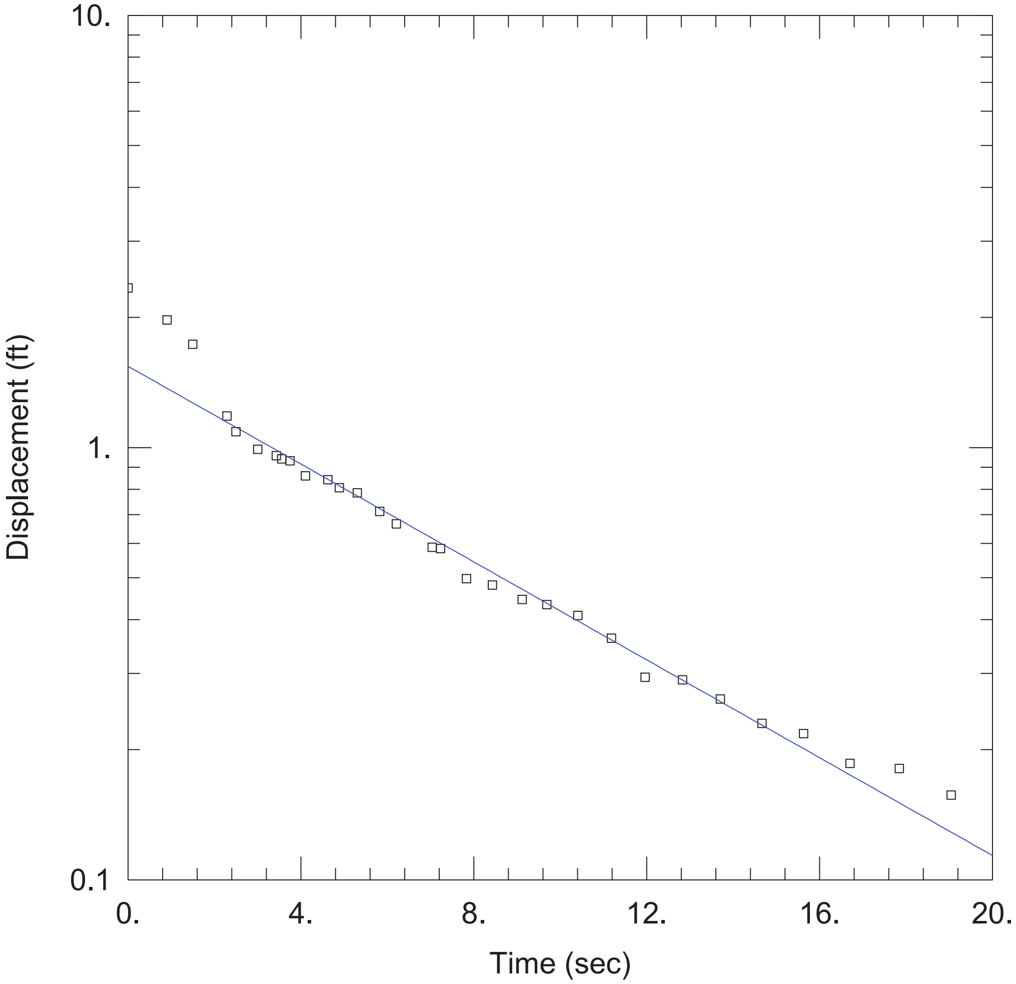
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 7.415 ft/day
y0 = 1.614 ft



JR MW-16006 SLUG IN 4

Data Set: S:\...\MW-16006.aqt
Date: 11/07/16 Time: 16:52:44

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16006
Test Date: 11/2/16

AQUIFER DATA

Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 1.

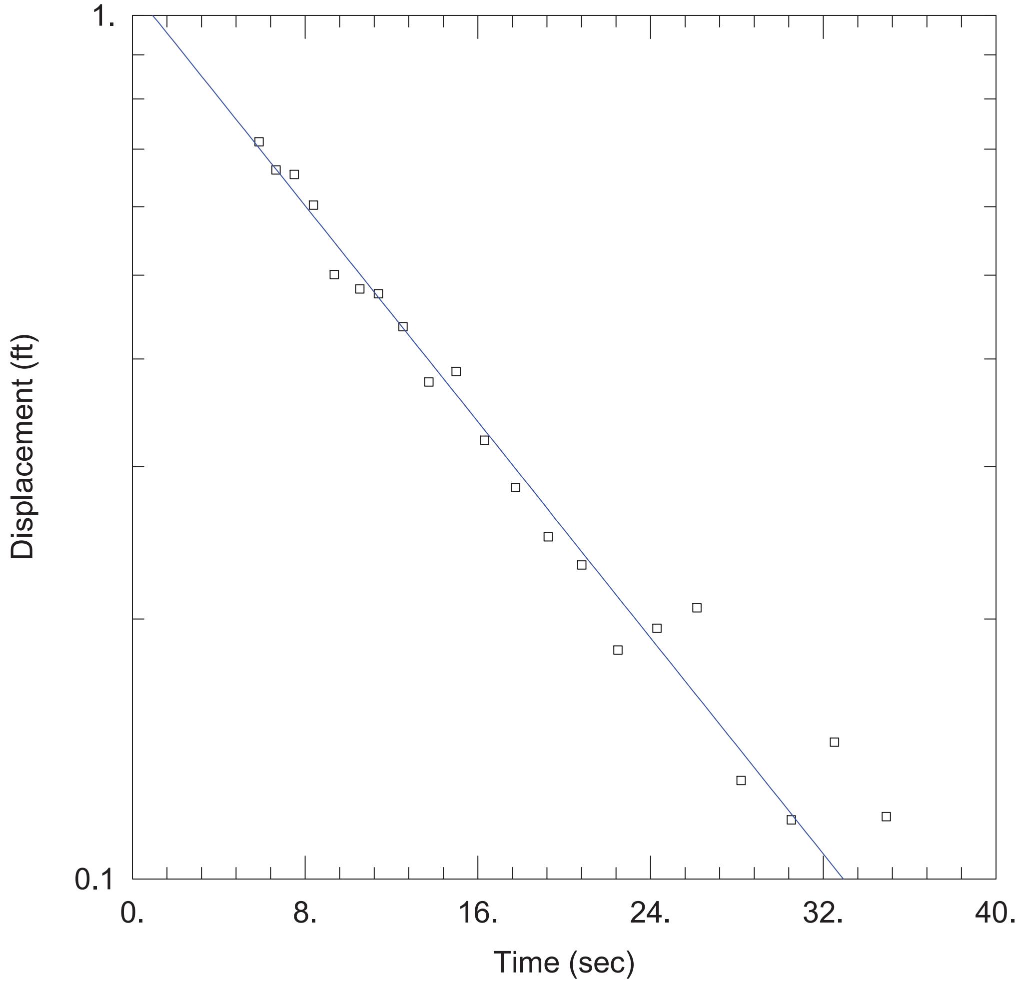
WELL DATA (JR MW-16006)

Initial Displacement: 2.34 ft
Static Water Column Height: 75. ft
Total Well Penetration Depth: 13. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 10.42 ft/day
y0 = 1.542 ft



JR MW-16007 SLUG IN 1

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 16:57:58

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

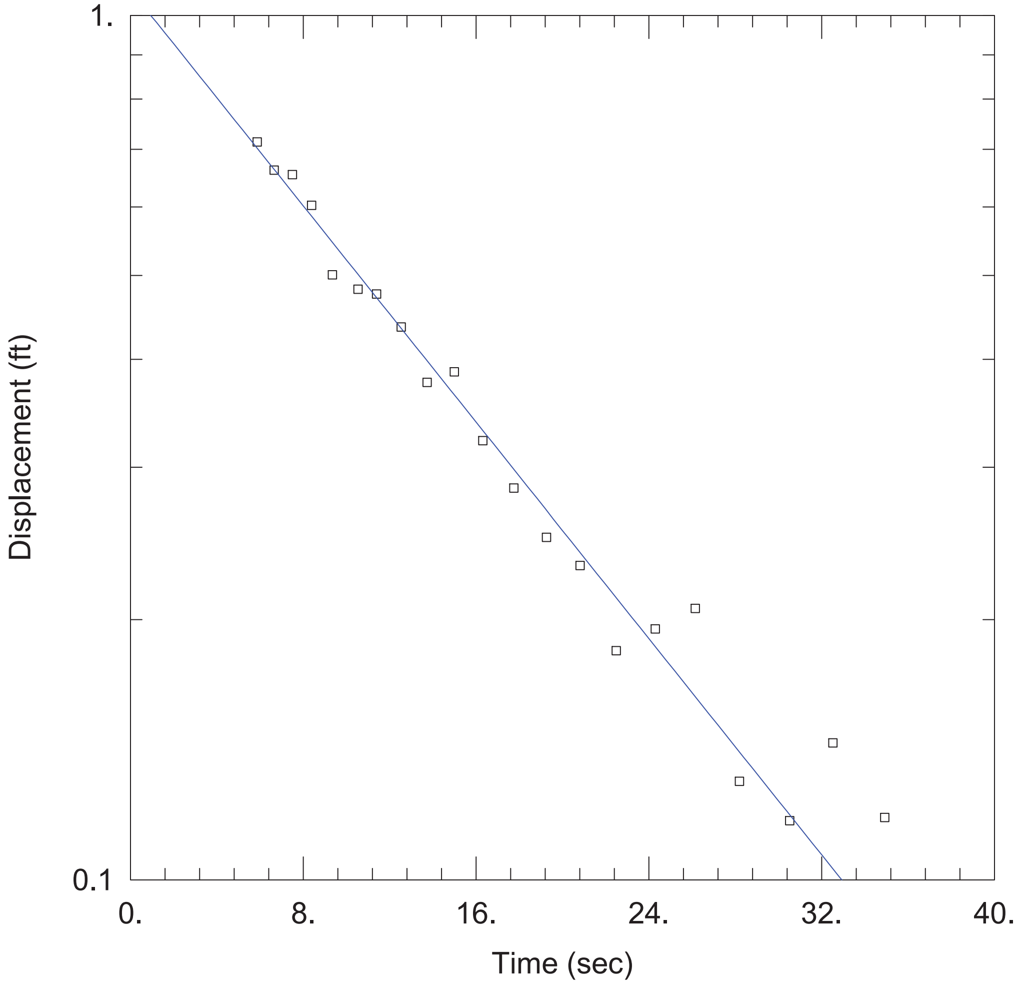
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 14. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.816 ft/day
y0 = 1.07 ft



JR MW-16007 SLUG IN 1

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 16:58:34

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

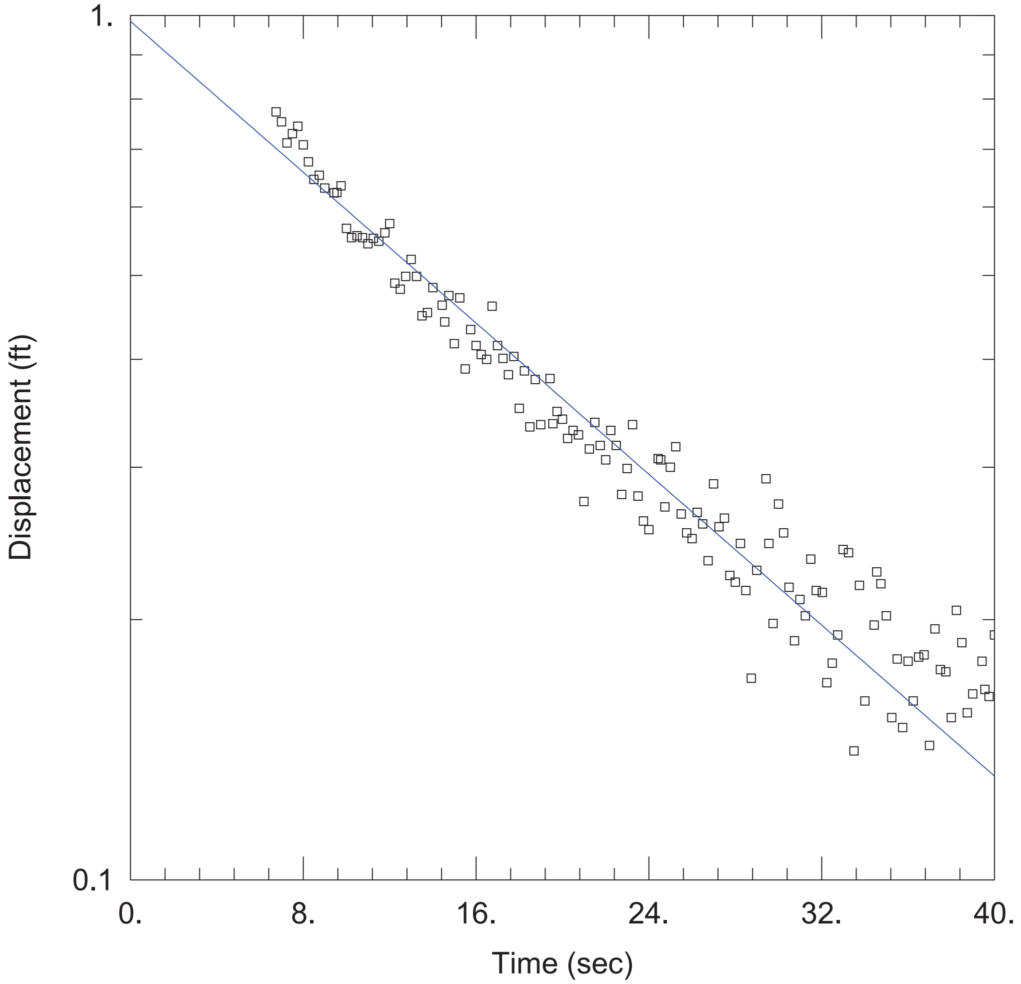
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 14. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.849 ft/day
y0 = 1.071 ft



JR MW-16007 SLUG IN 2

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:04:23

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

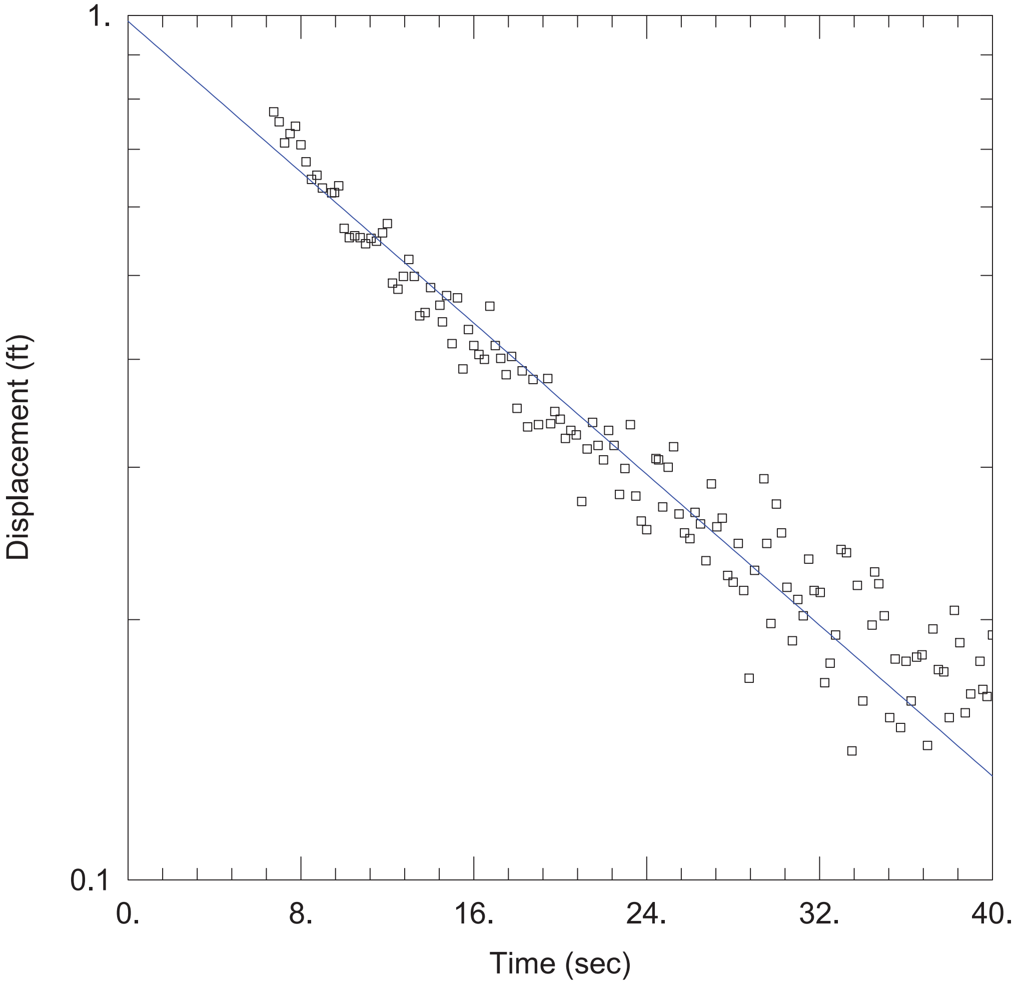
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 14. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.664 ft/day
y0 = 0.9841 ft



JR MW-16007 SLUG IN 2

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:03:06

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

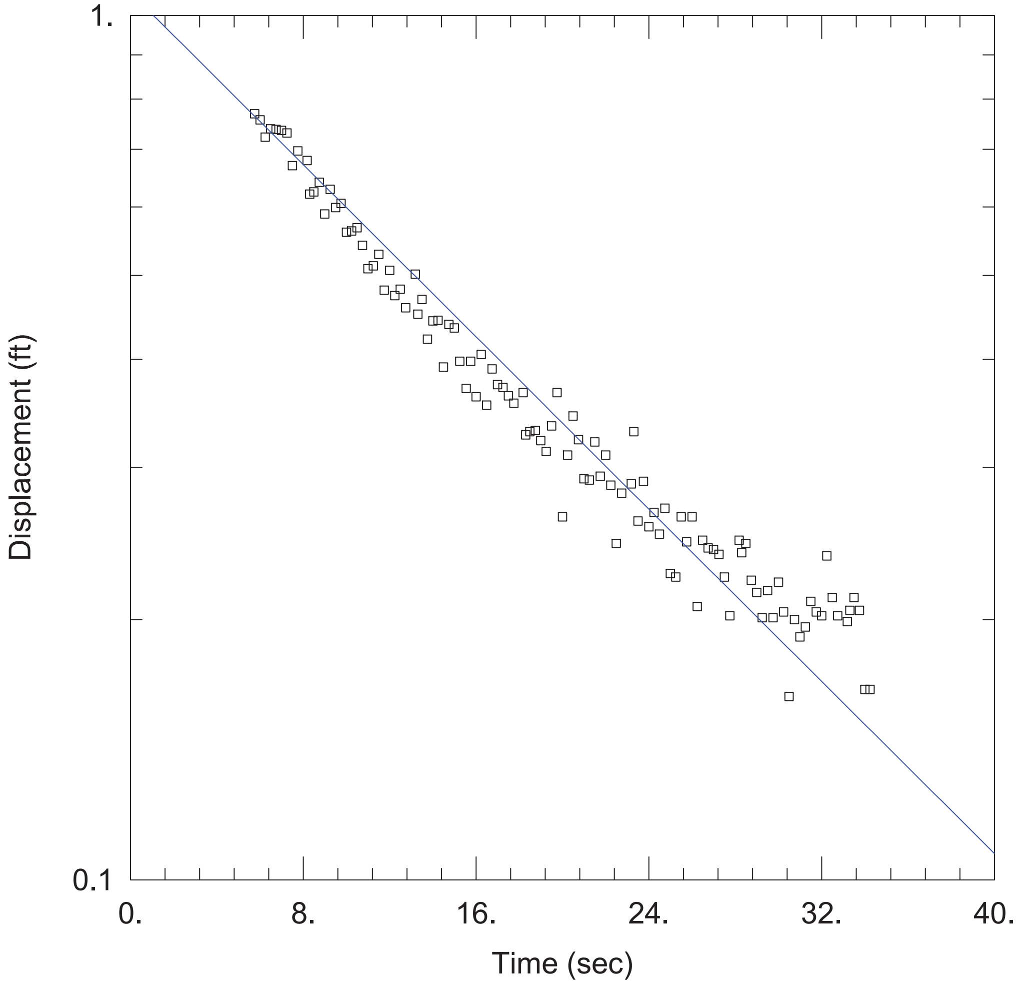
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 14. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 73. ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.385 ft/day
y0 = 0.9842 ft



JR MW-16007 SLUG IN 3

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:09:46

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

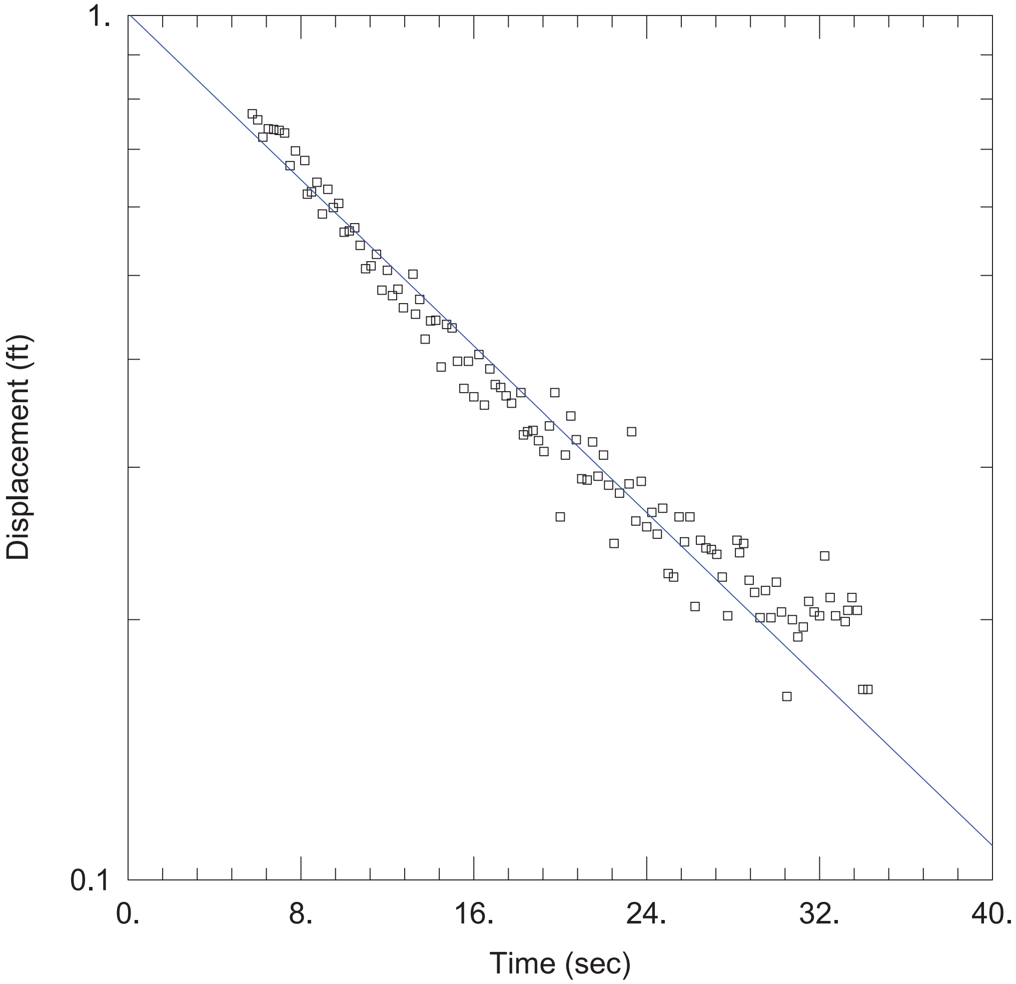
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 14. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.04 ft/day
y0 = 1.063 ft



JR MW-16007 SLUG IN 3

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:10:28

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

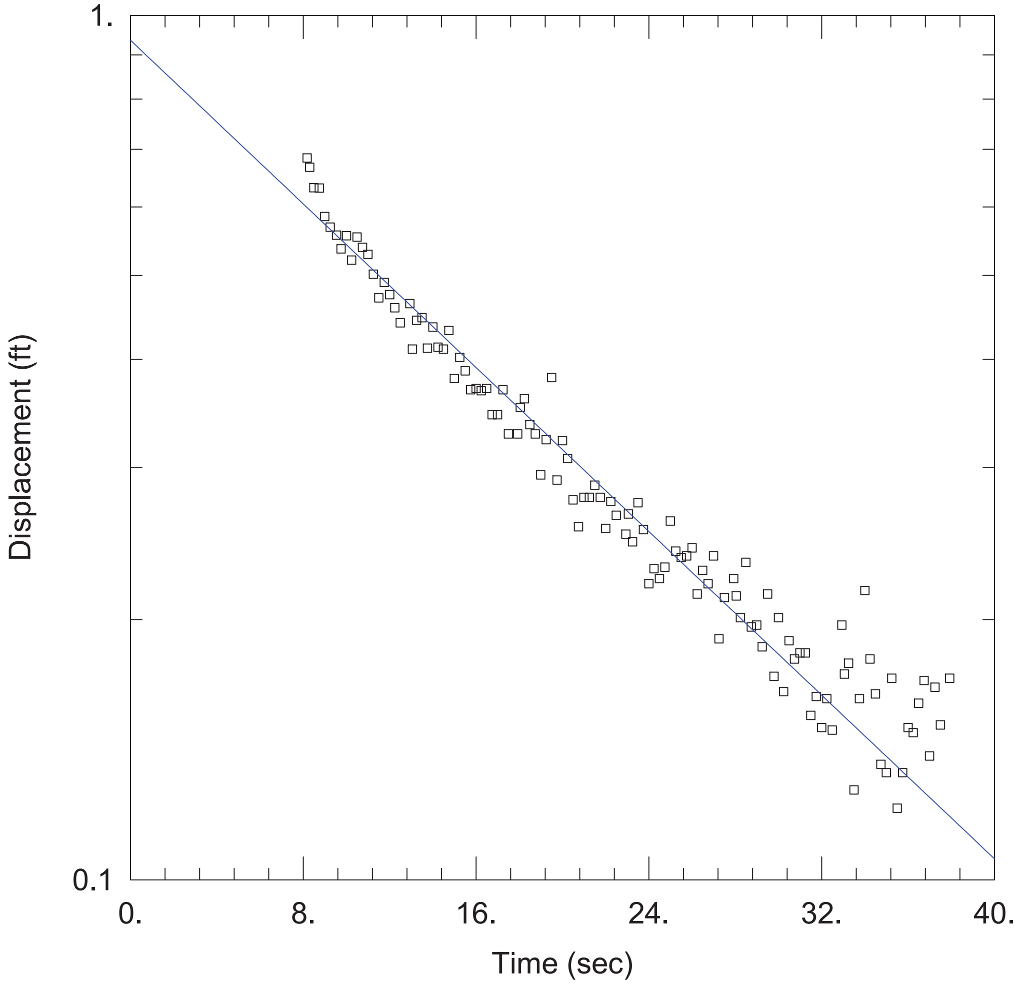
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 14. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.734 ft/day
y0 = 1.006 ft



JR MW-16007 SLUG IN 4

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:17:00

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

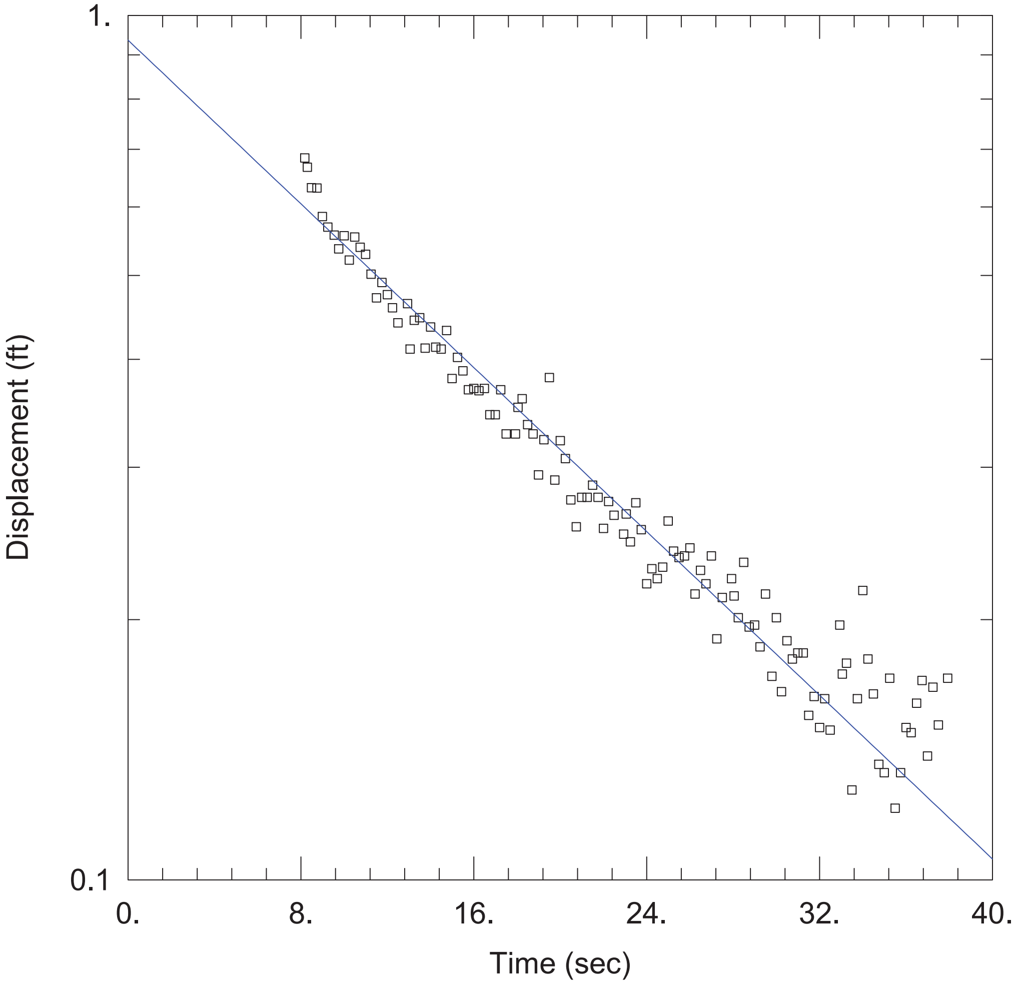
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 14. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.889 ft/day
y0 = 0.9357 ft



JR MW-16007 SLUG IN 4

Data Set: S:\...\MW-16007.aqt
Date: 11/07/16 Time: 17:16:21

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16007
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 14.3 ft
Anisotropy Ratio (Kz/Kr): 1.

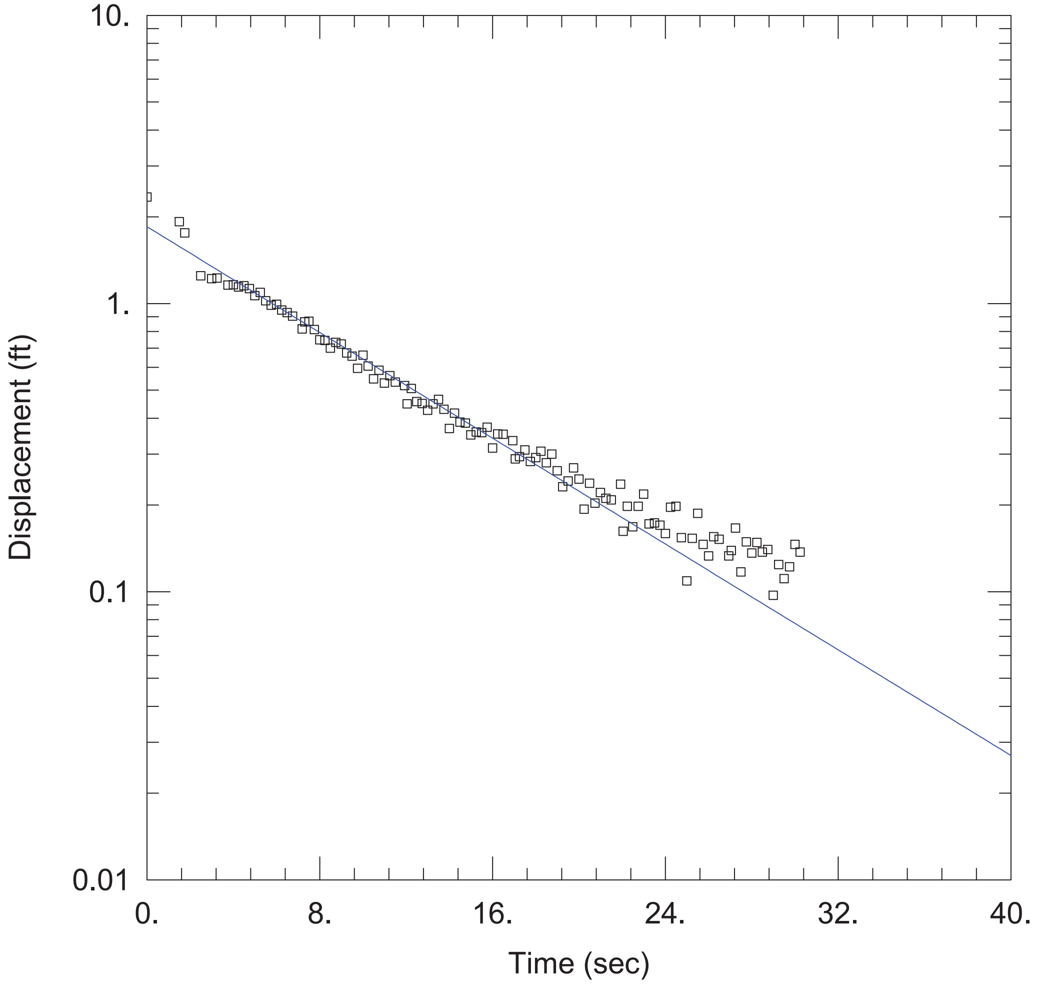
WELL DATA (JR MW-16007)

Initial Displacement: 2.34 ft
Static Water Column Height: 73. ft
Total Well Penetration Depth: 14. ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.671 ft/day
y0 = 0.9359 ft



JR MW-16008 SLUG IN 1

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16
Time: 17:26:45

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft
Anisotropy Ratio (Kz/Kr): 1.

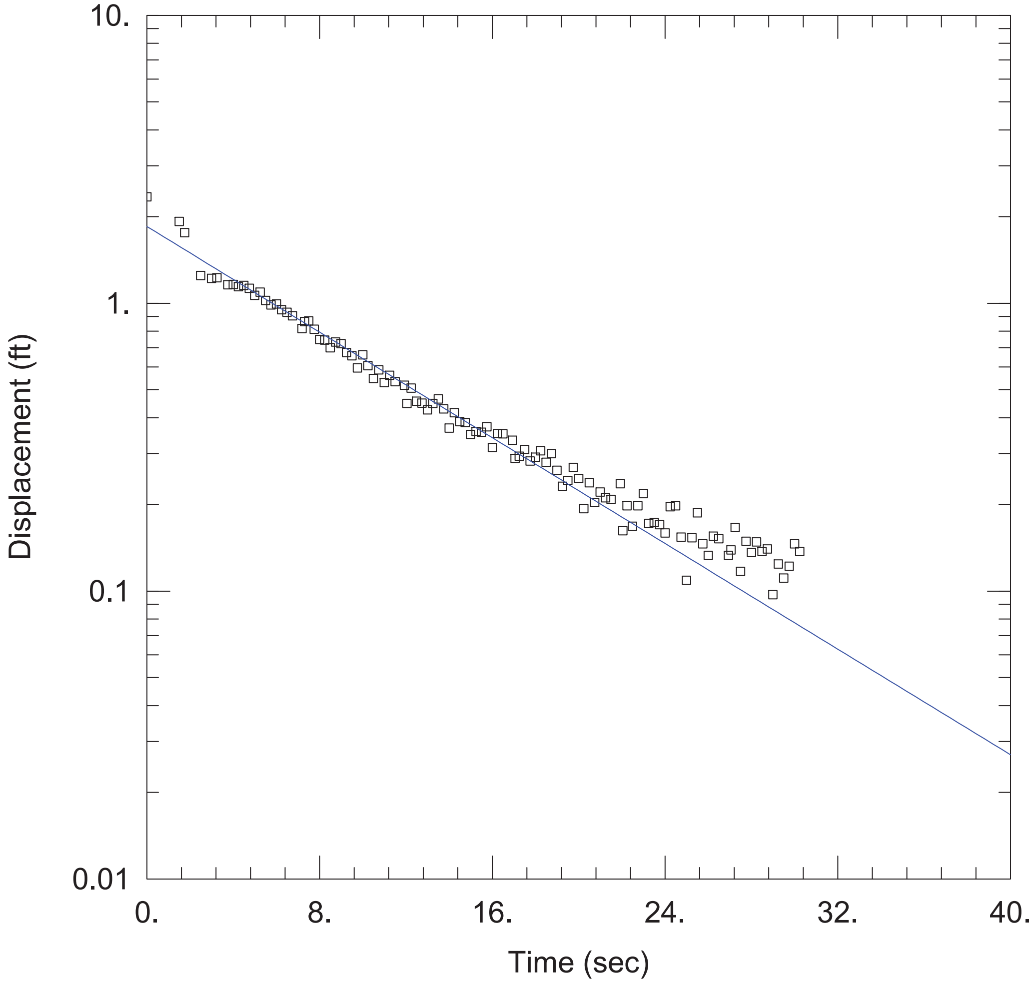
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Static Water Column Height: 67.2 ft
Total Well Penetration Depth: 10.5 ft
Screen Length: 5. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 8.826 ft/day
y0 = 1.846 ft



JR MW-16008 SLUG IN 1

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16 Time: 17:26:12

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft Anisotropy Ratio (Kz/Kr): 1.

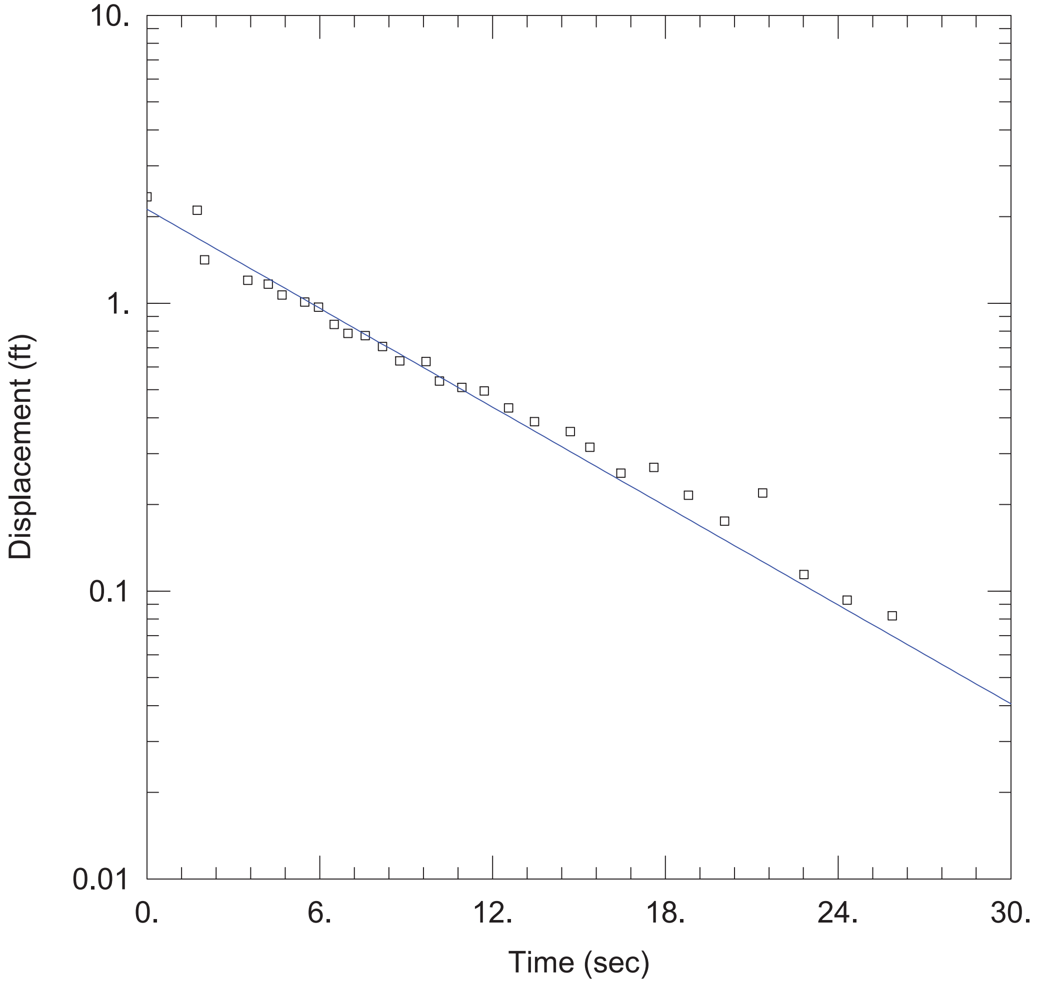
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 10.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 67.2 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 11.56 ft/day y0 = 1.846 ft



JR MW-16008 SLUG IN 2

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16 Time: 17:29:00

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft Anisotropy Ratio (Kz/Kr): 1.

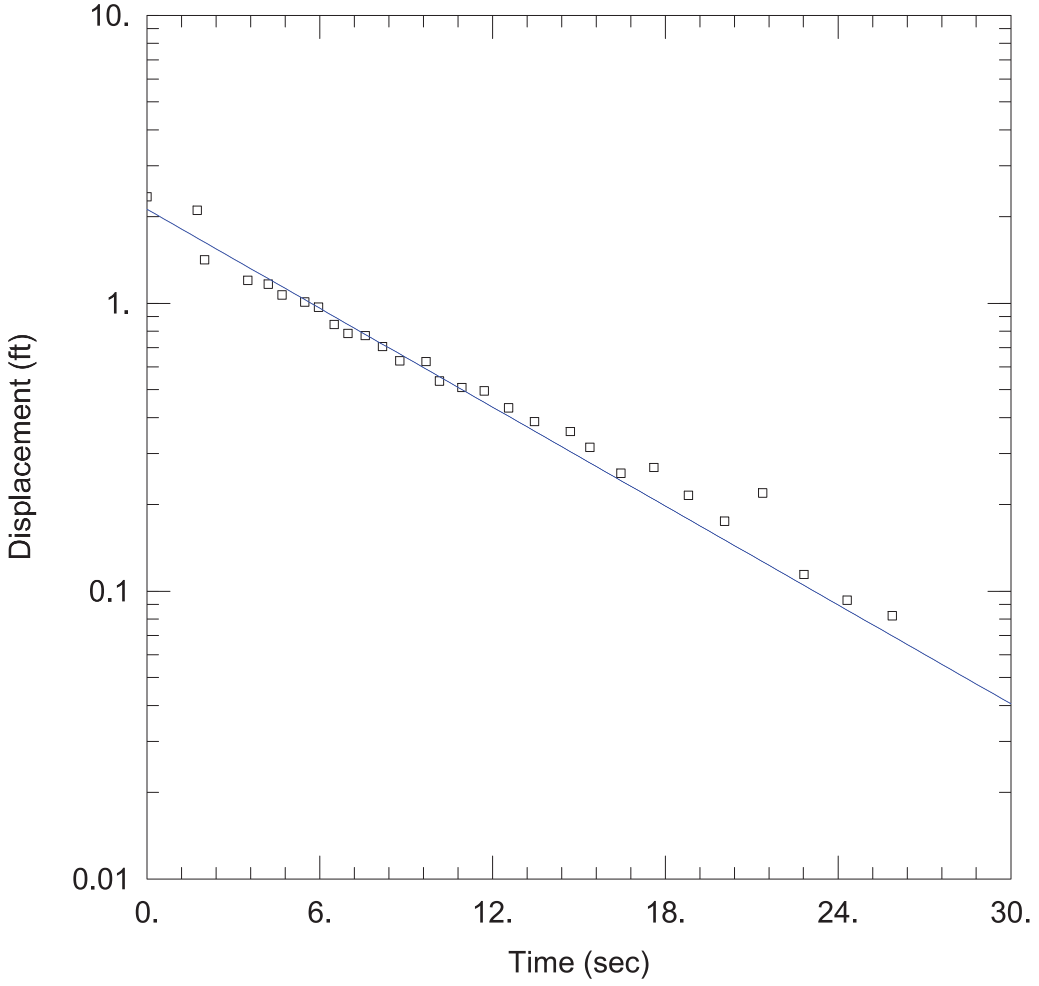
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft Static Water Column Height: 67.2 ft
Total Well Penetration Depth: 10.5 ft Screen Length: 5. ft
Casing Radius: 0.0833 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 11.02 ft/day y0 = 2.119 ft



JR MW-16008 SLUG IN 2

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16 Time: 17:30:07

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft
Anisotropy Ratio (Kz/Kr): 1.

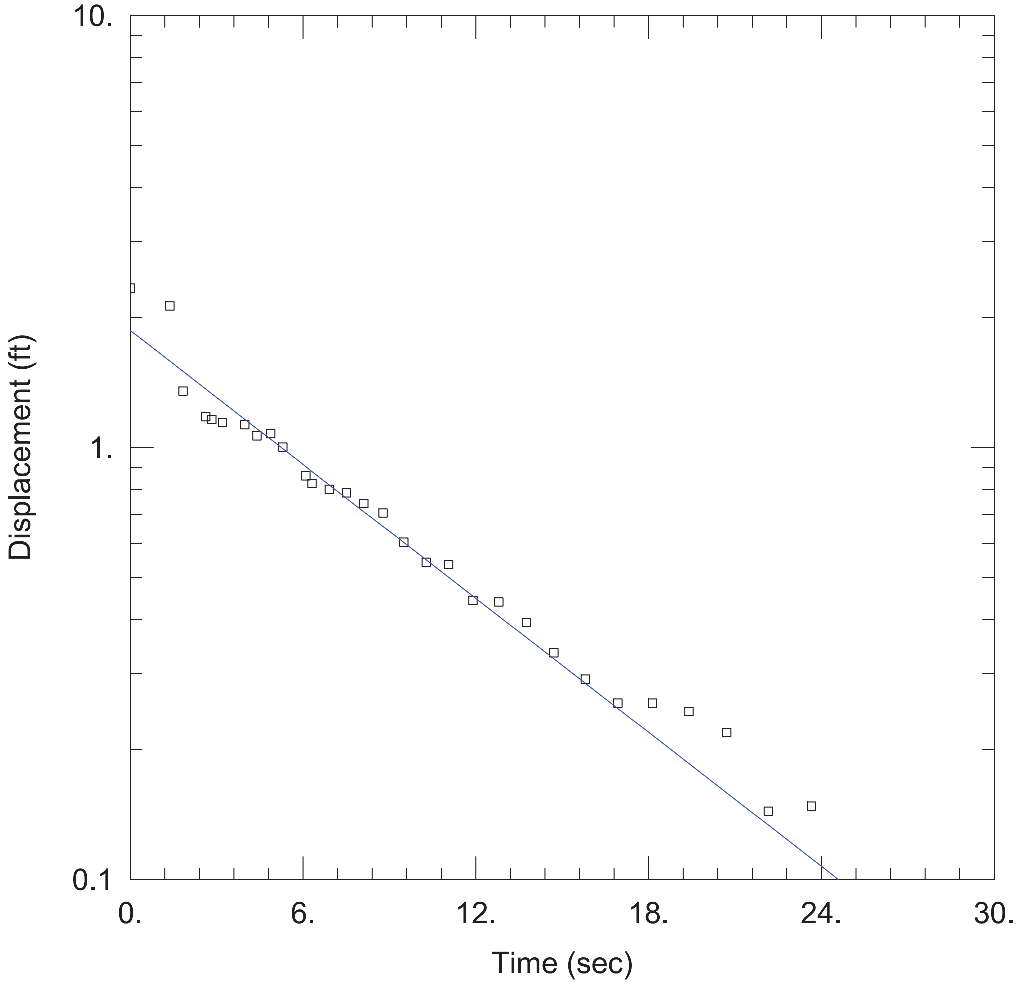
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 10.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 67.2 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 14.44 ft/day
y0 = 2.119 ft



JR MW-16008 SLUG IN 3

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16
Time: 17:33:37

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft
Anisotropy Ratio (Kz/Kr): 1.

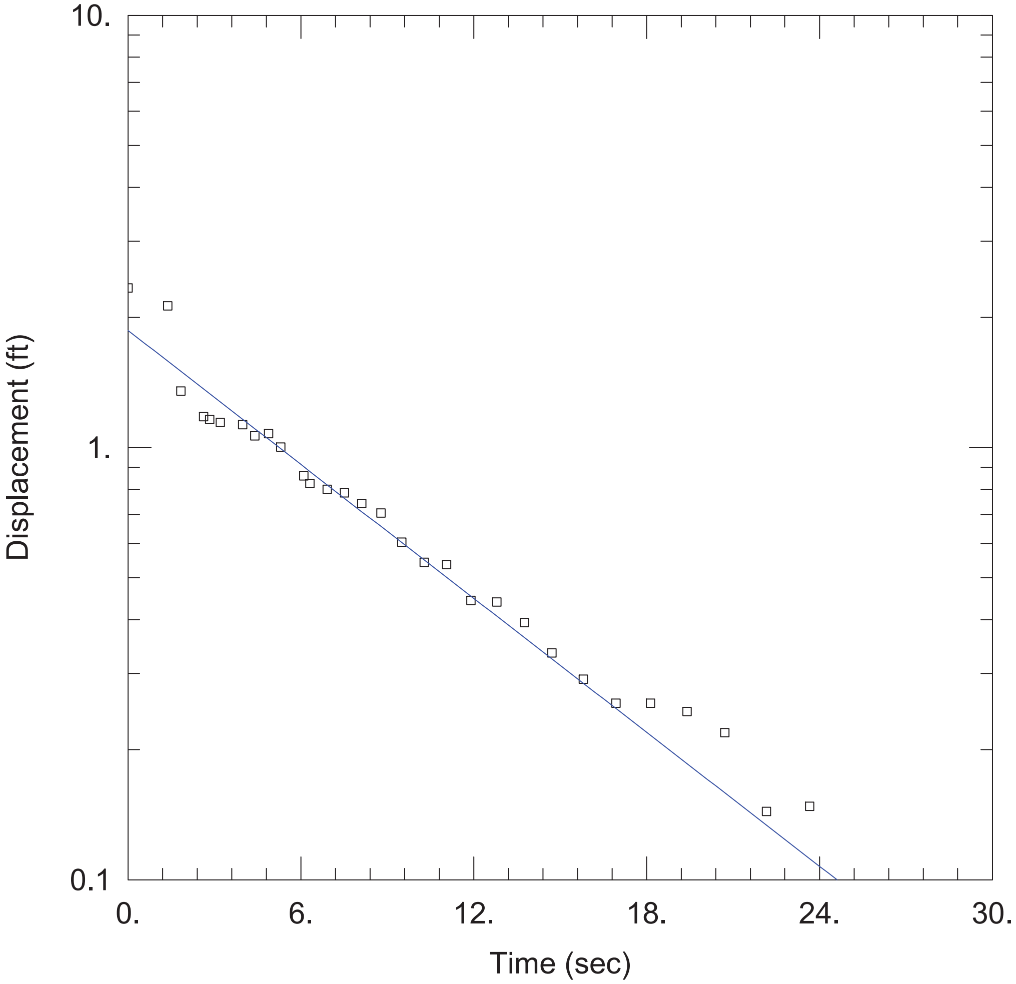
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Static Water Column Height: 67.2 ft
Total Well Penetration Depth: 10.5 ft
Screen Length: 5. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.947 ft/day
y0 = 1.867 ft



JR MW-16008 SLUG IN 3

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16 Time: 17:32:57

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft Anisotropy Ratio (Kz/Kr): 1.

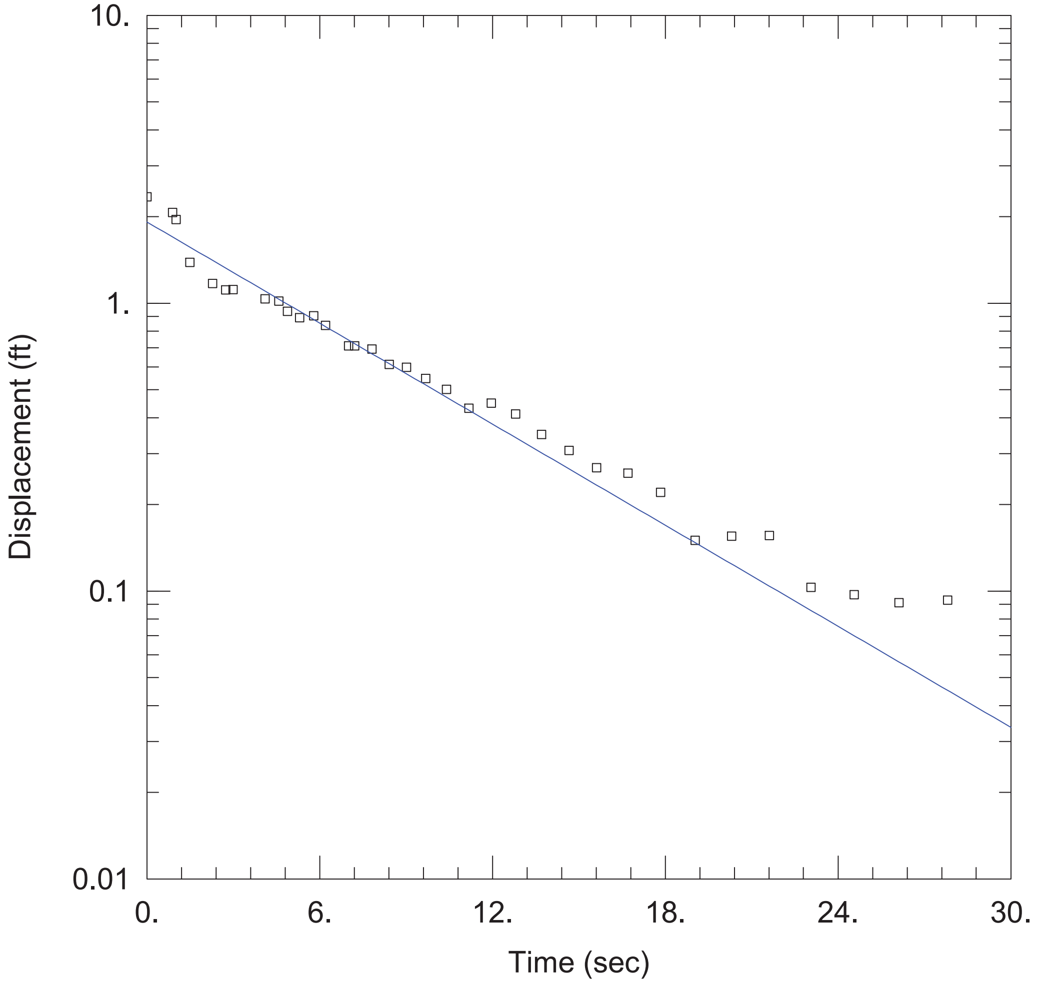
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft Static Water Column Height: 67.2 ft
Total Well Penetration Depth: 10.5 ft Screen Length: 5. ft
Casing Radius: 0.0833 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 13.02 ft/day y0 = 1.866 ft



JR MW-16008 SLUG IN 4

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16
Time: 17:35:15

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft
Anisotropy Ratio (Kz/Kr): 1.

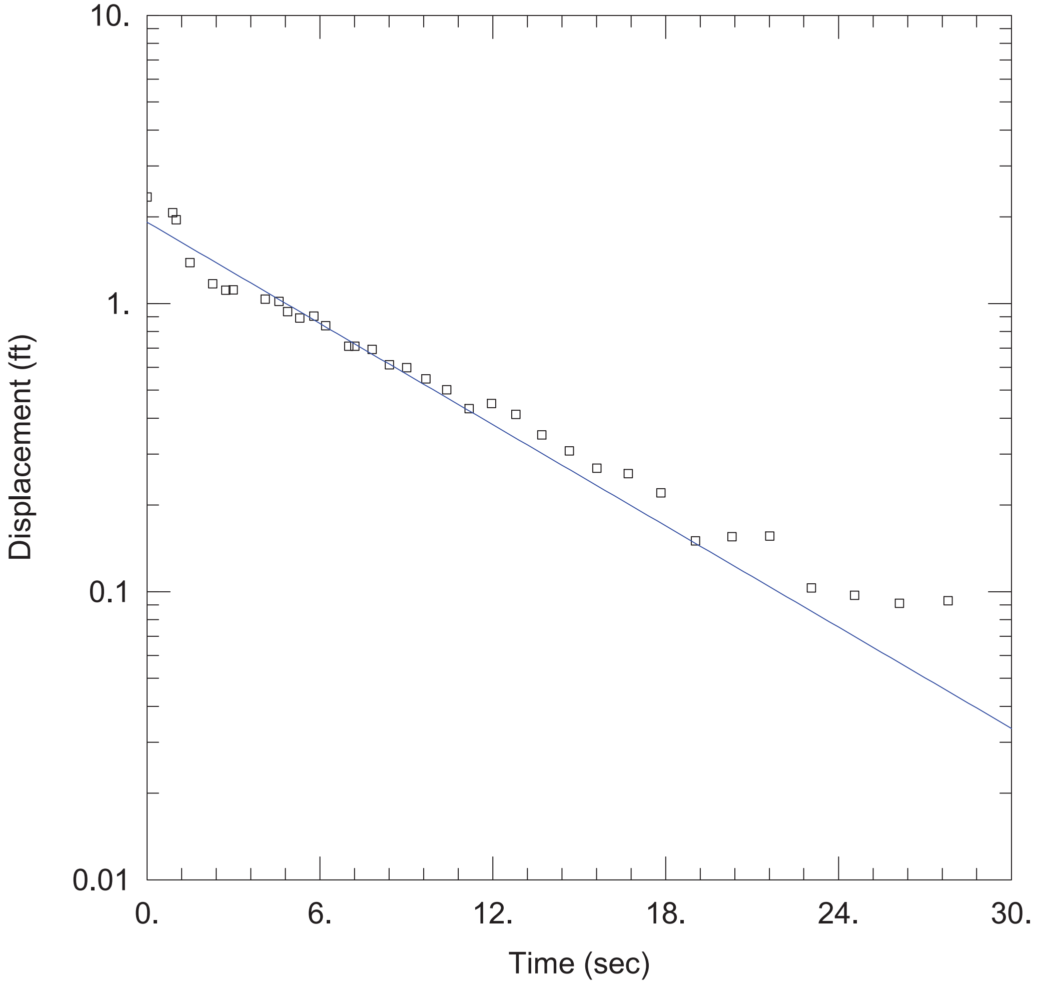
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Static Water Column Height: 67.2 ft
Total Well Penetration Depth: 10.5 ft
Screen Length: 5. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 11.26 ft/day
y0 = 1.914 ft



JR MW-16008 SLUG IN 4

Data Set: S:\...\MW-16008.aqt
Date: 11/07/16 Time: 17:35:53

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16008
Test Date: 11/4/16

AQUIFER DATA

Saturated Thickness: 12.5 ft
Anisotropy Ratio (Kz/Kr): 1.

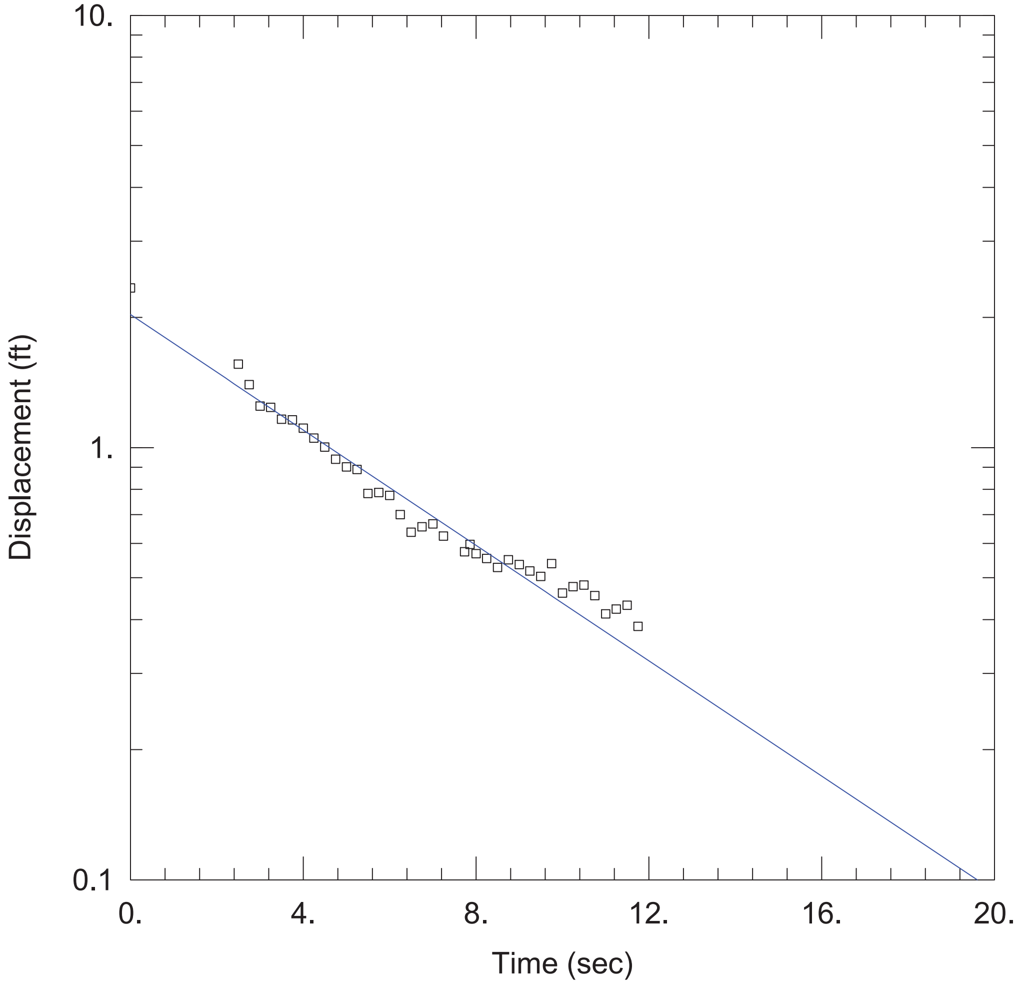
WELL DATA (JR MW-16008)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 10.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 67.2 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 14.76 ft/day
y0 = 1.914 ft



JR MW-16009 SLUG IN 1

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:40:30

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

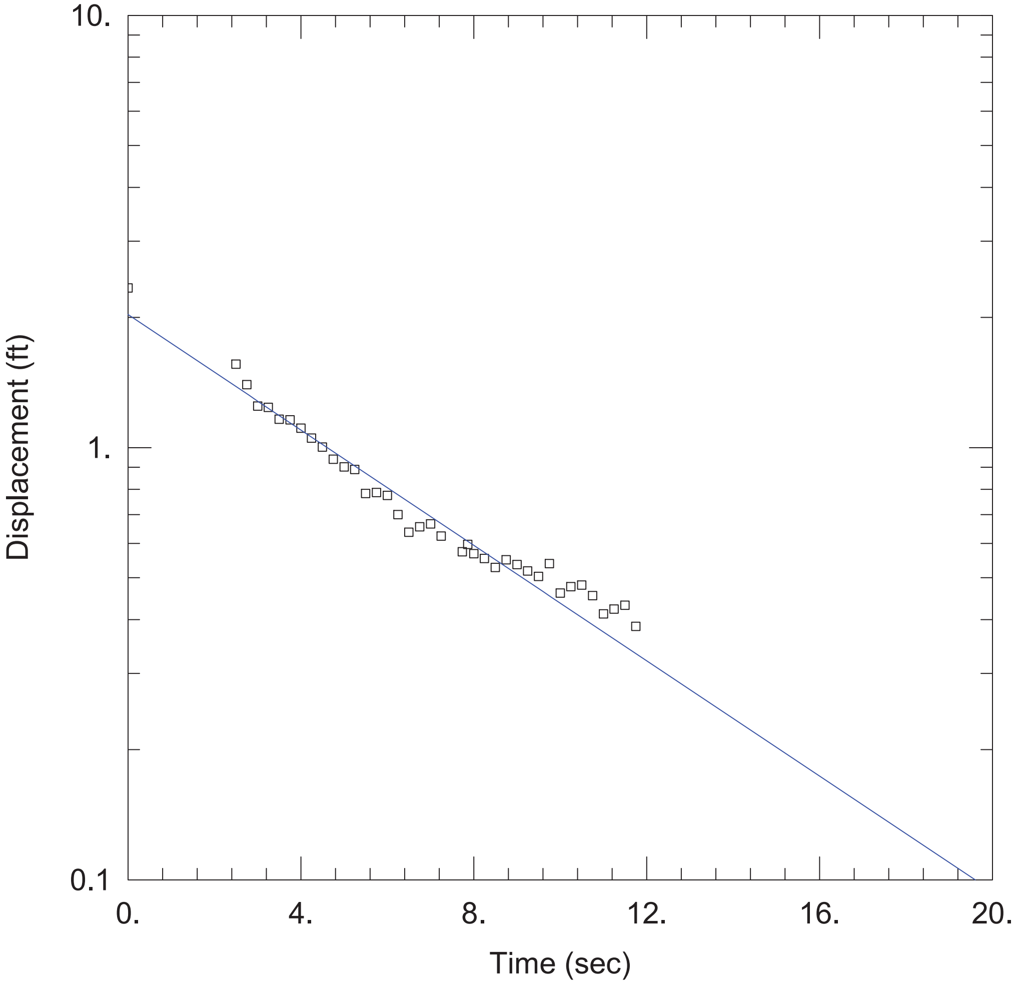
Saturated Thickness: 13.5 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Static Water Column Height: 53.3 ft
Total Well Penetration Depth: 13.5 ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 8.415 ft/day
y0 = 2.03 ft



JR MW-16009 SLUG IN 1

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:39:42

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft
Anisotropy Ratio (Kz/Kr): 1.

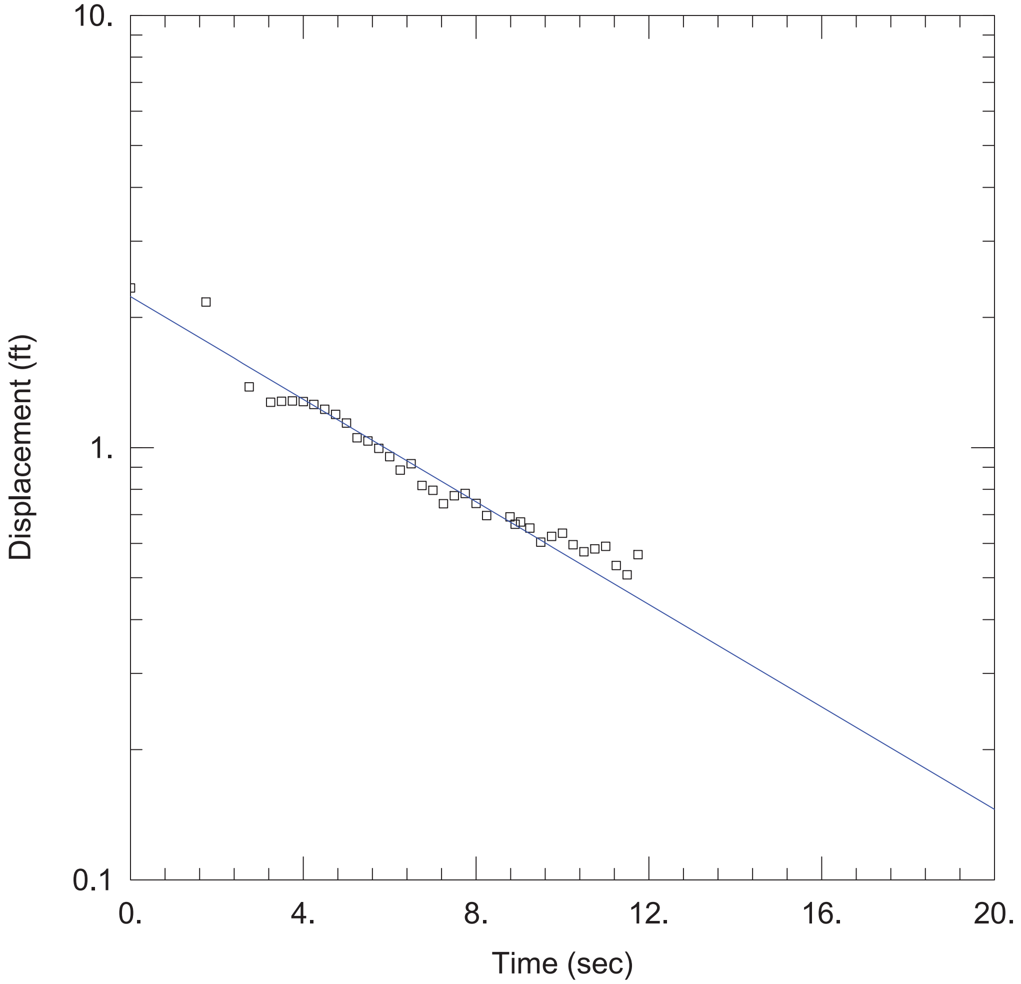
WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 53.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 12.29 ft/day
y0 = 2.03 ft



JR MW-16009 SLUG IN 2

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:42:22

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft Anisotropy Ratio (Kz/Kr): 1.

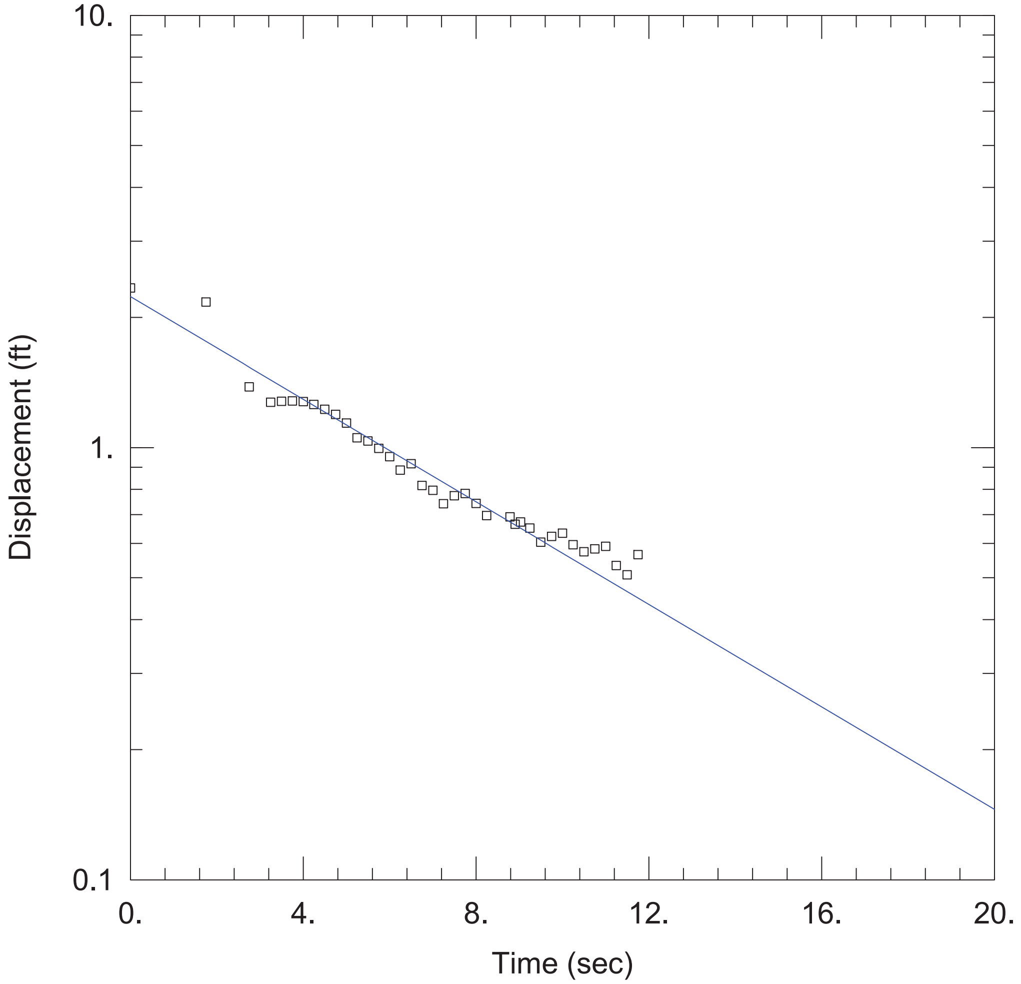
WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 53.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 7.481 ft/day y0 = 2.233 ft



JR MW-16009 SLUG IN 2

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:43:00

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft
Anisotropy Ratio (Kz/Kr): 1.

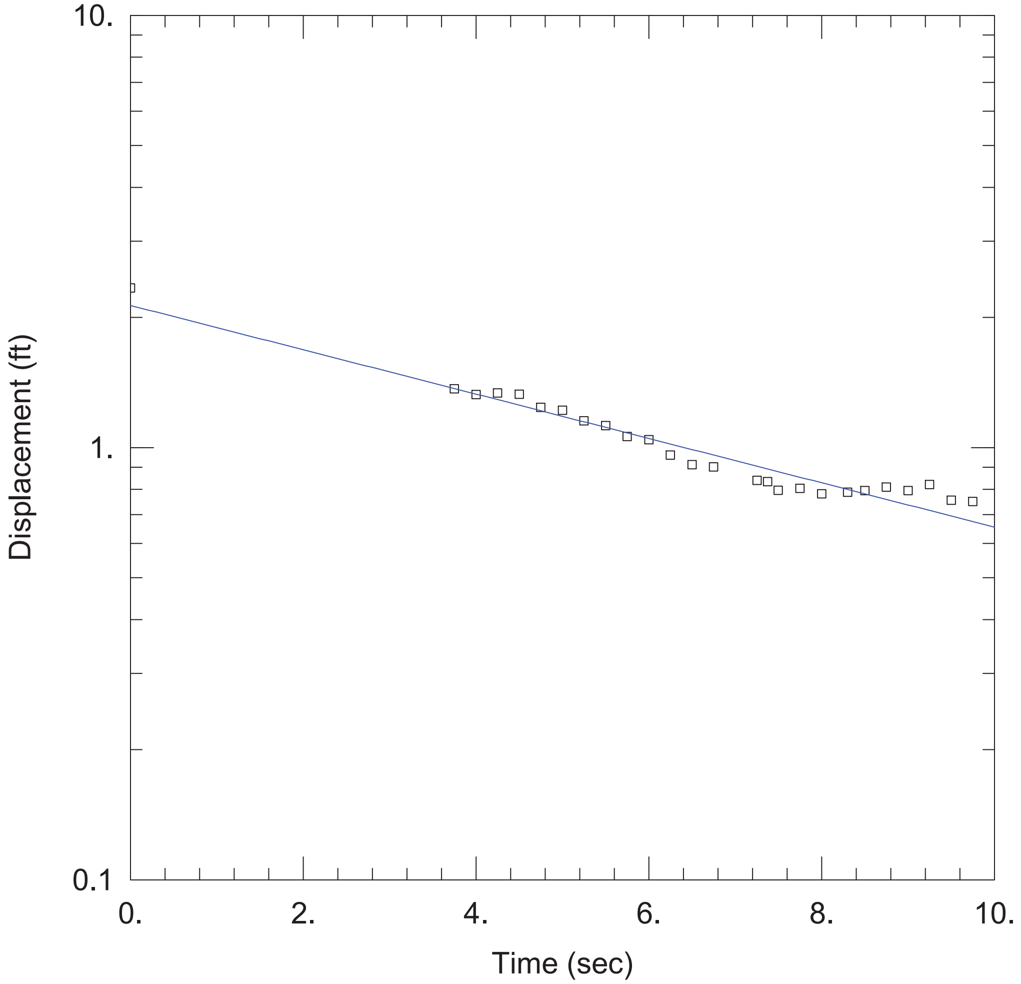
WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Static Water Column Height: 53.3 ft
Total Well Penetration Depth: 13.5 ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 10.92 ft/day
y0 = 2.233 ft



JR MW-16009 SLUG IN 3

Data Set: S:\...\MW-16009.aqt

Date: 11/07/16 Time: 17:45:33

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13.5 ft
Casing Radius: 0.0833 ft

Static Water Column Height: 53.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

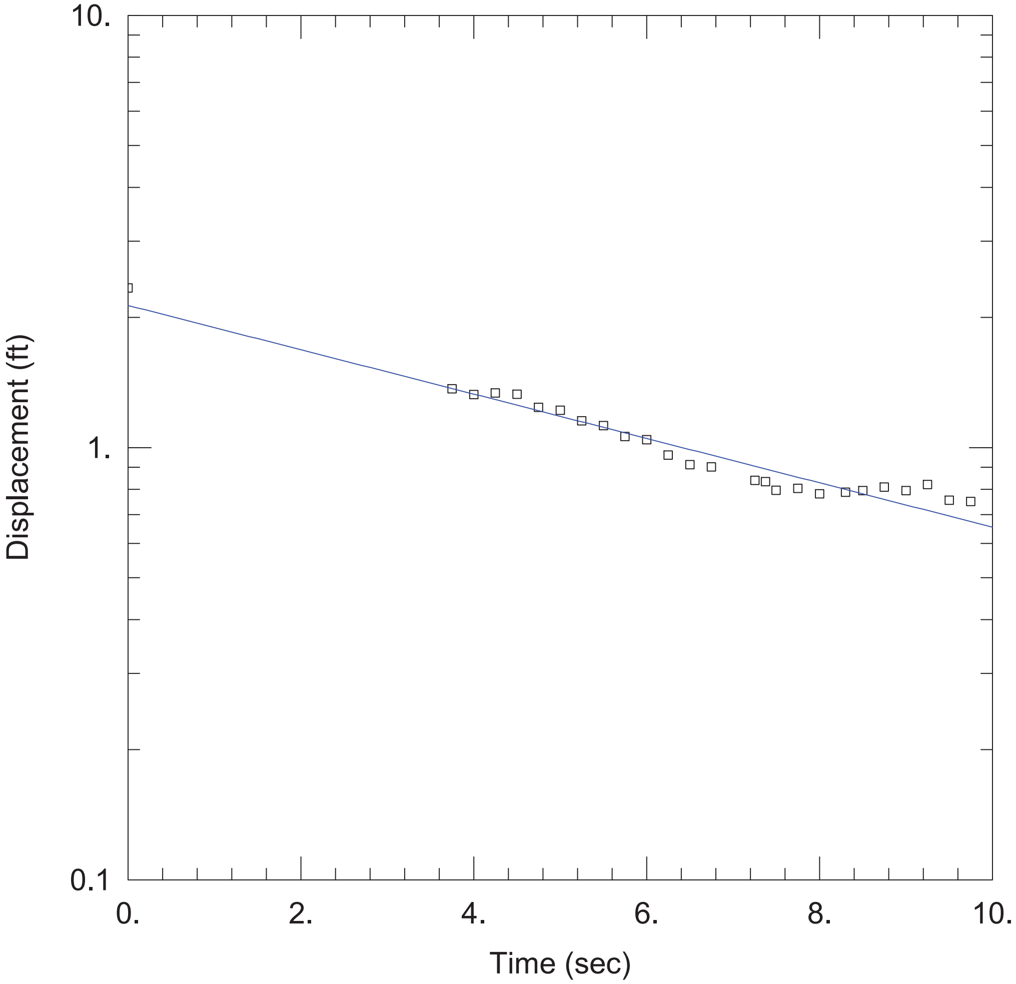
SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

K = 6.468 ft/day

y0 = 2.132 ft



JR MW-16009 SLUG IN 3

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:45:00

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft
Anisotropy Ratio (Kz/Kr): 1.

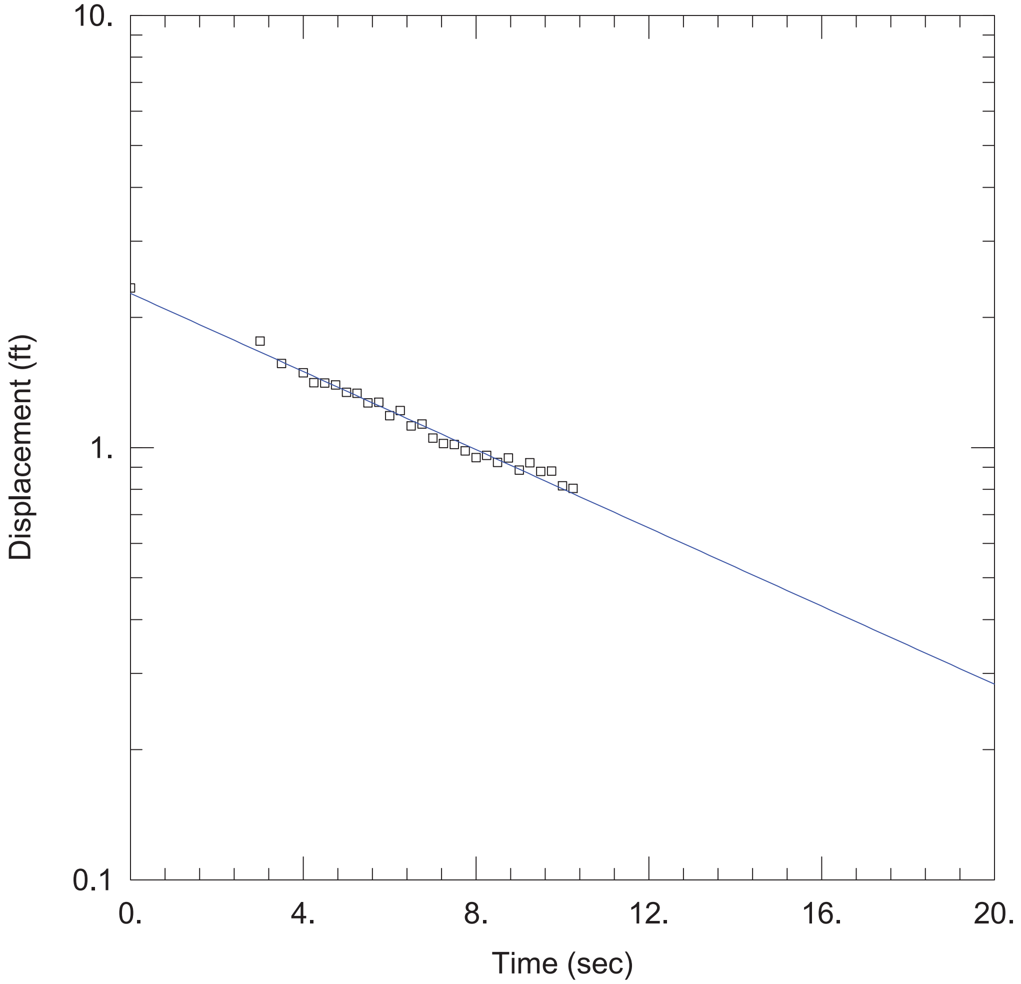
WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Static Water Column Height: 53.3 ft
Total Well Penetration Depth: 13.5 ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 9.446 ft/day
y0 = 2.132 ft



JR MW-16009 SLUG IN 4

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16
Time: 17:47:14

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft
Anisotropy Ratio (Kz/Kr): 1.

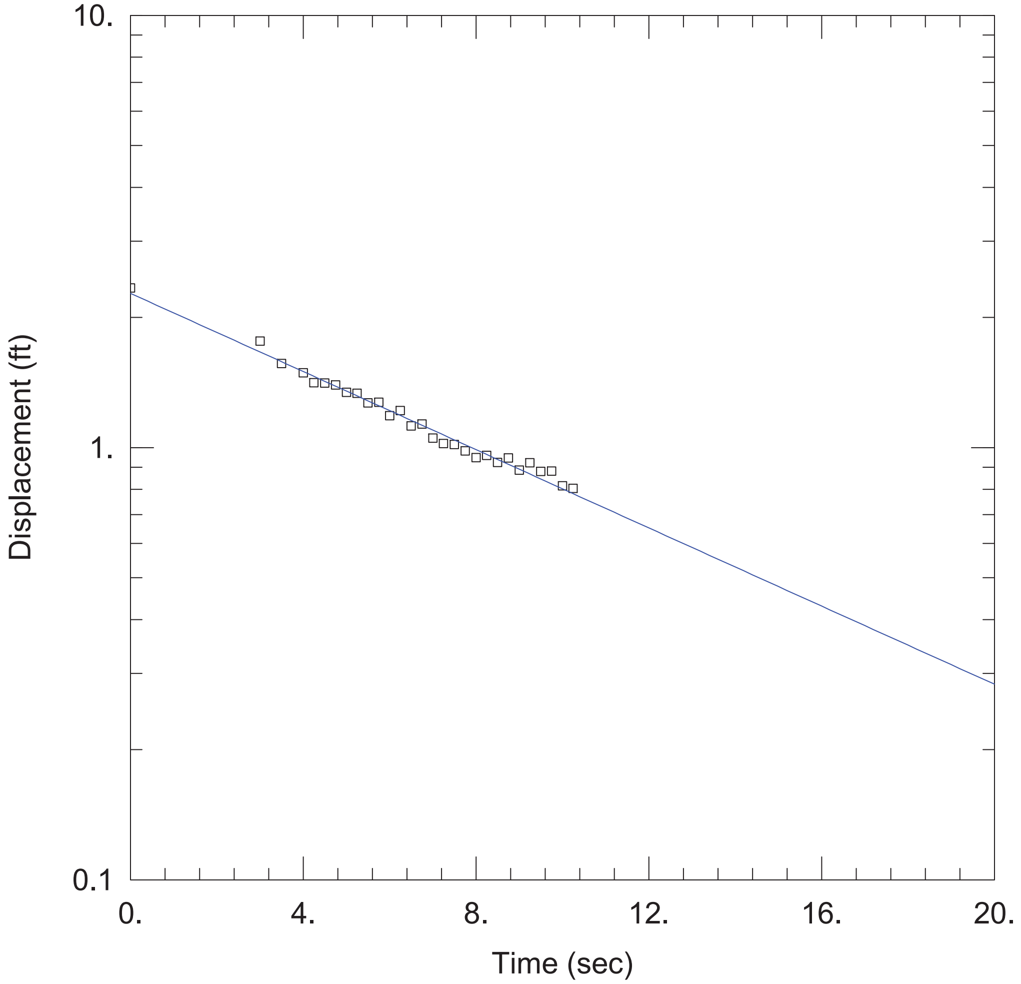
WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Static Water Column Height: 53.3 ft
Total Well Penetration Depth: 13.5 ft
Screen Length: 10. ft
Casing Radius: 0.0833 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 5.703 ft/day
y0 = 2.273 ft



JR MW-16009 SLUG IN 4

Data Set: S:\...\MW-16009.aqt
Date: 11/07/16 Time: 17:48:07

PROJECT INFORMATION

Company: FK Engineering
Client: Consumer's Energy
Project: 16-085
Location: Erie, Michigan
Test Well: JR MW-16009
Test Date: 10/31/16

AQUIFER DATA

Saturated Thickness: 13.5 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (JR MW-16009)

Initial Displacement: 2.34 ft
Total Well Penetration Depth: 13.5 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 53.3 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 8.327 ft/day y0 = 2.273 ft

Attachment B

Electric Generation Facilities
RCRA CCR Detection Monitoring Program
for the Pond 1&2 and Pond 6 Areas

Sample and Analysis Plan

JR Whiting Monitoring Program

Erie, Michigan

May 2017; Revised February 2020

Electric Generation Facilities
RCRA CCR Detection Monitoring Program
for the Pond 1&2 and Pond 6 Areas

Sample and Analysis Plan

JR Whiting Monitoring Program

Erie, Michigan

May 2017; Revised February 2020

Prepared For
Consumers Energy Company
Jackson, Michigan

Vincent E. Buening, C.P.G.
Senior Project Manager

Sarah B. Holmstrom, P.G.
Project Manager

TRC | Consumers Energy
Final
X:\WPAAM\PJT2\332751\0000\SAP\R332751.0 SAP.DOCX

1540 Eisenhower Place, Ann Arbor, MI 48108 ● 734.971.7080 Phone ● 734.971.9022 Fax
www.TRCcompanies.com

Table of Contents

List of Tables

List of Figures

List of Appendices

Section 1
Introduction

TRC has prepared this revised Groundwater Sampling and Analysis Plan (SAP) to evaluate background and downgradient groundwater quality at the Consumers Energy Corporation (Consumers Energy) JR Whiting electric generation facility (JRW), located in Erie, Michigan (Site). The collection of groundwater data will be completed to achieve compliance under 40 CFR Part 257, Subpart D – Standards for the Disposal of Coal Combustion Residuals (CCR) in Landfills and Surface Impoundments (herein after "the CCR Rule") published in the Federal Register on April 17, 2015, as amended, and the R299.4907(1) of the Michigan Part 115 Rules under the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended (Part 115). The methodologies outlined in this SAP are consistent with the regulations, general federal and state guidance, TRC and Consumers Energy Standard Operating Procedures (SOPs), and industry standards.

This SAP replaces the SAP prepared by ARCADIS for the Site dated May 18, 2016, and when originally prepared in May 2017 incorporated several new wells installed in late 2016, including six replacement CCR monitoring wells in the Pond 6 Area and three additional CCR monitoring wells intended to collect background data for the Pond 1&2 and Pond 6 Areas. The May 2017 SAP has been modified to incorporate subsequent changes in the monitoring program and additional information to comply with Part 115.

Section 2
Purpose and Objectives

The groundwater monitoring and corrective action compliance requirements for existing CCR units are set forth in 40 CFR 257.90 through 257.98 and R 299.4905(1) of the Part 115 Solid Waste Management Rules. The groundwater sampling and analysis requirements are detailed in R 299.4905 (2) Part 115 Rules. The objective of the SAP is to comply with the requirements of the CCR Rule and Part 115 by providing consistent sampling and analysis procedures that are protective of human health and the environment and designed to ensure monitoring results that accurately represent groundwater quality throughout the monitoring system. As per, R 299.4905 (2)(c) of the Part 155 Rules this SAP includes a description of the procedures and techniques that will be implemented for:

- Sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain of custody control
- Laboratory and field quality assurance and quality control
- Procedures for preventing cross-contamination in wells during well installation, purging, and sampling.

Reasonable attempts will be made to collect samples and analyze them in accordance with these procedures; however, if unforeseen circumstances prevent the collection and/or analysis of groundwater samples in accordance with this plan, the circumstances and result of those circumstances will be fully described in the monitoring report that includes the data.

Section 3

Implementation and Sampling Frequency

As set forth in 40 CFR 257.93, a minimum of eight (8) background samples were collected prior to October 17, 2017 for the Pond 1&2 Area (an active CCR surface impoundment) and prior to April 17, 2019 for the Pond 6 Area (an inactive CCR impoundment). Establishment of a groundwater monitoring system is necessary for the JR Whiting Pond 1&2 and Pond 6 Areas (CCR Surface Impoundments) with a minimum of three background wells. As discussed in the statistical analysis plans for Pond 1&2 and Pond 6, intrawell statistical methods for JR Whiting were selected based on the geology and hydrogeology at the site (primarily the presence of clay/hydraulic barrier, no apparent flow direction and lack of flow potential across the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data and similarities in concentrations in background and downgradient wells). An intrawell statistical approach requires that each of the downgradient wells doubles as the background and compliance well, where data from each individual well during a detection monitoring event is compared to a statistical limit developed using the background dataset from that same well.

Monitoring wells JRW-MW-15001 through JRW-MW-15006 are located around the perimeter of Pond 1&2 and monitoring wells JRW-MW-16001 through JRW-MW-16006 are located around the perimeter of Pond 6. These wells provide data on both background and downgradient groundwater quality that has not been affected by the CCR units (a total of six background/downgradient monitoring wells at each Pond 1&2 and Pond 6).

Background groundwater monitoring was conducted at Pond 1&2 from December 2016 through October 2017 (nine events) and at Pond 6 from November 2016 through November 2018 (12 events) in accordance with this SAP. Background data was collected at each of the six downgradient/background wells at each pond, in addition to JRW-MW-16007 through JRW-MW-16009, with analysis for parameters required in the CCR Rule's Appendix III and Appendix IV to Part 257, and field parameters (dissolved oxygen, oxidation reduction potential, pH, specific conductivity, temperature, and turbidity). Background will be established for detection monitoring constituents not already included in the CCR Rule Appendix III (i.e. iron) throughout eight semiannual sampling events per R 299.4440(7).

Detection monitoring will be conducted on a semiannual frequency at the Pond 1&2 and Pond 6. An alternative monitoring frequency of semiannual in accordance with R299.4440(5) is appropriate based on the site hydrogeology, specifically the lack of discernable groundwater flow direction and lack of groundwater movement within the aquifer. Potentiometric surface elevation data from groundwater within the CCR monitoring wells exhibit an extremely low hydraulic gradient across the site with no apparent flow direction. There are minor differences in hydraulic head across the monitoring wells (ranging from zero up to 0.13 feet across Pond 1&2 from event to event from November 2016 through September 2019), indicating that the potentiometric surface is flat the majority of the time. In the few instances since November 2016 where a slight gradient was observed and calculable, the direction of the flow potential was slightly to the northwest (2 events) and to the east (one event). Given that the hydraulic gradient is often so low, groundwater flow across the ponds is frequently incalculable and often stagnant. The most pronounced groundwater gradient between November 2016 and September 2019 was observed on December 19, 2016, which showed a slight horizontal gradient of approximately 0.00016 to the northwest across Pond 1&2. Using the highest hydraulic conductivity measured at the Pond 1&2 monitoring wells (20 feet/day from the 2016 ARCADIS well installation report) and an effective porosity of 0.1, this results in a conservatively high groundwater flow rate of approximately 0.03 feet/day or 11 feet/year. Given that the groundwater flow direction is inconsistent and often non-existent, it is likely that groundwater is moving back and forth within the vicinity of the wells over time. As such, sampling more frequently than semiannually would reduce the temporal independence of the dataset. This also suggests that JRW-MW-16007 through JRW-MW-16009 are not positioned hydraulically upgradient from the CCR units, rather there is no clear gradient or flow direction at the JR Whiting facility, and these wells (JRW-MW-16007 through JRW-MW-16009) have been designated for static water level measurements.

Resampling of a well due to an anomalous result, either relative to data collected from other monitoring wells of similar type, or relative to other time-series data at an individual monitoring well may be completed at any time. The timing of the resampling event, and the reason for additional data collection will determine if events are statistically dependent and inform the appropriate method for addressing interpretation or inclusion of data. Additional analytes may also be required pending the results of the monitoring events per R 299.4441 of the Part 115 Rules. This document does not cover collection and analysis of such additional data.

Consumers Energy will notify the Michigan Department of Environment, Great Lakes, and Energy (EGLE) that documentation of the design, installation, development, or decommissioning of any monitoring wells has been placed in the operating record per R 299.4906(4). Consumers Energy will also notify EGLE prior to undertaking well abandonment, plugging, replacement, or repair per R299.4906(9).

Section 4

Sample Collection and Handling Procedures

The following sections address the methods and procedures associated with the collection and handling of groundwater samples at the site as per the requirements in R299.4907(1). The monitoring well locations are shown in Drawing SG-22374, Sheet 1, Revision C. The relevant monitoring well construction details and well development information are provided in Table 1. A total of fifteen (15) monitoring wells are present at the JRW facility. Twelve monitoring wells are designated as background/downgradient monitoring wells to assess the uppermost aquifer at Pond 1&2 (monitoring wells JRW MW-15001 through JRW MW-15006), and Pond 6 (JRW MW-16001 through JRW MW-16006) at the site, which consists of limestone bedrock at approximately 50-70 ft bgs. Additionally, three monitoring wells (JRW MW-16007 through JRW MW-16009) will be utilized for static water level measurements.

4.1 Groundwater Elevations

Groundwater level data will be collected from all monitoring wells during each sampling event, prior to purging for the collection of groundwater samples. The monitoring well locations are depicted on Drawing SG-22374, Sheet 1 Revision C. Groundwater level monitoring will be conducted in accordance with Section 9.2 of the Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP presented in Appendix A.

Upon arrival at the site, all monitoring wells will be opened and allowed to equilibrate with ambient air pressures prior to measuring the depths to water. Groundwater level measurements will then be made to the nearest 0.01 foot with an electronic water level indicator from the entire monitoring well network prior to sampling – monitoring wells that constitute a groundwater monitoring system for a CCR Unit shall be preferentially sampled in order to further minimize water level elevational changes relative to the CCR Unit. The entire monitoring well network shall be gauged on the same day to minimize temporal bias of measured groundwater elevation changes for the monitoring well network. Depth to water will be measured from established top of casing reference points as referenced in the record survey drawing. Groundwater levels, well conditions, and any pertinent observations will be recorded on the depth to water level measurements field log provided in Appendix A.

The measured hydraulic gradient will be used along with previously completed hydraulic conductivity testing to determine the apparent groundwater rate and direction during each sampling event.

4.2 Groundwater Sample Collection

Groundwater samples will be collected from the monitoring wells following Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (US EPA, 1996), as detailed in the Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP (Appendix A). Low flow sampling will commence with the installation of either a peristaltic, stainless-steel 12-volt submersible impeller pump or bladder pump to a depth representing the middle of the saturated screen interval. An appropriate length of polyethylene tubing will be connected to the pump discharge prior to pump placement. The discharge line will be connected to a flow-cell and multi-meter to collect water quality indicator parameters (described below) during well purging to determine water quality stabilization.

The pump will be operated at a flow rate that ensures low volatilization and low well disturbance. Water quality indicator parameters and depth to water will be recorded at 3 to 5-minute intervals during the purging process and recorded on the sampling worksheet provided in Appendix B. Purging and sampling will proceed at a low pumping rate, expected to be between approximately 0.1 and 0.5 liters per minute or less, such that the water column in the well is not lowered more than 0.3 feet below the initial static depth to water measurement. The subject well will be considered ready to sample when three consecutive water quality measurements meet the stabilization criteria presented below.

PARAMETER	STABILIZATION CRITERIA
pH	3 readings within +/- 0.1 standard units (SU)
Specific Conductance	3 readings within +/- 3% millisiemens per centimeter (mS/cm)
Temperature	For Information Only
Turbidity	+/- 10% Nephelometric Turbidity Unit (NTU) variance between three consecutive readings and a turbidity less than 10 NTU
Oxygen Reduction Potential (ORP)	3 readings within +/- 10 millivolts (mV)
Dissolved Oxygen (DO)	3 readings within +/- 0.3 milligrams per liter (mg/L)

If the well is dry, no attempt at sampling will be conducted, as the aquifer is not considered to have sufficient quantity at that location. Additionally, if the well is pumped dry during low-flow monitoring activity, the well will be left overnight to accumulate water, then a sample collected assuming the NTU criteria can be met or, if necessary, filter the sample as laid out in Section 4.3 below. If during initial monitoring well purging the pH is elevated at the low flow purging rate (pH > 8 standard units (SU)) and does not decline quickly to below 8 SU under low flow purging rates, then increase the purge rate to on the order of 2 to 2.5 gpm and purge until the pH drops to below 8 SU. Once pH drops to below 8 SU, reduce the flow rate to < 500 ml/min and then purge, stabilize, and sample the well in accordance with the Purging and Sampling of Groundwater

Monitoring Wells SOP. Prior to use, all equipment will be calibrated in accordance with the manufacturer's recommendations. Calibration information will be recorded in the field notes.

4.3 Sample Preservation and Shipment

Samples will be collected immediately following stabilization of field parameters as set forth in in the preceding section. Groundwater samples will be collected into the laboratory provided sample containers required for the analyses specified in the following section. The groundwater samples will be collected from the discharge tubing upstream of the water quality meter flow cell. Care will be taken to allow for a non-turbulent filling of laboratory containers. Routine samples will not be filtered in the field to provide a measure of total recoverable metals that will include both the dissolved and particulate fractions of metals as per the CCR RCRA Rule and Section 324.11511a(3)(e) of Part 115.

If a more detailed understanding of the source of metals concentrations in groundwater is required for select monitoring wells, field filtered samples may be analyzed in addition to routine analysis. Field filtering may also be completed on highly turbid samples (greater than 10 NTU at stabilization). Field filtering will be completed using a 0.45 micron filter. If required, an attempt will be made to redevelop any monitoring wells that produce highly turbid prior to the subsequent sampling event. Where samples are filtered, a corresponding, unfiltered sample will also be collected.

The samples will be labeled, stored and transported to the laboratory according to the Chain-of-Custody, Handling, Packing and Shipping SOP presented in Appendix B. Following collection, samples will be immediately labeled, logged on the chain-of-custody, and placed in a cooler with ice. Sample coolers transported to the laboratory via overnight or next day air freight will be sealed with packing tape and a signed Chain-of-Custody seal. Sample coolers transported to the laboratory directly must be secured to ensure sample integrity is maintained. The samples will be packaged and shipped according to U. S. Department of Transportation and EPA regulations. The documentation of actual sample storage and transport will be by the use of chain-of-custody procedures. A laboratory provided chain-of-custody record will contain the dates and times of collection, receipt, and completion of all the analyses on a particular set of samples. The laboratory will return a copy of the chain-of-custody with the analytical report.

4.4 Quality Assurance/Quality Control (QA/QC)

Quality assurance/quality control (QA/QC) samples will be collected to ensure sample containers are free of analytes of interest, assess the variability of the sampling and laboratory methods, and monitor the effectiveness of decontamination protocols. The following QA/QC samples will be collected during each groundwater sampling event:

- Field duplicates will be collected at a frequency of one duplicate sample per 10 groundwater samples with at least one duplicate collected from each Unit. The field duplicates will be collected at the same time and in the same manner as the original sample. The duplicates will be labeled as a blind sample and noted on the sampling form of the designated well.
- Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one MS/MSD sample per 20 groundwater samples with at least one MS/MSD from each Unit. Duplicate and MS/MSD samples will be collected from different monitoring wells.
- Field blanks will be collected at a frequency of one field blank per 20 groundwater samples with at least one field blank collected from each Unit.
- Equipment blanks will be collected at a frequency of one equipment blank per 10 groundwater samples with at least one equipment blank collected from each Unit. The equipment blank will be collected by pouring distilled or deionized water over the decontaminated static water level meter or low flow pump and into the laboratory supplied containers.

The groundwater monitoring system at JRW consists of 15 monitoring wells. Therefore, a total of 2 field duplicates, 1 MS/MSD, 1 field blank, and 2 equipment blanks will be collected during each groundwater sampling event where the Pond 1&2 and Pond 6 Areas are sampled concurrently. The QA/QC samples will be submitted to the laboratory for the routine analyses specified in Section 5 and in Appendix III and IV to Part 257. The laboratory should provide adequate documentation of laboratory reporting and QA/QC procedures. The laboratory's QA/QC Plan will meet the quality assurance and quality control procedures given in SW-846 Test Methods for Evaluating Solid Waste. Any changes to the laboratory selected to perform the groundwater analyses will be documented in the following monitoring report.

4.5 Equipment Decontamination Procedures

If non-dedicated pumps or mobile sampling equipment is used, the following equipment decontamination procedures will be used to minimize the potential for cross-contamination of samples per the requirements outlined in R299.4907(10) of the Part 115 Rules. All non-dedicated equipment will be decontaminated prior to use and between samples, following procedures presented in paragraph 9.6 of the SOP in Appendix A. Additionally, all groundwater-monitoring wells shall be sampled from upgradient to downgradient, except in instances where monitoring wells are located in areas of known groundwater contamination, whereby wells should be sampled in order, from the least contaminated well to the most contaminated well. Non-dedicated equipment will include a water level meter and low flow sampling pump (submersible) (if used). Each item will be cleaned using distilled or deionized water, and when necessary, and non-phosphate detergent wash followed by a distilled or deionized water rinse. When a peristaltic pump is used for low flow sampling, decontamination is not required, only replacement of the pump head tubing.

All dedicated equipment will be disposed of after being retired from use at each sampling point (i.e. equipment once dedicated to one sampling point will not be reassigned to another sampling point). Dedicated equipment will include polyethylene tubing and bladders if a bladder pump is used for low-flow sampling.

The flow-cell and water quality multi-meter (sonde) will be decontaminated at the completion of low-flow sampling. All sample collection will occur upstream of this device and therefore will not affect groundwater sample analytical results.

4.6 Investigation Derived Waste (IDW)

All waste created during monitoring well sampling will remain on site. All purge water from wells installed within the CCR Units will be discharged back onto the ground near the well it was purged from. All purge water from wells installed outside of a CCR Unit will be discharged to the ground in a manner that it doesn't directly enter a surface water or drain. All IDW will be handled according to details provided in paragraphs 9.3.8 and 9.4.10 of the SOP provided in Appendix A.

4.7 Field Documentation

All information pertinent to the field activities and sampling efforts will be recorded in a log or notebook, following the documentation procedures presented in Section 5.4 of the SOP in Appendix B. Field logs are provided in the Attachments to Appendix A. At a minimum, entries in the sample logs will include the following:

- Property details and location
- Type of sample (for example, groundwater, surface water, waste)
- Number and volume of samples taken
- Sampling methodology
- Date and time of collection
- Sample identification number(s)
- Field observations including weather
- Any field measurements made (for example, pH, temperature, water depth and air monitoring data)
- Personnel present

Records shall contain sufficient information so that the sampling activity can be reconstructed without relying on the collector's memory. The sample logs will be preserved in electronic format.

Section 5
Analytical Suite and Procedures

Detection monitoring is conducted semiannually. All detection monitoring groundwater samples collected at Pond 1&2 and Pond 6 will be submitted to a laboratory for the analyses specified in Section 11511a. (3)(c) of PA 640 (which is inclusive of the list of constituents in Appendix III to Part 257 of the CCR Rule). The analytical methods and practical quantitation limits for each detection monitoring constituent are summarized below. If required, and in consultation with the laboratory, a comparable analytical method may be substituted for the analytical method recommended below. Analytical methods may also be modified to incorporate newer versions of the stated methods. All groundwater samples will be submitted to Consumers Energy Trail Street Laboratory or other qualified laboratories. Any samples shipped shall be shipped using appropriate methods and chain-of-custody documentation. All analyses will be performed within required hold times and consistent with the data quality objectives of this SAP.

Detection Monitoring Constituents

CONSTITUENT	MONITORED UNDER CCR RULE	ANALYTICAL METHOD	PRESERVATION	HOLD TIME (DAYS)	REPORTING LIMIT (µG/L)
Boron	✓	6010/6020	HNO_3, pH <2	180	20
Calcium	✓	6010/6020	HNO_3, pH <2	180	1,000
Chloride	✓	EPA 300.0	None, <6ºC	28	1,000
Fluoride#	✓	EPA 300.0	None	28	1,000
Iron		6010/6020	HNO3, pH <2	6 months	20
pH	✓	Stabilized field measurement	NA	NA	0.1 standard units
Sulfate	✓	EPA 300.0	None, <6ºC	28	2,000
Total Dissolved Solids	✓	SM 2540C	None, <6ºC	7	20,000

HNO_3 – Nitric acid
NA – Not applicable

The Appendix IV constituents listed in the table below were analyzed during background monitoring conducted at Pond 1&2 from December 2016 through October 2017 (nine events) and at Pond 6 from November 2016 through November 2018 (12 events) in accordance with this SAP and the analytical methods and practical quantitation limits summarized below. In the event that assessment monitoring is triggered through the statistical evaluation of detection monitoring parameters, an assessment monitoring plan will be prepared in accordance with R 299.4441 that includes analytical methods and practical quantitation limits for the assessment monitoring constituents required in Section 11519b. (2) of Part 115 that include the additional assessment monitoring constituents copper, nickel, silver, vanadium, and zinc.

Appendix IV to Part 257 – Constituents

CONSTITUENT	ANALYTICAL METHOD	PRESERVATION	HOLD TIME (DAYS)	REPORTING LIMIT (µG/L)
Antimony	EPA 6020B	HNO_3, pH <2	180	1
Arsenic	EPA 6020B	HNO_3, pH <2	180	1
Barium	EPA 6020B	HNO_3, pH <2	180	5
Beryllium	EPA 6020B	HNO_3, pH <2	180	1
Cadmium	EPA 6020B	HNO_3, pH <2	180	0.2
Chromium, total	EPA 6020B	HNO_3, pH <2	180	1
Cobalt	EPA 6020B	HNO_3, pH <2	180	15
Fluoride #	EPA 300	None, <6ºC	28	1,000
Lead	EPA 6020B	HNO_3, pH <2	180	1
Lithium	EPA 6020B	HNO_3, pH <2	180	10
Mercury	EPA 7470A	HNO_3, pH <2	28	0.2
Molybdenum	EPA 6020B	HNO_3, pH <2	180	5
Selenium	EPA 6020B	HNO_3, pH <2	180	1
Thallium	EPA 6020B	HNO_3, pH <2	180	2
Radium 226 and 228 combined ^	EPA 903.1/904.0	HNO_3, pH <2	None	1 picocurie per liter (pCi/L)

 # Listed in both Appendix III and Appendix IV

^ Requires a larger sample volume (minimum 2 liter)

5.1 Optional Additional Analyses

To interpret groundwater monitoring data and determine the appropriate statistical methods for use in comparison of background and downgradient data sets, an understanding of aquifer connectivity and water types may be required. To determine if samples are collected from comparable aquifer units the predominant water type will be determined using Piper and Stiff diagrams.

Piper and Stiff diagrams are a graphical representation of the major anion and cation composition of a water sample and are useful in establishing if groundwater samples are from the same or a similar aquifer unit. To generate Piper and Stiff diagrams additional analytical data beyond that collected during routine sampling will be required. The additional analytical requirements are shown in the table below.

CONSTITUENT	ANALYTICAL METHOD	PRESERVATION	HOLD TIME (DAYS)	REPORTING LIMIT (µG/L)
Bicarbonate, carbonate and total alkalinity	ASM 2320B	None, 6ºC	14	10,000
Magnesium	EPA 6020B	HNO_3, pH <2	180	1,000
Sodium	EPA 6020B	HNO_3, pH <2	180	1,000
Potassium	EPA 6020B	HNO_3, pH <2	180	500

Section 6
Data Evaluation

In accordance with the CCR Rule and Part 115, Consumers Energy will determine whether or not there is a statistically significant increase from the background data set for each of the detection monitoring constituents after completing the first round of sampling subsequent to completing the background data collection. After the eighth background sample has been obtained, the background dataset will be evaluated using the statistical procedures summarized in the statistical data evaluation plan developed for each of Pond 1&2 and Pond 6. The statistical method used for this analysis will be one, or a combination, of the statistical methods described below and in Per R 299.4908 and 40 CFR 257.93(f) and will meet the performance standards outlined in R 299.4908 (1)(e) and 40 CFR 257.93(g):

- A Parametric Analysis of Variance followed by a multiple comparisons test to identify statistically significant evidence of contamination. This will include estimation and testing of the contrasts between each monitoring well's mean and the background mean levels for the applicable indicator parameter.
- An Analysis of Variance based on ranks followed by a multiple comparison test to identify statistically significant evidence of contamination. This will include estimation and testing of the contrasts between each monitoring well's median and the background median levels for the applicable indicator parameter.
- A Tolerance or Prediction Interval Test in which an interval for each indicator parameter is established from the distribution of the pooled background data set, and the level of each parameter in each monitoring well is compared with the Upper Tolerance Limit or Prediction Limit.
- A control chart approach that gives control limits for each indicator parameter.
- Another suitable statistical method selected from applicable tests that meet the performance standards set forth in R 299.4908 (1)(e) and subpart 257.93(g) of the CCR Rule.

For data collected from background wells the following shall be adhered to:

- If reporting limits are increased due to laboratory interference during the period of background data collection and a nondetect is reported, the value will not be included in the background data set. The well will be re-sampled and analyzed in accordance with an alternate method (ICP-MS).
- If data quality review results in any anomaly or potential error, the value is subject to be excluded from the background data set and possibly re-sampled to confirm or disconfirm the anomalous result.

In compliance with R 299.4907(11) of the Part 115 Rules, all analytical results and data reports as defined above will be submitted to the director no later than 30 days after the end of the calendar quarter in which the samples were collected. All data collected from the wells in accordance with CCR Rule and Part 115 will be documented in the operating record in accordance with the recordkeeping requirements specific in 40 CFR 257.105(h) and, as necessary, made available on the CCR Website in accordance with 40 CFR 257.107, as referenced by Section 11519a. (2)(b) and (c) of Part 115.

Tables

Table 1
Monitoring Well Construction Summary
Consumers Energy Corporation
J.R. Whiting Generating Facility
Erie, Michigan

MW ID	Site Coordinates					Date Installed	Geologic Unit of Screen Interval	Well Construction	Well Screen Length (ft)	Screen Interval (ft bgs)
	Northing	Easting	Ground Surface Elevation	TOC Elevation	Bottom Elevation					
Ponds 1 & 2 Monitoring Wells										
JRW MW-15001	108330.83	13374236.18	NM	583.89	499.46	10/26/2015	Limestone	2" PVC, 10 slot	10	NM
JRW MW-15002	108651.05	13374586.78	NM	592.49	497.92	10/28/2015	Limestone	2" PVC, 10 slot	10	NM
JRW MW-15003	108321.86	13374980.23	NM	591.52	497.08	10/29/2015	Limestone	2" PVC, 10 slot	10	NM
JRW MW-15004	107881.56	13375045.59	NM	592.70	492.92	10/30/2015	Limestone	2" PVC, 10 slot	10	NM
JRW MW-15005	107545.15	13374686.90	NM	591.32	494.77	11/2/2015	Limestone	2" PVC, 10 slot	10	NM
JRW MW-15006	107843.22	13374281.80	NM	578.20	497.65	11/4/2015	Limestone	2" PVC, 10 slot	10	NM
Pond 6 Monitoring Wells										
JRW MW-16001	111255.91	13374012.08	589.19	592.32	508.4	10/25/2016	Limestone	2" PVC, 10 slot	10	71 - 81
JRW MW-16002	110463.28	13374460.66	585.78	588.68	494.24	10/24/2016	Limestone	2" PVC, 10 slot	10	81 - 91
JRW MW-16003	109687.92	13374452.98	586.19	589.02	503.07	10/23/2016	Limestone	2" PVC, 10 slot	10	73 - 83
JRW MW-16004	108834.64	13374076.00	586.48	589.35	500.59	10/23/2016	Limestone	2" PVC, 10 slot	10	75 - 85
JRW MW-16005	110509.27	13373630.27	589.29	592.13	500.81	10/25/2016	Limestone	2" PVC, 10 slot	10	78 - 88
JRW MW-16006	109719.88	13373640.49	588.26	591.03	499.43	10/19/2016	Limestone	2" PVC, 10 slot	10	79 - 89
Static Water Level Measurement Wells										
JRW MW-16007	108397.13	13372561.93	579.47	582.32	501.32	10/19/2016	Limestone	2" PVC, 10 slot	10	68 - 78
JRW MW-16008	108021.97	13372562.48	579.95	582.84	506.61	10/27/2016	Limestone	2" PVC, 10 slot	5	68 - 73
JRW MW-16009	107653.55	13372573.73	579.90	582.59	500.64	10/18/2016	Limestone	2" PVC, 10 slot	10	69 - 79

Notes:

Pond 1&2 top of casing elevation survey was conducted by Rowe Professional Services Company in October 2019.

Pond 1&2 Ground Surface and Screen Interval (ft bgs) elevations not measured due to on-going regrading activities in 2019.

Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).

ft = feet

bgs = below ground surface

NTU = Nephelometric Turbidity Unit

TOC = Top of Casing

NM = Not Measured

Figures

2016 Update Typical Mon. Well

Pictures

2015 Typical Surface Impoundment Monitoring Well

Pictures

NOTE: Aerial Image obtained from Google Earth.
Image date copyright date 2015 TerraMetrics .

Surface Impoundment Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5902	107843.22	13374281.80	590.3	592.01	JRW MW-15006	41.792150	-83.446597
5904	107545.15	13374686.90	592.7	594.25	JRW MW-15005	41.791322	-83.445125
5906	107881.56	13375045.59	590.8	592.52	JRW MW-15004	41.792233	-83.443797
5908	108321.86	13374980.23	589.6	591.36	JRW MW-15003	41.793444	-83.444017
5910	108651.05	13374586.78	590.6	592.31	JRW MW-15002	41.794358	-83.445447
5912	108330.83	13374236.18	589.6	590.71	JRW MW-15001	41.793492	-83.446744

Background Monitoring Wells

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5915	109293.21	13373656.23	587.1	588.38	JRW MW-15007/82MW-1	41.796147	-83.448833
5917	109790.80	13373648.04	587.5	588.71	JRW MW-15011/93MW-5	41.797514	-83.448844
5919	110458.57	13373631.59	587.1	588.09	JRW MW-15010/93MW4	41.799347	-83.448878
5921	110906.21	13373613.03	588.4	587.88	JRW MW-15008/82MW-2	41.800575	-83.448928
5923	110169.45	13374463.62	585.8	587.19	JRW MW-15012/93-MW6	41.798528	-83.445839
5925	109884.39	13374455.32	585.3	586.11	JRW MW-15009/79MW-3	41.797747	-83.445881

Survey Control Points

Pt #	Northing	Easting	Plant Elev	NAVD88	Name	Latitude	Longitude
1	107278.26	13374902.72	590.9	589.99	TP	41.790583	-83.444344
2	108903.66	13374018.38	600.0	599.20	TP	41.795069	-83.447522
4	111273.97	13373688.48	600.1	599.18	TP	41.801583	-83.448636
7	108765.66	13374471.45	577.9	577.09	TP	41.794678	-83.445867
9	108697.62	13372712.75	577.2	576.31	NE Sec. 15	41.794542	-83.452317
10	108610.28	13367111.76	580.4	579.56	BM Q178	41.794467	-83.472856
1918	108101.94	13374607.57	590.4	589.51	TP	41.792850	-83.445394
2168	109013.11	13374349.04	600.8	600.00	TP	41.795358	-83.446306
3081	108683.22	13373439.66	578.0	577.05	CP	41.794481	-83.449653

2016 Update

Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
9001	108397.13	13372561.93	579.5	582.32	JRW MW-16007	41.793722	-83.452881
9002	108021.97	13372562.48	580.0	582.84	JRW MW-16008	41.792694	-83.452894
9003	107653.55	13372573.73	579.9	582.59	JRW MW-16009	41.791681	-83.452869
9004	108834.64	13374076.00	586.5	589.35	JRW MW-16004	41.794878	-83.447314
9005	109687.92	13374452.98	586.2	589.02	JRW MW-16003	41.797208	-83.445897
9006	110463.28	13374460.66	585.8	588.68	JRW MW-16002	41.799336	-83.445836
9007	111255.91	13374012.08	589.2	5992.32	JRW MW-16001	41.801522	-83.447450
9008	110509.27	13373630.27	589.3	592.13	JRW MW-16005	41.799486	-83.448881
9009	109719.88	13373640.49	588.3	591.03	JRW MW-16006	41.797319	-83.448875

Elevation Basis

BM Q 187
Elevation = 579.56' NAVD88

Coordinate Basis

State Plane Coordinates Michigan South Zone 2113
MDOT CORS VRS (G12AUS) NAD83 2011

Legend

- 🟠 -- CCR UNIT Monitoring Well
- 🔵 -- Background Monitoring Well
- ⚪ -- Abandoned Monitoring Well
- ▲ -- Traverse Point
- ⊕ -- Section Corner

GRAPHIC SCALE

100 0 50 100 200 4

(IN FEET)
1 inch = 100 ft.

Elevations are NAVD88 from Benchmark (BM) Q 178 per NGS Data Sheet (Not Shown, Approximately 1.1 miles West of Northeast Corner Section 15. On 11-19-2015, a level loop was performed between BM and Control Point (CP) #3081. A second loop was done from CP to Traverse Point (TP) #1918 and to TP #2168. On 11-20-15, a loop was performed utilizing TP #1918 to determine elevations on Monitoring Wells at Top of Pipe on Pond 1 & 2 and TP #1 (not shown). Another loop was performed from TP #2168, determining elevations for MWs and TP #4 & #2 on Pond 6. Ground elevations at base of MW pipe were obtained on 11-10-15 by GPS observation.

2016 Update

On 11-30-16, a level loop was performed from Control Point (CP) #3081 and Monitoring Wells #16007, #16008, and #16009. Another loop was performed from CP #3081 and Monitoring Wells #16004, #16003, #16002, #16001, #16005, and #16006. Both Top of Casing and Ground (Top of Concrete at Base) were included in level loop.

NOTE: Previous Wells #15007 thru #15012 now abandoned/removed or to be abandoned/removed.

DRAWING NO.	REFERENCE DRAWINGS
SF-19884	Sheet 34, Pond 1 & 2
SF-19884	Sheet 35, Pond 6
	FIELD BOOK NO. 1997A

REV.	DATE	DESCRIPTION	BY	APP.
C	12/9 '16	Abandoned Wells, Historic Well ID, Pictures	RST	
B	12/1 '16	New Mon. Wells JRW MW #16001 thru #16009	RST	
A	12/7 '15	Changes per email request	RST	

		DATE
DN.	RST	11-24-15
FLD.	DEE	11-10-15
CHKD.		
APP.		
APP.	DEPARTMENT HEAD	

Consumers Energy

SSC SHERIDAN SURVEYING CO.
910 Fifth Street Michigan Center, MI 49254

Whiting Plant Monitoring Wells
CCR Monitoring
SAP WO #25477976

Sec. 11 & 14
City of Luna Pier

T8S, R8E
Monroe County

SCALE: 1" = 100'
CE FILENAME: 22374base.dwg
SSC FILENAME: 3708_SPCadj.dwg

Drawing No.	Sheet	Rev.
SG-22374	1	C

Appendix A
Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP
(Procedure CHEM-2.7.06)

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Written or Revised by Katharyn L Schlueter Date 08/07/09
Level I or Above

Technical Review by Gordon L Cattell Date 08/07/09
Level II or Above (not author)

Technical Approval by Emil Blaj Date 08/07/09
Level III

This electronically produced document has been reviewed and approved by the above-named individuals. The original document bearing the approval signatures is maintained on file by Consumers Energy, Laboratory Services.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

1.0 SCOPE

1.1 This procedure is a general method for collecting low stress/low flow ground water samples from monitoring wells. Upon approval by the responsible party, this procedure may be used as a substitute for macro-purging techniques where 3 to 5 well volumes have traditionally been purged prior to sampling. The low stress/low flow method is the preferred technique for ground water monitoring wells located at the former Manufactured Gas Plant (MGP) sites of Consumers Energy.

1.2 The presented technique applies to monitoring wells that have an inner casing with a nominal diameter of at least 1.0 inch, and maximum-screened lengths of ten feet per interval.

1.3 The technique is appropriate for collection of ground water samples that will be analyzed for: volatile and semi-volatile organics including pesticides and polychlorinated biphenyls (PCBs), total and dissolved metals, and various other analytes such as sulfates, cyanides, and nitrates/nitrites.

1.4 The technique is also appropriate when the following conditions are desired: lower turbidity in the sample containers, significantly less purge water for disposal, and higher analyte repeatability.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 CHEM-1.1.02, Chemistry Department Procedure Requirements.

2.2 Ground Water Issue, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, Puls and Barcelona, USEPA, Office of Research and Development, Office of Solid Waste and Emergency Response, EPA/540/S-95/504, April 1996.

2.3 Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells, USEPA Region 1, SOP No GW 0001, Revision 2, July 30, 1996.

2.4 Technical Guidance on Low-Flow Purging and Sampling and Passive Sampling, D M and G L Nielson, The Nielson Environmental Field School, NEFS-TG001-99, December 1999.

2.5 Manufacturer Operation Manual, as appropriate.

2.6 Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations, D6452-99, American Society for Testing and Materials.

2.7 MDEQ RRD Operational Memorandum 2, Attachment 5, Sampling and Analysis, October 2004, Revision.

2.8 Field worksheets (Attachments A-D).

3.0 DEFINITIONS

3.1 COC – Chain of Custody

3.2 NAPL – Non-aqueous Phase Liquids

3.3 LNAPL – Light Non-aqueous Phase Liquids

3.4 DNAPL – Dense Non-aqueous Phase Liquids

3.5 DTW – Depth-to-Groundwater

4.0 SUMMARY OF METHOD

4.1 Once depth-to-water is measured; a suitable pumping device is lowered to the target depth, generally mid-screen. Ground water is purged from the well casing at a slow rate, typically 100-500 mL/minute. While drawdown is measured and minimized, the purged water is diverted to a flow cell that contains several probes for indicating stabilization parameters, such as pH, conductively, etc. Once the parameters have stabilized within pre-determined limits, the purged water stream is diverted from the flow cell to sample containers for collection of proper test parameters.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Flow-cell, hand-held monitor, and sonde, containing in-line probes calibrated for at least dissolved oxygen and oxidation-reduction potential (ORP). If necessary, pH and conductivity may be monitored with external monitors, although in-line probes are recommended. Turbidity or other probes/monitors may be added as site-specific requirements dictate.

5.1.2 Adjustable rate groundwater pumping devices including: Peristaltic pump with pump head and electrical power source; bladder pump(s) with controller and a source of compressed air; gear pump (Keck or “bullet”), with controller and electrical power source. Gear and bladder pumps should be constructed of stainless steel or PTFE.

5.1.3 Tubing of the appropriate size, length, and material.

5.1.4 Interface probe for determining the presence or absence of NAPLs.

5.1.5 Water level measuring device with a minimum 0.01-foot accuracy.

5.1.6 Flow measurement supplies such as a rotometer or graduated cylinder with a stopwatch.

5.1.7 Portable PID meter, calibrated the same day as use.

5.1.8 Decontamination supplies, including deionized water, brushes, buckets, and commercially available 2-propanol soaked wipes.

5.1.9 Sample bottles with appropriate preservatives.

5.1.10 Field hazardous materials kit, including eyewash, sampling gloves, goggles, earplugs, etc.

5.1.11 Purge water collection device, such as a sturdy plastic bucket.

5.2 REAGENTS

5.2.1 Assorted standards as needed to fully calibrate the above system.

5.3 CALIBRATION REQUIREMENTS

5.3.1 All meters, probes, etc must be calibrated according to manufacturer’s instructions. Periodic checks are recommended during or at the end of the day to ensure the calibration curves. Written documentation is required for all calibrations and periodic checks.

5.3.1.1 In general, daily recalibration will be required. In some cases where a periodic check indicates the calibration curves are still valid, no daily calibration may be necessary.

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 Historical documentation, including well construction data (eg, screen depth), well location map, and field data from a previous sampling event.

5.4.2 Material Safety Data Sheets (MSDSs) for all reagents taken to the job site.

5.4.3 A field log book or field worksheet must be kept at each sampling event (see Attachments A-D). The following should be documented:

5.4.3.1 Field instrumentation calibration data.

5.4.3.2 Monitoring well identification number and physical condition.

5.4.3.3 Monitoring well data such as casing material, casing diameter, and screen length.

5.4.3.4 Monitoring well depth and DTW, measurement technique, date and time of measurement.

5.4.3.5 Presence and thickness of NAPLs and detection method.

5.4.3.6 Sample tubing material, diameter, length, placement, and pump type.

5.4.3.7 Pumping rate, water level, water quality indicator values, date and time of measurements.

5.4.3.8 Identification of any unacceptable water quality indicator values.

5.4.3.9 Time and date of sample collection.

5.4.3.10 Sample ID and control number.

5.4.3.11 Field observations.

5.4.3.12 Sampler’s name or initials.

5.4.4 The COC must contain the analytical parameters requested, sample time and date, sampler’s name or initials, site location, sample ID, control number, preservatives added, and filtration status.

5.4.5 The sample labels must contain the sample ID, control number, sample time and date, sampler's initials, preservative, filtration status, and analytical parameter requested.

5.4.6 Field worksheets (Attachments A-D).

5.4.6.1 Monitoring Well Sampling Worksheet (Attachment A)

5.4.6.2 Monitoring Well Depth-To-Water Measurements Worksheet (Attachment B)

5.4.6.3 Flowcell/Sonde Calibration and Periodic Checks Worksheets (Attachment C)

5.4.6.4 Field Screening of Monitoring Wells Via PID (Attachment D)

5.5 PERSONNEL REQUIREMENTS

5.5.1 All tests and data reporting shall be performed by certified persons of Level I or above, in the appropriate discipline. (The project report shall be issued and reviewed by a certified person of Level II or above, in the appropriate discipline. The project report, if so indicated on the work request [or form similar in intent], may require approval from a certified person of Level III, in the appropriate discipline.)

5.6 ENVIRONMENTAL CONDITIONS

See Section 6.0.

6.0 PRECAUTIONS

6.1 The site-specific Health and Safety Plan is used to identify any physical or chemical precautions and actions to be taken to prevent injury. A pre-job briefing shall be conducted prior to initiating sampling.

6.2 Observe normal safety practices as specified in the latest online revision of the Environmental and Laboratory Services Accident Prevention Manual and the Consumers Energy Chemical Hygiene Plan in Lotus Notes.

7.0 LIMITATIONS AND ACTIONS

7.1 This technique is generally not suitable for very low-yield wells (<50 mL/minute with continued drawdown).

7.2 Even with pre-planning, a number of problems may be encountered which will challenge the sampler. These include: insufficient yield, failure of one or more key indicator parameters to stabilize, cascading, and equipment failure. Each of these problems will be addressed on a case-by-case basis and their impact can be minimized by consulting the references in Section 2.

7.3 This method does not address the collection of light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). Collection of these sample types is both atypical and non-standardized and must therefore be addressed on an as-needed basis.

8.0 ACCEPTANCE CRITERIA

Refer to Section 9.3.9.3 in this procedure.

9.0 PROCEDURE

9.1 Orient the equipment and yourself upwind of the monitoring wells if possible.

9.2 DETERMINATION OF DEPTH-TO-GROUNDWATER (DTW)

9.2.1 Start at either the well known, or believed to have, the least contaminated groundwater and proceed systematically to the well known, or believed to have, the highest level of contamination.

9.2.2 Check the well casing protector, lock, locking cap, and well casing for obvious damage or evidence of tampering. Record any abnormal observations.

9.2.3 The sampler may desire to minimize contamination from the ground and provide a clean area for laying down equipment. This can be accomplished by cutting a section from a sheet of plastic and fitting it around the well casing protector.

9.2.4 Remove the well cap. At some sites, it may be necessary to remove all well caps first, then proceed to 9.2.5. This will be determined prior to any field events.

9.2.5 If the site has not been characterized yet, or there is insufficient history, it will be useful to determine the concentration of organic vapors in the heads case. Using a portable, calibrated, PID meter measure and record the organic vapor concentration as follows: (1) At the highest risk breathing zone elevation, defined here as the point located at roughly 6" above the center of the top of the well casing. (2) At 0-6" within the well casing.

9.2.6 If the well casing does not have a reference point, make one. The reference point is typically a V-cut or an indelible mark in the well casing.

9.2.7 Measure and record the DTW to 0.01 feet. Duplicate the reading. Hold the tape against the reference point when making the reading. Care should be taken to minimize disturbance of the water column.

9.2.8 Measure and record the thickness and depth of any NAPLs.

9.2.9 If desired or required by the site plan, measure the depth of the well. Care should be taken to minimize disturbance of the water column and any sediment that has accumulated.

9.2.10 Decontaminate the electronic tape and interface meter. Wipe dry using a clean Kaydry-type material. Rinse with DI water and wipe dry again. If organic contamination is suspected, the sampler must decontaminate accordingly before proceeding. One option is to use commercially prepared decontamination wipes that are saturated with 2-propanol.

9.2.11 If the monitoring well will be sampled the same day and will remain in visual range and/or without a reasonable risk of tampering, loosely recap the well and leave the well casing protector unlocked. Otherwise, secure the well as if not returning.

9.2.12 If a sheet of plastic has been fitted around the well casing protector, leave it in place if the well will be sampled the same day.

9.2.13 Continue with the determination of DTW on the rest of the monitoring wells. Continue with purging and sampling when appropriate (ie, large distance between wells).

9.3 PURGING

9.3.1 If not already determined at the laboratory or by prior sampling events, determine the type of pump to be used (operation of each pump type will not be covered here).

9.3.2 For ease of use and portability, a peristaltic pump may generally be used for any well where DTW plus casing height above grade does not exceed 15 feet.

9.3.3 Keck (gear or “bullet”) and bladder pumps can be used in any instance where there is sufficient water in the casing to completely submerge the pump and intake screen at all times.

9.3.4 Use well installation and historical data to determine the length of tubing needed to place the pump intake or tubing at the desired sample depth, generally mid-screen. Attach the tubing to the pump and prepare to lower the tubing or tubing/pump down the well. To keep from introducing contamination into the monitoring well, never allow the tubing or tubing/pump to touch bare ground.

9.3.5 Install the tubing or pump/tubing. Slowly lower the pump, tubing, and any safety cable and electrical lines into the monitoring well. Final placement is generally at mid-screen. Typically, the intake must be kept at least 2 feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Once the desired depth is reached, clamp or otherwise secure the tubing to prevent the pump/tubing from dropping any lower. Record the depth to which the pump was lowered.

9.3.6 Before starting the pump, wait a few minutes and measure the water level again. Record this level. This short waiting period allows for reduced turbidity and reequilibrium of the water level. Leave the electronic tape in the well for later use.

9.3.7 Attach the in-line flow cell. Start the pump and collect roughly 100 mL/minute. Start with a faster or slower pumping rate if historical data suggests to do so.

9.3.8 Collect all water for proper disposal.

9.3.9 Monitor and record the water quality parameters and water level every 3-5 minutes.

9.3.9.1 Ideally, a steady flow rate should be maintained that results in a stabilized water level. Pumping rates should be reduced or increased to ensure stabilization of the water level in the well. Avoid entrainment of air in the tubing.

9.3.9.2 Record the time of the readings and the pump rate.

9.3.9.3 The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows:

- ± 0.1 pH units
- ± 3% conductivity units (specific conductance)
- ± 10 mV for redox potential (Eh/ORP)
- ± 10% for DO and turbidity
- Temperature – For information only. Record only.

Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. (Above criteria may not apply to very clean wells.)

9.4 SAMPLE COLLECTION

9.4.1 The pump must not be removed from the well between purging and sample collection. It is recommended that the pump not be turned off between purging and sample collection. Continue to collect excess groundwater for proper disposal.

9.4.2 Disconnect or bypass the flow cell.

9.4.3 Collect samples at the same flow rate as the purging rate. Minimize potential contamination from dust, rain, etc by shielding the open bottles as needed.

9.4.4 Samples will be collected directly into the sample containers. Minimize aeration by allowing the water to flow down the side of the container rather than splashing against the bottom of the bottle. Avoid placing the sample tubing below the liquid level of the sample being collected. Label the containers and chill immediately.

9.4.5 VOC samples must be collected first except as noted below for Low Level Mercury. Check for air bubbles in the container before proceeding to collecting the next parameter. Carbonacious waters will naturally produce bubbles in the containers, which cannot, and should not, be removed.

NOTE: A sample for low level mercury should be the first sample collected when multiple analyte containers will be filled. Low level mercury sample bottles should be pre-cleaned and individually stored in Ziploc®-style plastic bags. Use clean nitrile gloves for each sample collection point, immediately prior to handling any bagged sample bottles.

When collecting a sample from a monitoring well:
- Remove the sample bottle from the plastic bag and remove the cap.
- The bottle should be thoroughly rinsed with the sample stream, holding the sample tubing very close to, not within, the open bottle (approximately 1/8"). Never place the sample tubing within the bottle.
- Fill to approximately ¼" below the bottle threads, affix a label, cap the bottle, and return it to the plastic bag.
- Place the bagged bottle in a cooler designated only for low level mercury.

9.4.6 Semi-volatile samples must be collected next, followed by any other parameters that do not require filtration.

9.4.7 Samples that require only filtration with no additional preparation steps should be collected using in-line filters. Filtered samples are typically collected last One exception is collection for available cyanide, which must be collected last due to the potential for cross-contamination from the lead carbonate reagent.

9.4.8 Once all samples from the monitoring well are collected, remove the tubing or pump/tubing. Record the stop time, if required. In addition, the total volume purged can be calculated and recorded.

9.4.9 Cap and secure the monitoring well.

9.4.10 In general, the purged water is poured on to the ground next to the monitoring well. Whether to collect in a drum or to use another strategy will be determined prior to starting any field activities.

9.4.11 Continue with sampling all of the other monitoring wells.

9.5 FIELD QUALITY CONTROL (QC) SAMPLES

9.5.1 Field QC samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. All QC samples are treated the same as samples with regard to volume, bottle type, preservatives, and any pretreatment.

9.5.2 TYPES OF QC SAMPLES

9.5.2.1 Trip Blank – For VOCs only. Consists of DI water in a VOC vial (contains preservative) and is prepared at the lab prior to the field event. The vial is left capped and chilled while sampling. Used to determine if sample holding and transport has introduced contamination into the samples.

9.5.2.2 Field Blank – Consists of DI water in an appropriate bottle with the appropriate preservative. Obtained from the lab prior to the sampling event and can prepare for a variety of analytes. The bottle is uncapped while sampling to indicate contamination that may have occurred during the operation.

9.5.2.3 Equipment Blank – DI water is exposed to the sample path at any time decontamination needs to be verified. Collect for any suspect parameter and treat it exactly the same as if collecting a sample.

9.5.2.4 Sample Duplicate – One monitoring well per 20 will be selected for collection of a duplicate sample. This is simply an additional set of the sample collected in exactly the same manner as the original sample. The sample type is used to determine precision.

9.5.2.5 Matrix Spike and Matrix Spike Duplicate – One monitoring well per 20 will be selected. These are additional sets of samples collected in exactly the same manner as the sample is collected. This sample type is used to determine accuracy but can also indicate matrix bias.

9.6 DECONTAMINATION

9.6.1 **General Considerations**

9.6.1.1 All nondedicated sampling equipment that is to be reused must be decontaminated prior to its reuse.

9.6.1.2 All disposable tubing will be properly discarded and new tubing used in its place. No tubing will be reused.

9.6.1.3 All equipment washings/rinsates must be collected for proper disposal.

9.6.1.4 The flow cell may be cleaned using the procedure in Section 9.6.2.1 or a manufacturer recommended procedure. Special attention must be paid to care of the probes on the sonde portion of the unit.

9.6.1.5 To avoid cross-contamination, pumps that are contaminated with NAPLs will be isolated and decontaminated at the laboratory.

9.6.2 Between Well and End-of-Day Decontamination Process

9.6.2.1 Flow Cell

A. In the case of the flow cell when new tubing will be used, a double rinse at half volume using deionized water is typically adequate. Continue with sampling. If the sample location is historically not contaminated, this step may be omitted.

B. If NAPLs, odors, or colors are present and cannot be flushed out, assess if the probes are fouled by spot-checking the calibration curves. If the probes are not fouled, no further action is necessary since the flow cell does not contact the sample. Continue with sampling.

C. If the probes are fouled, contact the MGP sample coordinator at the laboratory for guidance.

D. At the end of the day, the in-line flow cell should be free of sediment and NAPLs. Fill the cell with tap water, insert the sonde, and store.

9.6.3 Pumps

9.6.3.1 Peristaltic pumps need to only have the pump head tubing and sample tubing replaced.

9.6.3.2 If the equipment, such as the peristaltic pump case, is contaminated with organic material, wipe down with commercially available wipes presaturated with 2-propanol. If the organic material does not dislodge, stop now, isolate for decontamination at the lab, and use different equipment for the next monitoring well.

9.6.4 Specific Bladder and Keck (gear or bullet) Pump Decontamination Measures

9.6.4.1 Pump pre-rinse – Operate the pump in a deep basin containing 1-5 gallons of deionized water and continue through several cycles.

9.6.4.2 Pump wash – Operate the pump in a deep basin containing 1-5 gallons of nonphosphate detergent solution, such as Alconox. Operate through several cycles.

9.6.4.3 Pump rinse – Operate the pump in a deep basin containing 1-5 gallons of DI water. Continue for several cycles.

9.6.4.4 Disassemble pump, if required, and continue with 9.6.4.5. If not required, go to 9.6.4.7.

9.6.4.5 Pre-rinse, wash, and rinse as above, scrubbing as needed at the wash stage.

9.6.4.6 Reassemble the pump.

9.6.4.7 Store the pump so as to keep it clean until needed.

10.0 CALCULATIONS

None

11.0 DATA REPORTING

Refer to Section 5.4 in this procedure. At a minimum the COC shall be stored in the project folder.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Consumers Energy Company
Chemistry Section – Laboratory Services Department
Monitoring Well Sampling Worksheet

MW_ID **Today's Date** **Control Number**
Location
MW Reference Name **GPS Grid Reference**
Top-of-Casing Elevation (ft) **Depth-to-Screen Bottom (ft)** **Depth-to-MidScreen (ft)**
Screen Length (ft) **Casing ID (in)** **Typical Purge Volume** **Protective Casing Mount**
Comments

Field Measurements

Depth-to-Water (ft) **HC Layer Detected** **PID Reading (ppm)**

Time	**pH**	**Temp**	**Sp Cond**	**DO**	**DO**	**ORP**	**Pump Rate Indicate**	**Water Level**	**Turbidity**
Hr : Min	Units	°C	µS/cm	ppm	% Sat	mV	mL/min gal/min	Draftdown (ft)	NTU
3-5 Min	± 0.1	na	± 3%	± 10%	± 10%	± 10%	See Notes	<0.33	± 10%
Completed By >>			**Total Pump Time >>**			**Total Purge Volume >>**			

Acceptance criteria are low-flow general acceptance. Pump rate should be <500 mL/min for low-flow and <1 gal/min for high-volume.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Monitoring Well Depth-to-Water Measurements

Site: ____________________

Analyst: ____________________

Date: ____________________

Project No: ____________________

Method: Electronic Tape

Tape ID: Solinst, Model 122, S/N 122001406-1

Well ID Number	Time of Measurement	Trial 1	Trial 2	Depth to Bottom of Screen, ft	Remarks
		DWL, ft	DWL, ft		

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Project Sonde Check; As-Found Readings & Recalibration

Page 1 of 2

I. *Site or Project Tracking*

Site or Project : ________________ Chem. Control # : ________________

II. *System Identifiers*

Monitor Brand, Model & S/N:	YSI 650MDS S/N 08C100135
Sonde Brand, Model & S/N:	YSI 6820V2 S/N 08C101426
Flow Cell Brand & Model:	YSI 6160
DO Probe Brand, Model & S/N:	YSI 6150 S/N 08C101539
Turbidity Probe Brand, Model & S/N:	YSI 6136 S/N 08C101363
pH With ORP Brand, Probe Model & Lot:	YSI 6565 Lot Number 08B*26
Conductivity & Temperature Probe Model & S/N:	YSI No additional information

Sample

III. *pH Check*

Standard vs As-found, pH Units	Standard Source	Catalog # & Lot #	Exp. Date
4.00			
7.00			
10.00			

Analyst Initials: ________________ Date & Time: ________________

As-Found Evaluation

Are the readings within +/- 0.10 of their calibration points? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

IV. *ORP Check With Zobell Solution*

Standard vs As-found, mV	Source	Catalog # & Lot #	Exp. Date
231			

Analyst Initials: ________________ Date & Time: ________________

As-Found Evaluation

Is the reading in the 221-241mV range? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solution listed above was used.

V. *DO Check With DI Water; 100% Saturation*

As-Found: ________________ Analyst Initials, Date & Time: ________________

As-Found Evaluation

Is the reading in the 90-110 % saturation range? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, lab DI water was used.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Project Sonde Check; As-Found Readings & Recalibration

Page 2 of 2

Site or Project : ________________ Chem. Control # : ________________

VI. *Conductivity Check*

Standard vs As-Found, us	Source	Catalog # & Lot #	Exp. Date
0 (DI Water)	Lab DI System	- - - -	- - - -

Analyst Initials: ________________ Date & Time: ________________

Sample

As-Found Evaluation

Is the reading +/- 3% of the reference point? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

Linearity Check

Standard vs As-Found, us	Source	Catalog # & Lot #	Exp. Date

Analyst Initials: ________________ Date & Time: ________________

VII. *Turbidity Check*

Standard vs As-Found, NTU	Source	Catalog # & Lot #	Exp. Date
0 (DI Water)	Lab DI System	- - - -	- - - -

Analyst Initials: ________________ Date & Time: ________________

As-Found Evaluation

Is the reading +/- 10% of the reference point? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

Linearity Check

Standard vs As-Found, NTU	Source	Catalog # & Lot #	Exp. Date

Analyst Initials: ________________ Date & Time: ________________

Reviewed By ______________________________ Date ______________________

Field Screening of Monitoring Wells Via PID

Project Information

Site: ________________________________

Project No: ________________________________

Date: ________________________________

Instrument Information

Instrument ID and Serial Number: ____________________________

Calibration (Span) Gas ID, Lot Number Concentration, etc: ____________________________

Zero Gas ID, Lot Number, Concentration, etc: ____________________________

Periodic Calibration Checks

Time	Analyst	Cal Gas Conc, ppm v/v	Display Conc, ppm v/v

Monitoring Well Screening

MW ID	Time	Analyst	Breathing Zone Display Conc	0-6" Within Casing Display Conc
Background Air				NA

Appendix B
Chain-of-Custody, Handling, Packing and Shipping SOP (Procedure CHEM-1.2.04)

TITLE: CHAIN OF CUSTODY REQUIREMENTS (CoC)

1.0 PURPOSE

To provide guidance for uniform preparation of a Chain-of-Custody document.

2.0 SCOPE

The Chain-of-Custody (CoC) document is required for all samples where the analysis results are used for environmental reporting. It may also be used as requested by the customer for other forms of reporting. This method provides guidance for the use of the CoC document.

3.0 DEFINITIONS

Chain-of-Custody (CoC) – A document that is a management tool used to verify sample identification information, sample inventory and sample possession from the time the sample is collected to the time the sample is received by a laboratory.

4.0 REFERENCE DOCUMENTS

4.1 Chapter 1 – SW-846, Test Method for Evaluating Solid Waste, USEPA

4.2 ASTM Method D 5283-92, Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation

4.3 ASTM Method D 4840-95, Standard Guide for Sampling Chain-of-Custody Procedures

4.4 Chemistry Department Standard Operating Procedures, as applicable

4.5 Laboratory Services Quality Assurance (LSQA) Procedure Manual, as applicable

5.0 PROCEDURE

5.1 Prior to sampling, the sample team shall be provided with CoC forms. It shall be the responsibility of the on-site supervisor or designated representative to ensure that CoC requirements, sample collection protocol and proper sample handling protocol are initiated on-site.

5.2 A sample is considered under custody if one or more of the following criteria are met:

- The sample is in the sampler’s possession.
- The sample is within the sampler’s view after being in possession.
- The sample was in the sampler’s possession and then placed in a secure container to prevent tampering.
- It is in a designated secure area.

5.3 Each CoC shall identify basic site information and include the following:

- The sampling site name, project name or other site/project identification.
- The initials of the sampling teams.
- Project Leader or report distribution personnel.
- If a site sketch or other documents are to be found with the CoC.
- Necessary remarks as required.

5.4 Each sample entry into the CoC shall include the following:

- Date of sample collection.
- Time of sample collection.
- Type of sample matrix (soil, water, vapor, product, etc).
- Sample identification, name or description.
- Sample depth, if applicable.
- Number of sample containers.
- Specific analytical test parameters. In some cases the specific test parameters may not be known at the time of sample collection. However, the samples are collected in accordance with the protocol for a general group of analytes (e.g., dissolved metals, volatile organic compounds) and the specific test analytes are determined after the sampling event. In these cases, the entry for the analytical test parameter is not required.

5.5 The original of the CoC record shall accompany the samples and a copy should be maintained by the on-site supervisor.

5.6 When transferring the possession of samples, the individuals relinquishing and the individuals receiving the samples should sign, date and note the time on the CoC record.

5.7 In cases where the sample leaves the originator’s immediate control, such as shipment to the laboratory by a common carrier (e.g., Federal Express or

Consumers Energy's internal mail) a seal should be placed on the shipping container to detect unauthorized entry to the samples. Any shipping containers that arrive at the Laboratory with the seals damaged should be evaluated to ascertain if the contents have been in valid custody.

5.8 In the event samples requiring the CoC protocol arrive at the Laboratory without the CoC document, the Laboratory shall complete the CoC document upon sample login and under the supervision of the assigned Laboratory Project Leader or Area Coordinator. The person completing the CoC shall enter the statement "CoC completed by the Laboratory upon receipt of sample(s)" in the remarks section of the CoC and initial the entry.

5.9 A sample CoC form is attached (Attachment A).

5.10 Other CoC formats and forms may be used as long as the CoC meets the recommendations of this procedure.

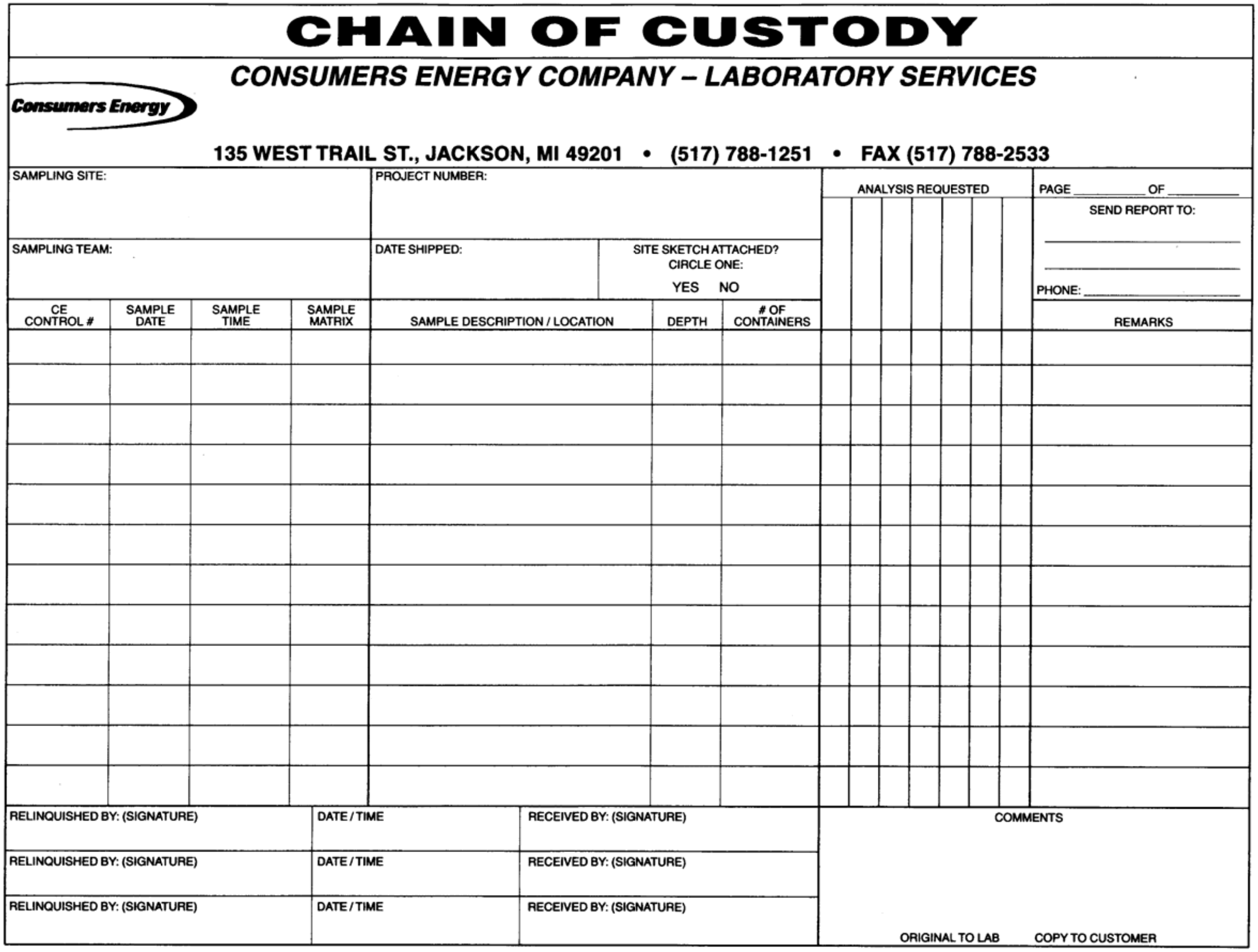
5.11 The CoC shall be stored in the project folder and retained according to CHEM-1.1.7, Record Retention.

QA Review Katharyn L Schlueter Date 02/27/08
Chemistry Quality Assurance Coordinator

Administrative Approval Gordon L Cattell Date 02/27/08
Chemistry Department Supervisor

This electronically produced document has been reviewed and approved by the above-named individuals. The original document bearing the approval signatures is maintained on file by Consumers Energy, Laboratory Services.

TITLE: CHAIN OF CUSTODY FORM (CoC)



CHAIN OF CUSTODY

CONSUMERS ENERGY COMPANY – LABORATORY SERVICES

Consumers Energy

135 WEST TRAIL ST., JACKSON, MI 49201 • (517) 788-1251 • FAX (517) 788-2533

SAMPLING SITE:

PROJECT NUMBER:

SAMPLING TEAM:

DATE SHIPPED:

SITE SKETCH ATTACHED?
CIRCLE ONE:
YES NO

ANALYSIS REQUESTED

PAGE ________ OF ________

SEND REPORT TO:

PHONE: ____________

CE CONTROL #	SAMPLE DATE	SAMPLE TIME	SAMPLE MATRIX	SAMPLE DESCRIPTION / LOCATION	DEPTH	# OF CONTAINERS								REMARKS

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)

COMMENTS

ORIGINAL TO LAB COPY TO CUSTOMER

Attachment C

Consumers Energy
Count on Us®

A CMS Energy Company

Date: May 5, 2020

To: Operating Record

From: Harold D. Register, Jr., P.E. HDR

RE: Selection of Statistical Procedures Professional Engineer Certification, §257.93(f)(6)
Former JR Whiting Power Plant, Pond 1 & 2 and Pond 6

Professional Engineer Certification Statement [40 CFR 257.93(f)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations §257.93 (40 CFR Part 257.93), I attest that this Groundwater Statistical Evaluation Plan has been prepared to include a narrative description of the statistical method selected to evaluate the groundwater monitoring data for JR Whiting Pond 1 & 2 and Pond 6 in accordance with the requirements of 40 CFR 257.93.

Harold D. Register Jr.
Signature

May 5, 2020
Date of Certification

Harold D. Register, Jr., P.E.
Name

6201056266
Professional Engineer Certification Number

STATE OF MICHIGAN
HAROLD D.
REGISTER, JR.
ENGINEER
No.
6201056266
LICENSED PROFESSIONAL ENGINEER

05/05/2020

ENCLOSURES

TRC Environmental Corporation (February 2020). "*Groundwater Statistical Evaluation Plan, Former JR Whiting Power Plant Pond 1 & 2 and Pond 6.*"

Groundwater Statistical Evaluation Plan

Former JR Whiting Power Plant
Pond 1 & 2 and Pond 6
Erie, Michigan

February 2020

Groundwater Statistical Evaluation Plan

Former JR Whiting Power Plant
Pond 1 & 2 and Pond 6
Erie, Michigan

February 2020

Prepared For
Consumers Energy Company

Graham Crockford, C.P.G.
Senior Project Geologist

Sarah B. Holmstrom, P.G.
Project Hydrogeologist

TRC | Consumers Energy
Final
X:\WPAAM\PJT2\332751\0000\GW SEP\R332751.0 SEP.DOCX

Table of Contents

List of Figures

Section 1
Introduction

1.1 Regulatory Framework

JR Whiting monitored groundwater under the Hydrogeological Monitoring Plan (HMP), dated October 1995, revised November 10, 1997, and November 26, 1997 until a ground monitoring waiver was granted by the Michigan Department of Environmental Quality, now the Department of Environment, Great Lakes, and Energy (EGLE) on September 2, 2009. JR Whiting was required to maintain the HMP for possible future use.

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule). The CCR Rule, which became effective on October 19, 2015, and Part 115 apply to the Consumers Energy Company (Consumers Energy) Pond 1 & 2, and inactive Pond 6 at the JR Whiting Site (JRW Pond 1&2; JRW Pond 6) thus JR Whiting resumed groundwater monitoring as required under the CCR Rule. On August 5, 2016, the USEPA published the CCR Rule companion *Extension of Compliance Deadlines for Certain Inactive Surface Impoundments,* which established the compliance deadlines for inactive CCR units that were closed prior to April 17, 2018.

On December 28, 2018, the State of Michigan enacted Public Act No. 640 of 2018 to amend Part 115 of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended (Part 115). The December 2018 amendments to Part 115 were developed to provide the State of Michigan oversight of CCR impoundments and landfills and to better align existing state solid waste management rules and statutes with the CCR Rule. This alignment would ensure compliance with the CCR standards through a state-approved permitting program that would be deemed to be “equivalent to” or “as protective as” through an administrative application that would be reviewed and authorized by U.S. EPA.

Pursuant to the CCR Rule and Part 115, the owner or operator of a CCR unit must develop the groundwater sampling and analysis program to include selection and certification of the statistical procedures to be used for evaluating groundwater in accordance with the Part §257.93 Title 40 Code of Federal Regulations and R 299.4908 of the Part 115 Solid Waste Management Rules. This certification must include a narrative description of the statistical method that will be used for evaluating groundwater monitoring data.

TRC prepared this Groundwater Statistical Evaluation Plan (Statistical Plan) for the JRW Pond 1&2, and Pond 6 CCR units on behalf of Consumers Energy. This Statistical Plan was prepared in accordance with the requirements of §257.93 and R 299.4908 and describes how data collected from the groundwater monitoring system will be evaluated for each of the two CCR units. Upon approval from EGLE, this Statistical Evaluation Plan will replace the statistical analysis portion of the existing Part 115 HMP. As part of the evaluation, the data collected during detection monitoring events, are evaluated to identify statistically significant increases (SSIs) in detection monitoring parameters (Section 11511a. (3)(c) of PA 640) to determine if concentrations in detection monitoring well samples exceed background levels.

The CCR Rule and Part 115 are not prescriptive with regards to the actual means and methods to be used for statistically evaluating groundwater data, and there is flexibility in the method selection, as long as specific performance metrics are met. A description of statistical methods that meet the performance objectives of the CCR Rule and Part 115 are described in *USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (U*nified Guidance,* USEPA, 2009).

1.2 Site Hydrogeology

Pond 1& 2 and Pond 6 are located adjacent to Lake Erie. The subsurface materials encountered at the JR Whiting site are predominately clay-rich till. The surficial CCR fill material is underlain by approximately 40 to 50 feet of laterally extensive clay-rich till that acts as a natural hydraulic barrier across the site. Limestone bedrock is present beneath the till and is considered the uppermost aquifer at the site.

Groundwater present within the uppermost aquifer is confined and protected from CCR constituents by the overlying clay-rich aquitard and is typically encountered around 50 feet below ground surface (ft bgs) in the limestone (beneath the till). Potentiometric surface elevation data from groundwater within the CCR monitoring wells exhibit an extremely low hydraulic gradient across the site with no consistent or discernible flow direction. There are minor differences in hydraulic head across the monitoring wells (ranging from zero up to 0.13 feet across Pond 1&2 from event to event from November 2016 through September 2019), indicating that the potentiometric surface is flat the majority of the time. In the few instances since November 2016 where a slight gradient was observed and calculable, the direction of the flow potential was slightly to the northwest (two events) and to the east (one event). Additionally, there are minor differences in hydraulic head across the monitoring wells (ranging from zero up to 0.24 feet across Pond 6 from event to event from November 2016 through September 2019), indicating that the potentiometric surface is flat with no discernable flow direction the majority of the time.

Given that the hydraulic gradient is often so low, groundwater flow across Pond 1&2 and Pond 6 is frequently incalculable and often stagnant. The most pronounced groundwater gradient between November 2016 and September 2019 was observed in December 19, 2016, which showed a slight horizontal gradient of approximately 0.00016 to the northwest across Pond 1&2.

Based on the hydrogeology at the Site, particularly the extremely low to non-existent gradient or lack of flow direction at the JR Whiting site in addition to the presence of 40 to 50 feet of laterally extensive clay-rich till that acts as a natural hydraulic barrier across the site, an intra-well statistical approach is recommended for detection monitoring.

Section 2
Groundwater Monitoring System

2.1 Groundwater Monitoring System

A groundwater monitoring system has been established for Pond 1&2, which established the following locations for detection monitoring. The locations are shown on Figure 1.

- JRW MW-15001
- JRW MW-15002
- JRW MW-15003
- JRW MW-15004
- JRW MW-15005
- JRW MW-15006

A groundwater monitoring system has been established for Pond 6, which established the following locations for detection monitoring. The locations are shown on Figure 1.

- JRW MW-16001
- JRW MW-16002
- JRW MW-16003
- JRW MW-16004
- JRW MW-16005
- JRW MW-16006

2.2 Constituents for Detection Monitoring

R 299.4440 and §257.94 describe the requirement for detection monitoring. The detection monitoring parameters are identified in Section 11511a. (3)(c) of PA 640 (which are inclusive of the detection monitoring parameters in Appendix III of §257.94) and consist of the following:

- Boron
- Calcium
- Chloride
- Fluoride
- pH
- Sulfate
- Total Dissolved Solids (TDS)
- Iron

2.3 Constituents for Assessment Monitoring

Assessment monitoring per R 299.4441 is required when a SSI over background has been detected for one or more of the constituents identified in Section 11511a. (3)(c) of PA 640 or Appendix III to Part 257 – Constituents for Detection Monitoring. In the event that assessment monitoring is triggered through the statistical evaluation of detection monitoring parameters, as required in Section 11519b. (2), the following additional assessment monitoring parameters will be monitored for:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Lithium
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc
- Radium 226 and 228 (combined)

Section 3
Statistical Analysis

Groundwater sampling and analytical requirements are described in and R 299.4908. The owner or operator of the CCR unit must select a statistical method specified pursuant to R 299.4908(1) to be used in evaluating groundwater monitoring data. The test shall meet the performance standards outlined in R 299.408(2). The goal of the statistical evaluation plan is to provide a means to formulate an opinion or judgement as to whether the CCR unit has released contaminants into groundwater. This plan describes the statistical procedures to be used to determine if a statistically significant increase (SSI) or in the case of pH, a statistically significant difference (SSD), indicating that data is from a different population than background. This plan was developed using applicable guidance, including the *Unified Guidance*. In addition to using applicable guidance documents, commercially available statistical evaluation tools will be applied to the JRW Pond 1&2 groundwater data to develop statistically derived limits so that detection monitoring results can be compared to background.

The CCR Rule and Part 115 allow a variety of methods for conducting statistical evaluations. The specific procedure for a given data set depends on several factors including the proportion of the data set with detected values and the distribution of the data. These will not be known until the data are collected. It is generally anticipated, however, that the tolerance or prediction interval procedure will be the preferred method of conducting detection monitoring data evaluation to the extent that the data support the use of that method. This statistical procedure is described below in this section of the plan and in detail in the *Unified Guidance*.

3.1 Establishing Background

Background groundwater monitoring was initially conducted for constituents in Appendix III and Appendix IV of the CCR Rule from November 2016 through October 2017 in accordance with the Sampling and Analysis Plan (SAP). Additional Appendix III background data have been collected semiannually through March 2019. Background will be established for the Section 11511a. (3)(c) constituents not already included in the CCR Rule Appendix III (i.e., iron) throughout eight sampling events. Per R 299.4907(7), the owner or operator of the CCR unit must establish background groundwater quality in hydraulically upgradient or background well(s). The development of a groundwater statistical evaluation program for detection monitoring involves the proper collection of background samples, regardless of whether an inter-well or intra-well monitoring strategy is implemented. Background may be established at wells that are not located hydraulically upgradient from the unit if it meets the requirement of R 299.4906(1)(a). A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where:

i. Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or
ii. Sampling at other wells will provide an indication of background groundwater quality that is as representative as or more representative than that provided by the upgradient wells.

The purpose of obtaining adequate background groundwater data is to approximate, as accurately as possible, the true range of ambient concentrations of targeted constituents. Background groundwater data should eliminate, to the extent possible, statistically significant concentration increases not attributable to the CCR unit. Specifically, the owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit as outlined in R299.4906(1). The sampling frequency should be selected so that the samples are physically independent. These background groundwater parameters can be adequately qualified by doing the following:

- Collecting the minimum number of samples that satisfy the requirements of the statistical methods that are used (*i.e.*, that result in adequate statistical power);
- Incorporating seasonal and/or temporal variability into the background data set; and
- Incorporating the spatial component of variability into the background data set (*i.e.*, the variability that comes with obtaining samples from different locations within the same groundwater zone).

The initial background/baseline sampling period is at least eight independent events. This provides a minimal background data set to initiate statistical comparisons. Over time, the short baseline period may result in a high risk of false positive statistical results. The facility may periodically update background data to account for variability in background conditions. The *Unified Guidance* recommends that background data be updated every 4 to 8 measurements (i.e., every two to four years if samples are collected semi-annually, or one to two years if samples are collected quarterly). The background data will be reviewed for trends or changes that may necessitate discontinuation of earlier portions of the background data set. Updates to the background statistical limits will be submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for approval.

3.2 Data Evaluation and Data Distributions

Consumers Energy will evaluate the groundwater data for each constituent included in the groundwater monitoring program using intra-well tolerance or prediction limits. The tolerance or prediction interval statistical procedure establishes an interval that bounds the ranges of expected concentrations representative of unaffected groundwater using the distribution of background data. The upper tolerance or prediction limit of that interval is then used for comparison to the concentration level of each constituent in each compliance well. Development of the tolerance or prediction limits used for comparison during detection monitoring will be conducted in accordance with the *Unified Guidance.* The following is a summary of descriptive statistics and tolerance or prediction limit choices.

3.2.1 Background Determination

Statistical limits will be calculated after the collection of a minimum of eight independent samples. The analytical results from the eight "background" samples will be used to determine the statistical limits for each individual parameter. For intra-well, the background data set is comprised of the historical data set established at each individual monitoring well.

The background dataset (and hence the prediction limits) will be updated as appropriate (as discussed above in Section 3.1) to maintain necessary statistical sensitivity. New data will be compared to the existing background data set to determine if there are outlier values, and whether the data are statistically similar. If there are no outliers and the data are statistically similar, the new data will be added to the existing background data set.

3.2.2 Outlier Evaluation

Outliers and anomalies are inconsistently large or small values that can occur as a result of sampling, analytical, or transcription errors; laboratory or field contamination; or shelf-life exceedance; or extreme, but accurately detected environmental conditions (*e.g.*, spills). Data will be reviewed graphically using tools such as time concentration trend plots, box and whisker plots and/or probability plots to illustrate and identify outliers, trends, or otherwise unusual observations at each monitoring location. This will be accomplished prior to further in-depth review of the data sets to identify any obvious field or laboratory anomalies. Data points that are determined to be non-representative will be 'flagged' for further detailed evaluation prior to removing from the background data or designating as an outlier.

3.2.3 Testing for Normality

Statistical tests often assume that data are normally distributed or that data can be normalized by various standard methods. The assumption of normality can be tested in various ways. Formal normality testing such as utilizing the Shapiro-Wilk test (for n<50) or the Shapiro-Francia Test (for n>50) or calculation of a coefficient of skewness may be utilized in accordance with the *Unified Guidance*. Alternatively, graphing data on a probability plot can also be used to test for normality. If the data appear to be non-normal, mathematical transformations of the data may be utilized such that the transformed data follow a normal distribution (e.g, lognormal distributions). Alternatively, non-parametric tests may be utilized when data cannot be normalized.

The following are guidelines for decision making during normality testing:

1. If the original data show that the data are not normally distributed, then apply a natural log-transformation to the data and test for normality using the above methods.
2. If the original or the natural log-transformed data confirm that the data are normally distributed, then apply a normal distribution test.
3. If neither the original nor the natural log-transformed data fit a normal distribution, then apply a distribution-free test.

3.2.4 Evaluation of Non-Detects

Background concentrations that are reported as less than the practical quantitation limit (PQL) (herein referred to as non-detects) will be evaluated differently, depending upon the percentage of non-detects to the reported concentrations for a given parameter at a given monitoring well. The evaluation of non-detects was as follows:

Less Than 15% Non-detects

For data that was normally or lognormally distributed and less than 15% non-detects, one-half the value of the method detection limit will be used to calculate the prediction limit. If normally or lognormally cannot be met using one-half of the method detection limit, and if the method detection limits were equal, alternating zero with the value of the method detection limit will be considered in order to determine the normality of the data set.

15% to 50% Non-detects

If more than 15% but less than 50% of the overall data are less than the detection limit, either Aitchison's adjustment, or Cohen's adjustment, or the Kaplan Meijer adjustment will be used to determine the statistical limits in accordance with the *Unified Guidance*.

51% to 100% Non-detects

For data sets that contain greater than 50% non-detects, the non-parametric statistical limits will be utilized as described below.

3.3 Parametric Tolerance or Prediction Limits

Tolerance and prediction intervals are similar approaches to establish statistical ranges constructed from background or baseline data. However, tolerance limits define the range of data that fall within a specified percentage with a specified level of confidence (where a proportion of the population is expected to lie), whereas prediction limits involve predicting the upper limit of possible future values based on a background or baseline data set and comparing that predicted limit to compliance well data.

Intra-well tolerance or prediction limits are calculated using baseline period or background data from each well. The tolerance or prediction limit will be calculated in accordance with the *Unified Guidance*. If the data set is log-normally distributed, the tolerance or prediction limits will be calculated using the log-normally transformed data, and subsequently un-transformed to normal units.

R 299.4908(2)(b) states that for multiple comparisons, each testing period should have a Type I error rate no less than 0.05 while maintaining an individual well Type I error rate of no less than 0.01. Per R 299.4908(2)(d), these Type I limits do not apply directly to tolerance intervals or prediction intervals; however, the levels of confidence for the tolerance or prediction limit approach must be at least as effective as any other approach based on consideration of the number of samples, distribution, and range of concentration values in the background data set for each constituent.

3.4 Non-Parametric Tolerance or Prediction Limits

Parameters that consist of mainly non-detect data usually violate the assumptions needed for normal based parametric tolerance or prediction intervals. Therefore, as recommended in the *Unified Guidance*, the non-parametric tolerance or prediction limit method will be chosen.

A non-parametric upper tolerance or prediction limit is constructed by setting the limit as a large order statistic selected from background (*e.g.*, the maximum background value). This method has lower statistical power than parametric methods; therefore, it is important to control outliers within the dataset to maintain adequate statistical power that this method can provide. Due to the lack of statistical power of this method, it will only be used when other methods are not available.

3.5 Double Quantification Rule

The double quantification rule is discussed in Section 6.2.2 of the *Unified Guidance*. In the cases where the background dataset for a given well is 100% non-detect, a confirmed exceedance is registered if any well-constituent pair exhibits quantified measurements (*i.e.*, at or above the reporting limit) in two consecutive sample and resample events. This method will be used for non-detect data sets.

3.6 Verification Resampling

In order to achieve the site wide false positive rates (SWFPR) recommended in the *Unified Guidance*, a verification resampling program is necessary. Without verification resampling, the SWFPR cannot be reasonably met, and much larger statistical limits would be required to achieve a SWFPR of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. Under these circumstances, if there is an exceedance of a tolerance limit or prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 90 days of the original sample date. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes. This verification sampling must be performed within the same compliance period as the event being verified. If the verification sample remains statistically significant, then statistical significance will be considered. If the verification sample is not statistically significant, then no SSI will be recorded for the monitoring event.

Section 4
Evaluation of Detection Monitoring Data

4.1 Statistical Evaluation during Detection Monitoring

According to R 299.4440(8), if the facility determines, pursuant to R 299.4908(5), that there is a statistically significant increase (SSI) over background levels for one or more of the detection monitoring constituents during verification sampling, the facility will, within 14 days of the determination of an SSI, place a notice in the operating record that indicates which constituents show an SSI and notify EGLE. Within 45 days of detecting an SSI, the facility will prepare an assessment monitoring plan **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

The owner or operator must complete a written demonstration (i.e., Alternative Source Demonstration; (ASD)), of the above within 30 days of confirming the SSI and submit the ASD to EGLE as required by R 299.4440(9). If a successful ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring. If the ASD is successful and approved by EGLE, the facility must determine if the constituents in the groundwater render the unit unmonitorable in accordance with R 299.4440(9)(b).

If a successful ASD is not completed within the 30-day period, EGLE will issue a notification that the ASD was unsuccessful. Within 15 days of notification from EGLE that the demonstration was unsuccessful, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under R 299.4441 and submit a response action plan in accordance with requirements in R 299.4442. The facility will initiate the assessment monitoring program within 60 days of the submittal of the assessment monitoring plan as required in R 299.4441 and within 90 days of detecting a SSI as described further in Section 5.

Section 5
Assessment Monitoring

As discussed in Section 4, the facility must begin assessment monitoring for the CCR unit if an SSI is identified, and the SSI cannot be attributed to an ASD. Per R 299.4441, assessment monitoring must begin within 60 days of the assessment monitoring plan submittal. Per the CCR Rule, assessment monitoring must begin within 90 days of identification of an SSI that is not attributed to an alternative source. Wells included in the groundwater monitoring system will be sampled for assessment monitoring constituents identified in Section 11519b. (2) of Part 115. Within 14 days of receiving sample results, the owner or operator will place a notice of the detected assessment monitoring parameters in the operating record and notify EGLE in accordance with R 299.4441(4)(a). Within 90 days of obtaining the results from the first assessment monitoring event, all of the wells will be sampled for detection monitoring and the detected assessment monitoring constituents in the initial assessment monitoring event. Background will be established for the Section 11519. (2) constituents not already included in the CCR Rule Appendix IV (i.e., copper, nickel, silver, vanadium, and zinc) throughout eight sampling events in accordance with R 299.4441(4)(c) in the event that assessment monitoring is initiated.

If assessment monitoring is triggered pursuant to R 299.4440(8), data are compared to Groundwater Protection Standards (GWPSs) or background groundwater quality. The CCR Rule [§257.95(h)] and the Part 115 Rule [R 299.4441(4)(d)], require GWPSs to be established for assessment monitoring constituents that have been detected during baseline sampling, in addition, Part 115 requires GWPSs to be established for detection monitoring constituents. The GWPSs will be developed in accordance with R 299.4441(9). For GWPSs that are established using background, tolerance limits are anticipated to be used to calculate the GWPS. The background will be updated every two years, along with the resulting GWPS, consistent with the *Unified Guidance*. If additional assessment monitoring parameters become detected during the assessment monitoring, GWPSs will be developed for those parameters in the same manner as the initial parameters.

Consistent with the *Unified Guidance*, the preferred method for comparisons to a fixed standard will be confidence limits. An exceedance of the standard occurs when the 95 percent lower confidence level of the downgradient data exceeds the GWPS. Confidence intervals will be established in a manner appropriate to the data set being evaluated (proportion of non-detect data, distribution, etc.). If the statistical tests conclude that an exceedance of the GWPS has occurred, verification resampling may be conducted by the facility. Once the resampling data are available, the comparison to the GWPS or background will be evaluated.

Additionally, it is noted in §257.95(e) that if the concentrations of all constituents listed in Appendices III and IV are shown to be at or below background values using statistical procedures in §257.93(g) for two consecutive sampling events, the owner or operator may return to detection monitoring of the CCR unit. A notification must be prepared stating that the detection monitoring is resuming for the CCR unit. If statistical tests and verification resampling results corroborate the finding that an exceedance of the GWPS has occurred, the facility will conduct an assessment of corrective measures by selecting an appropriate remediation plan for the affected groundwater and implementing a remedial action plan per the requirements and schedules outlined in R 299.4444, and R 299.4445.

Section 6
References

ASTM. 2012. *Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs*. D6312-98(2012) el. West Conshohocken, PA: ASTM International.

ITRC (Interstate Technology & Regulatory Council). 2013. Groundwater Statistics and Monitoring Compliance, Statistical Tools for the Project Life Cycle. GSMC-1. Washington, D.C.: Interstate Technology & Regulatory Council, Groundwater Statistics and Monitoring Compliance Team. http://www.itrcweb.org/gsmc-1/.

Sanitas Technologies. 2012. Sanitas Statistical Software. http://www.sanitastech.com/.

Sanitas Technologies. August 22, 2013. H Horsey, Phyllis Carosone-Link, Megan R Sullivan, Jim Loftis.

United States Environmental Protection Agency (USEPA). 2010. *ProUCL Version 5.0.00 (5.0) Technical Guide*. EPA/600/R-07/041. Washington. DC: United States Environmental Protection Agency. https://www.epa.gov/land-research/proucl-software.

USEPA. 2015. *ProUCL Version 5.1.00 (5.1) Technical Guide.* EPA/600/R-07/041. Washington. DC: United States Environmental Protection Agency. https://www.epa.gov/land-research/proucl-software.

USEPA. 1989. *Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Interim Final Guidance.* Office of Solid Waste.

USEPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Unified Guidance*. Office of Conservation and Recovery. EPA 530/R-09-007.

.

Figure

LEGEND

- ✛ MONITORING WELL (STATIC WATER LEVEL ONLY)
- ✛ CCR UNIT MONITORING WELL

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO,2019.
2. STATIC WATER & POND 6 WELL LOCATIONS SURVEYED BY SHERIDAN SURVEYING CO. ON 11/19/2015.
3. PONDS 1 & 2 WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES CO. ON 10/19/2019.

0 500 1,000 Feet

1 " = 500 '

1:6,000

PROJECT:

CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:

SITE PLAN WITH CCR MONITORING WELL LOCATIONS FOR PONDS 1,2, & 6

DRAWN BY: S. MAJOR
PROJ NO.: 367388
CHECKED BY: K. REMINGA
APPROVED BY: S. HOLMSTROM
DATE: FEBRUARY 2020

FIGURE 1

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 367388-001-001.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 2/20/2020, 12:42:42 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\367388-001-001.mxd

Attachment D

Natural Clay Liner Equivalency Evaluation Report

DTE Electric Company and
Consumers Energy Company
Six Southeast Michigan Coal Combustion Residual Units

December 2018

Natural Clay Liner Equivalency Evaluation Report

DTE Electric Company and
Consumers Energy Company
Six Southeast Michigan Coal Combustion Residual Units

December 2018

Prepared For
DTE Electric Company and
Consumers Energy Company

Graham Crockford, CPG
CCR Program Manager

Stephen Sellwood

Steve Sellwood, PhD
Senior Hydrogeologist

Vincent E. Buening

Vincent E. Buening, CPG
Senior Project Manager

TRC Engineers Michigan, Inc. | DTE Electric Company/Consumers Energy Company
Final
\\NTAPB-MADISON\MSN-VOL6\-\WPMSN\PJT2\319742\0000\R3197420000-001.DOCX

Table of Contents

List of Tables

List of Appendices

Section 1
Introduction

1.1 Background and Objective

The minimum composite liner specified by federal regulations promulgated on April 17, 2015 (CCR Rule) for coal combustion residual (CCR) disposal units includes a geomembrane directly overlying two feet of compacted clay having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s. For new and existing CCR disposal units, Michigan regulations define a natural soil barrier having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s that may be permitted as a protective liner system in lieu of a constructed composite liner if it can be demonstrated that the natural soil liner meets the performance standards outlined in Rule 299.4307 of PA 451 of the Natural Resources and Environmental Protection Act (NREPA), Part 115 (Solid Waste Management). Michigan's Solid Waste Management Program codified in Part 115 is the state's equivalent Subtitle D permitting program for solid waste management, and is a United States Environmental Protection Agency (EPA) authorized program and consequently there is an inherent acknowledgement that natural soil liners can provide equivalent protection as composite liner systems by Michigan and the EPA.

On August 21, 2018 the United States Court of Appeals District of Columbia Circuit Court (DC Court) ruled on a number of CCR issues, some that have been pending since promulgation of the CCR Rule in 2015. The primary response from the DC Court was to rule on whether EPA's request to stay litigation pending anticipated court-mandated rulemaking from a settlement agreement entered on April 18, 2016 where EPA committed to addressing issues in a Remand Rule by June 2019. The court requested oral argument on all remaining issues of litigation at the time of the request for stay in order to weigh merits of the motion. The DC Court decision ultimately denies the motion and issues an opinion on all of the remaining issues of litigation which included vacatur and remand of:

- 257.101(a), which governed the conditions that would force an unlined surface impoundment to cease receiving CCR and non-CCR if a groundwater protection standard was exceeded unless strict conditions and timelines for alternative closure could be certified by the owner or operator pursuant to 257.103.
- 257.71(a)(1)(i), which defined 2 feet of compacted soil (K value of no more than 1x10^{-7} cm/s) for existing impoundments as meeting the liner standard (i.e., "clay lined" pond considered a lined pond).

By vacating 257.101(a) and 257.71(a)(1)(i), electric power generators who intended to continue using their existing ponds for CCR or non-CCR (assuming they met all of the remaining provisions/standards of 257.101), would potentially have to close or retrofit/reline these ponds.

Multiple CCR impoundments in southeast Michigan are documented to be constructed within thick (> 20 feet thick, in some cases more than 100 feet thick) laterally contiguous glacially compacted natural clay-rich soils with a hydraulic conductivity no greater than 1 x 10^{-7} cm/s prior to implementation of the CCR Rule requiring composite liners (§257.70) or demonstration of equivalent performance to alternative composite liners. As the natural soil underlying these CCR impoundment units consists of thick, low-hydraulic conductivity clay, it is likely that the natural soil is providing the same, or better level of protection from potential migration of contaminants than the composite liner defined in 257.70(b). The purpose of our study is to present existing site data to assess whether the natural soils below six CCR impoundment units at four sites in southeast Michigan are performing equivalently to a composite liner using recognized and generally accepted good engineering practices.

1.2 Description of CCR Units

Natural clay liners were evaluated for six CCR units at four power generation facilities in southeast Michigan:

- Bell River Power Plant (BRPP) Bottom Ash Basins (BAB) CCR Unit
- BRPP Diversion Basin (DB) CCR Unit
- St. Clair Power Plant (SCPP) BAB CCR Unit
- Monroe Power Plant (MONPP) Fly Ash Basin (FAB) CCR Unit
- J.R. Whiting Power Plant (JRWPP) Ponds 1 and 2 CCR Unit
- JRWPP Pond 6 Inactive CCR Unit

Data used for the natural clay liner evaluations were obtained from existing reports and Conceptual Site Models (CSMs) previously developed for each site. A summary of the CSM for each site is provided in the following sections.

1.2.1 BRPP Bottom Ash Basins CCR Unit

The BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the DB CCR unit. The North and South BABs run roughly east to west approximately 420 feet long by 120 feet wide with bottom elevations of approximately 580 feet and outflow weir elevations of approximately 590.25 feet (TRC 2017a).

1.2.2 BRPP Diversion Basin CCR Unit

The DB is an incised CCR surface impoundment located west of the BRPP. Water flows into the DB from the North and South BABs through a network of pipes and ditches. The DB discharges to the St. Clair River with other site wastewater in accordance with a National Pollution Discharge Elimination System (NPDES) permit. The DB has an approximately 300 foot long entrance channel that connects to the main portion of the basin that runs approximately north-south. The main portion of the DB is approximately 400 feet long by approximately 120 feet wide with a bottom elevation of approximately 576 feet with the water level being maintained at approximately 580 feet (TRC 2017a).

1.2.3 SCPP Bottom Ash Basins CCR Unit

The SCPP BABs are two adjacent sedimentation basins that are incised CCR surface impoundments. The impoundments are sheet piled around the perimeters to approximately 13 feet below ground surface (bgs) into the native clay-rich soil. The BABs are located south of the SCPP and adjacent to the St. Clair River and are used for receiving bottom ash and other process flow water from the power plant, which is first sent to the East BAB then to the West BAB through a connecting concrete canal. Discharge water from the basins flows with other site wastewater into the Overflow Canal in accordance with a NPDES permit (TRC 2017b).

The West and East BABs run roughly north to south with the following approximate dimensions (TRC 2017b):

- The West BAB is approximately 300 feet long by 90 feet wide with a bottom elevation of approximately 572 feet (when fully cleaned out) with an outflow weir elevation of approximately 579.3 feet; and
- The East BAB is approximately 400 feet long by 70 feet wide with a bottom elevation of approximately 572 feet (when fully cleaned out) with an outflow weir elevation of approximately 579.4 feet.

1.2.4 MONPP Fly Ash Basin CCR Unit

The MONPP FAB CCR unit is approximately 410-acres with an original design storage capacity of 18,500 acre-feet at a maximum elevation of 614 feet. The FAB consists of an earthfill clay-rich soil embankment (raised surface impoundment) with a crest perimeter length of approximately 18,200 feet and a general height (from the lowest toe elevation to the top of embankment) of approximately 40 feet, with a maximum height of 44 feet. A road along the top of the crest has an elevation of approximately 614 feet with the typical water operational level being 609 feet. The FAB base is keyed into the existing natural clay-rich soil ground surface at an elevation of 563.4 feet. CCRs are placed into the FAB by use of a "wet" (sluiced) disposal method (TRC 2017c).

1.2.5 JRWPP Ponds 1 and 2 CCR Unit

The JRWPP Ponds 1 and 2 CCR unit is located east of the JRWPP adjacent to Lake Erie. The JRWPP is no longer an active power generating facility and Ponds 1 and 2 are no longer active. The ponds were constructed in the native clay soil and received ash by sluicing. Sluice water was discharged to Pond 2 and then flowed into Pond 1 via a connecting pipe. Discharge water from the basins flowed into the adjacent Forebay in accordance with a NPDES permit (Golder Associates 2017). The Pond 1 outlet had an elevation of 586.3 feet and a perimeter crest of approximately 590 feet (AECOM 2009).

1.2.6 JRWPP Pond 6 CCR Unit

The JRWPP Pond 6 CCR unit is located north of the JRWPP. Pond 6 is no longer in operation and has received a final cap. Pond 6 was constructed in the native clay soil and received ash by sluicing. Discharge water from Pond 6 flowed into the adjacent LaPointe Drain in accordance with a NPDES permit. When in operation, the pool elevation in Pond 6 was maintained between elevations of 592.6 feet and 596.5 feet with a perimeter crest elevation of approximately 600 feet (AECOM 2009).

Section 2
Composite Liner Leakage Literature

2.1 Literature Review

A single composite liner specified by state and federal regulations for new CCR disposal units includes a geomembrane directly overlying two feet (0.61 meters) of compacted clay having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s. These composite liners are intended to prevent advective flow of leachate through the liner. However, studies of installed composite liner systems have identified that composite liners leak through holes in the geomembrane that result from manufacturing defects, damage during installation, or degradation of the membrane over time (Rowe 2012). Holes in the geomembrane allow migration of leachate from the liner cell into the compacted clay portion of the liner. Once in the clay, leachate can migrate through the clay via porous media flow, eventually exiting the clay liner as leakage.

The amount of leakage through a composite liner is controlled in part by the number of holes in the geomembrane, the size of the holes, and the quality of contact between the geomembrane and the underlying clay. Based on a review of available literature, Rowe (2012) reports that the median radius of geomembrane holes is greater than 5 mm (meaning geomembrane holes at a scale of millimeters to centimeters are not uncommon) and the number of holes ranges from 2.5 to 12 holes per hectare of liner. Gaps between the geomembrane and the underlying clay also influence leakage rates by increasing the surface area through which leachate can penetrate the underlying clay (Rowe 2012).

Liner performance can be quantified in terms of the rate of leakage of leachate through the liner into the underlying soils. Researchers have quantified leakage rates for composite liners through the use of leak detection systems (e.g., Bonaparte et al. 2002) and calculations (e.g., Giroud et al. 1998; Rowe 2012). Leakage rates are measured in terms of the volume of liquid (liters or gallons) leaking through the liner each day over the surface area of the liner (hectares or acres) e.g. liters per hectare per day (lphd).

Leakage through the compacted clay portion of a composite liner or through a natural clay liner is controlled by several factors, including the hydraulic conductivity of the clay, the hydraulic head gradient across the liner, and the thickness of the clay. Flow through clay liners can be calculated using physical parameters of the system in question and applying Darcy's Law. The performance of natural clay liners can be assessed by comparing calculated leakage rates for natural clay liners with calculated leakage rates for composite liners.

Section 3
Site Conceptual Models

3.1 Belle River Power Plant

The BRPP CCR units are underlain by more than 130 feet of unconsolidated sediments, consisting mostly of silty clay-rich till. The silty clay-rich till is present from the surface to depths of 86 to 130 feet bgs at the BRPP CCR units. Falling head permeameter tests were completed on four samples of the site clay, producing hydraulic conductivity values ranging from 2.1 x 10^{-8} cm/s to 2.9 x 10^{-8} cm/s. Saturated silts and sands underlie the clay and form the shallowest aquifer below the CCR units. The unconsolidated sand and silt aquifer is underlain by the uppermost bedrock consisting of the Bedford Shale, which is generally encountered from 135 to 145 feet bgs (TRC 2017a).

3.1.1 Bottom Ash Basins CCR Unit

As described above, the uppermost aquifer units beneath the BABs CCR unit are hydraulically isolated by at least 80 feet of silty clay-rich till. The first observed sand-rich units that meet the 40 CFR §257.53 definition of uppermost aquifer is encountered at depths ranging from 90 to 136 feet bgs. The sand-rich unit rapidly thins to the south and east of the BABs and pinches out in the southeastern portion of the BABs CCR unit area (TRC 2017a).

The water level in the BABs is maintained at an elevation of approximately 590 feet. The hydraulic head in the aquifer below the BAB is approximately 574 feet (TRC 2018a). The bottom of the BABs is at an elevation of approximately 580 feet and the bottom of the clay underlying the BABs is at an elevation of approximately 500 feet, thus 80 feet of clay separate the bottom of the BABs CCR unit from the underlying aquifer.

3.1.2 Diversion Basin CCR Unit

The potential uppermost aquifer under the DB CCR unit is located at depths ranging from 131 to 145 feet bgs at the silt/shale bedrock interface. The DB CCR unit is isolated from the underlying potential uppermost aquifer by approximately 130 feet of silty clay-rich till. Although the encountered zone of saturation along the interface did not yield significant groundwater, it was conservatively interpreted as the first underlying saturated zone that would presumably become affected with CCR constituents since it was saturated, and although the hydraulic conductivity was low, exhibited a much higher hydraulic conductivity than the clay-rich soils between the bottom of the basin and the monitored zone (TRC 2017a).

The water level in the DB is maintained at an elevation of 580 feet or less. The hydraulic head in the aquifer below the DB is approximately 575 feet (TRC 2018b). The bottom of the DB is at an elevation of approximately 576 feet and the bottom of the clay underlying the DB is at an elevation of approximately 459 feet, thus 117 feet of clay separate the bottom of the DB CCR unit from the underlying aquifer.

3.2 St. Clair Power Plant BABs

The SCPP CCR unit is underlain by glacial silty-clay till, with few isolated sand lenses, and a silt and clay-rich hardpan base directly overlying the shale bedrock (likely the Bedford Shale). The shale bedrock is generally encountered below 130 feet bgs. No significant soil or gravel intervals were encountered at any of the groundwater monitoring system well locations. However, during soil boring advancement for the groundwater monitoring system well locations, some signs of saturation were observed throughout a 5-foot interval along the interface between the overlying till/hardpan and the underlying shale bedrock. The underlying shale does not yield groundwater, rather it is an aquiclude that prevents groundwater flow (i.e., is not an aquifer). Although the encountered zone of saturation along the interface did not yield significant groundwater, it was conservatively interpreted as the uppermost aquifer, because it is saturated and exhibits higher hydraulic conductivity than the clay-rich soils between the bottom of the basin and the monitored zone (TRC 2017b).

The potential uppermost aquifer as defined in 40 CFR §257.53 is encountered at an elevation of approximately 462 feet. The bottom of the BABs is at an elevation of approximately 572 feet, thus 110 feet of vertically contiguous silty clay-rich till separates the BABs CCR unit from the underlying aquifer and serves as a natural confining hydraulic barrier that isolates the underlying uppermost potential aquifer. The overlying silty clay-rich low-permeability soil has a hydraulic conductivity on the order of 2.3 to 3.1 x 10^{-8} centimeters per second (cm/s) as found in soil testing performed during the CCR monitoring well installation in the area of the BABs (TRC 2017b).

The water level in the BABs is maintained at an elevation between 579 feet and 580 feet. The hydraulic head in the aquifer below the BABs is approximately 580 feet (TRC 2018c), thus the little hydraulic head gradient between the BABs CCR unit and the underlying aquifer is very small.

3.3 Monroe Power Plant FAB

The MONPP FAB overlies unconsolidated clay-rich glacial till and/or lacustrine deposits with saturated limestone of the Bass Islands Group bedrock generally encountered from 37 to 53.5 feet below ground surface. The limestone aquifer encountered at the site is generally artesian except in the area of monitoring well MW-16-01. Monitoring well MW-16-01 is located within several hundred feet of several off-site domestic residential water supply wells located to the north along Dunbar Road adjacent to Plum Creek that likely lower the hydraulic head in the area of MW-16-01 (TRC 2017c).

The MONPP FAB CCR unit uppermost aquifer as defined in 40 CFR §257.53 consists of saturated limestone present beneath at least 37 feet and up to 53.5 feet of thick contiguous silty clay-rich soil that serves as a natural confining hydraulic barrier that isolates the underlying uppermost aquifer. At its deepest incised area the MONPP FAB has approximately 23 feet of clay-rich soil separating the bottom of the FAB from the uppermost aquifer. Near the north end of the FAB where the hydraulic gradient is steeper, the clay is at least 30 feet thick. The overlying low permeability silty clay-rich soil has a hydraulic conductivity of 2.7×10^{-8} cm/s calculated as the geometric mean of 33 hydraulic conductivity values obtained from testing of the clay. The water level in the FAB is maintained at an elevation of approximately 609 feet. The hydraulic head in the aquifer below the FAB is ranges from approximately 580 feet to 597 feet (TRC 2018d).

3.4 J.R. Whiting Power Plant

The JRWPP overlies more than 50 feet of unconsolidated clay-rich glacial till and/or lacustrine deposits overlying limestone bedrock. Bedrock is generally encountered from 52 to 64 feet below ground surface (elevations of 524 to 516 feet) (STS Consultants 1993). Permeameter tests completed on eight samples of the site clay produced hydraulic conductivity values ranging from 5.5×10^{-9} cm/s to 2.23×10^{-8} cm/s. The limestone bedrock aquifer underlying clay deposits forms the shallowest aquifer below the CCR units.

3.4.1 JRWPP Ponds 1 and 2 CCR Unit

As described above, the uppermost aquifer unit beneath the Ponds 1 and 2 CCR unit is limestone bedrock that is hydraulically isolated by the overlying clay-rich till. The shallowest bedrock is encountered at an elevation of approximately 520 feet (TRC 2016) and the bottom of the pond is at an elevation of approximately 555 feet (Golder Associates 2016), thus 35 feet of clay separate the bottom of the Ponds 1 and 2 CCR Unit from the underlying aquifer. The water level in Ponds 1 and 2 was maintained at an elevation of approximately 586 feet. The hydraulic head in the aquifer below Ponds 1 and 2 is approximately 575 feet (TRC 2018e).

3.4.2 JRWPP Pond 6 CCR Unit

As with Ponds 1 and 2, the shallowest bedrock is encountered at an elevation of approximately 520 feet below the Pond 6 CCR unit (TRC 2016). The bottom of Pond 6 is at an elevation of approximately 560 feet, thus 40 feet of clay separate the bottom of the Pond 6 CCR unit from the underlying aquifer. During its operational years, the water level in Pond 6 was maintained at elevations between approximately 592 feet to 597 feet. The hydraulic head in the aquifer below Pond 6 is approximately 575 feet.

Section 4
Leakage Rate Calculations

To assess the performance of the natural clay liners underlying the six CCR units at the sites discussed above, leakage rates were calculated for each of the units using site-specific parameters and Darcy's Law:

$$Q = -KA\frac{dh}{dl}$$

where Q is the leakage rate, K is the hydraulic conductivity of the clay, A is the cross-sectional area of flow, dh is the difference between the hydraulic head in the CCR unit and the hydraulic head in the aquifer below the natural clay, and dl is the thickness of the clay. This analysis assumes that flow through the liner is vertical and one-dimensional. Input parameters for K, dh, and dl for each CCR unit are summarized in Table 1. By assuming the cross-sectional area of flow to be one hectare, leakage rates are determined on a per hectare basis, consistent with the liner leakage literature. Calculated leakage rates (in lphd) are also summarized in Table 1. Calculation documentation is provided in Appendix B. Calculated leakage rates for the natural clay liners ranged from 2 lphd (SCPP BABs) to 227 lphd (MONPP FAB).

The calculated leakage rates represent the expected leakage through the natural clays below the CCR units under currently operating conditions, except for the JRWPP CCR units, which are no longer operating. For the JRWPP CCR units, the calculated leakage rates are conservatively based on conditions experienced while they were operating. Now that Pond 6 is capped, it is expected that the hydraulic head within the CCR unit is less than it was during operation, and therefore, the leakage rate under capped conditions is expected to be less than the calculated leakage rate. Ponds 1 and 2 are planned to be capped in the near future, which will also likely reduce the leakage rate associated with that CCR unit.

To compare the performance of the natural clay liners with the expected performance of a single composite liner, potential leakage rates were also calculated for a hypothetical composite liner meeting state and federal regulations. Giroud et al. (1998) provide an equation for calculating the expected leakage through a composite clay liner resulting from a geomembrane defect:

$$Q = 0.976C_{qo}\left[1 + 0.1\left(\frac{h}{T}\right)^{0.95}\right]d^{0.2}h^{0.9}K^{0.74}$$

where Q is the leakage rate (m^3/s), C_{qo} is a dimensionless coefficient that characterizes the quality of contact between the geomembrane and the clay, h is the hydraulic head of the leachate on the liner (m), T is the thickness of the compacted clay (m), d is the diameter of the defect (m), and K is the hydraulic conductivity of the compacted clay (m/s).

The composite liner leakage calculations assume that liner construction consists of two feet (0.61 m) of compacted clay having hydraulic conductivity of 1 x 10^{-7} cm/s (1 x 10^{-9} m/s) underlying a geomembrane. A leachate head of one foot (0.3 m) over the liner and head of zero below the liner is also assumed. As previously discussed, the composite liner leakage calculation also requires assumptions regarding the number of defects, the size of the defects, and the quality of contact between the geomembrane and the clay. To assess the effects of these assumed parameters on the calculated leakage rate, calculations were made using two different values for defect diameter (0.001 m and 0.00564 m), contact coefficient (per Giroud et al. 1998, C_{qo} = 0.21 for good contact, C_{qo} = 1.15 for poor contact), and defect frequency (2.5 defects per hectare and 5 defects per hectare). Using multiple inputs results in a range of potential leakage rates for the hypothetical composite liner in question.

Calculated leakage rates for a composite liner are shown in Table 2. Calculation documentation is provided in Appendix B. The calculated rates range from a low of 0.9 lphd (for 2.5 small defects per hectare and assuming good contact between the geomembrane and underlying clay) to 14 lphd (for 5 large defects per hectare and assuming poor geomembrane-clay contact). Thus a composite liner built in accordance with current regulations could be expected to leak up to 14 lphd.

Rowe (2012) suggests that calculated leakage rates actually underestimate actual leakage. As a result, actual leakage rates from composite liners may be higher than 14 lphd. Nevertheless, two of the investigated CCR units (BRPP DB and SCPP BABs) have leakage rates less than 14 lphd, indicating they are performing at least as well as a single composite liner. Three of the other four CCR units have leakage rates within one order of magnitude of 14 lphd indicating that these natural liners provide a fairly comparable, if not equal, level of protection as a composite liner.

In addition to leakage rate, leachate travel time can also be used to assess liner performance. To determine the amount of time required for leachate to travel through a clay liner the average linear velocity of the leachate must be calculated. Average linear velocity is calculated using a version of Darcy's Law:

$$v = -\frac{K}{n_e}\frac{dh}{dl}$$

where v is the average linear velocity of leachate advection, n_e is the effective porosity of the clay, and K, dh, and dl are as previously defined. Using the values for K, dh, and dl from

Table 1 and assuming an effective porosity for clay of 0.4, average linear velocity was calculated for each of the CCR units. Leachate travel time (t) was then calculated using:

$$t = \frac{dl}{v}$$

Travel times for the six natural clay liners are shown in Table 1. Calculation documentation is provided in Appendix B. Calculations for the MONPP FAB CCR Unit used average hydraulic conductivity due to the amount of historical hydraulic conductivity values. For all other units, calculations used the highest hydraulic conductivity value obtained at the site to produce conservative results. Travel times range from 441 years (MONPP FAB) to 150,800 years (SCPP BABs). All of the computed travel times suggest that the natural clay liners below the six CCR units will be protective of the underlying aquifers well into the future.

For comparison, the calculated time for leachate to travel through 2 feet of compacted clay in a composite liner (assuming leachate head of 1 foot (0.3 meters) above the liner and head of zero below the liner) after having penetrated through a geomembrane defect is only 5 years. Thus even for the natural liners that have higher leakage rates than a composite liner, the thickness of the natural clay results in protection over a much longer timeframe than can be provided by a composite liner.

An additional point of comparison relates to US EPA Statutory Interpretive Guidance – Criteria for Identifying Areas of Vulnerable Hydrogeology Under the Resource Conservation and Recovery Act (July 1986). This document develops criteria and a method for determining groundwater vulnerability at hazardous waste facilities. The method requires calculation of the travel time along a 100-foot flow line originating at the base of the hazardous waste unit. The intent is for the 100-foot flow line to represent a sample of the geologic material at the site representing an area of likelihood of investigation for release. The criterion established by this method relates a travel time along 100-ft of flow line on the order of 100 years is the threshold for vulnerability (US EPA, p. ES-3).

This analog is a very important concept for responding to the DC Court Opinion that found that the record evidence showed that the vast majority of existing impoundments are unlined and that unlined impoundments have a 36.2 to 57 percent chance of leaking at a harmfully contaminating level during their foreseeable use (DC Court, pg. 18). Based on this record, the DC Court found that it isn’t reasonable to rely on leak detection followed by closure in order to address reasonable protectiveness of human health and the environment.

The travel time results from this study show travel times that far exceed the vulnerability criterion, demonstrating that site-specific evaluation can demonstrate protectiveness.

Interestingly, the DC Court also found that the self-implementing one-size-fits-all may have been necessary as a national minimum standard, but also acknowledged that more precise risk-based standards are both feasible and enforceable under the individualized permitting programs and direct monitoring provisions authorized by WIIN Act (DC Court, pg. 38). The sites presented in this study and the methods and criterion used to evaluate the competency of the liner systems meet the regulatory standard "does not pose a reasonable probability of adverse effects on health or the environment."

Section 5

Conclusions

Multiple CCR impoundments in southeast Michigan are documented to be constructed within thick (> 20 feet thick, in some cases more than 100 feet thick) laterally contiguous glacially compacted natural clay-rich soils with a hydraulic conductivity no greater than 1 x 10^{-7} cm/s prior to implementation of the CCR Rule requiring composite liners (§257.70) or demonstration of equivalent performance to alternative composite liners. The natural soil underlying these CCR impoundment units consists of thick, low-hydraulic conductivity clay, that provides the same, or better level of protection from potential migration of contaminants than the composite liner defined in 257.70(b). Using recognized and generally accepted good engineering practices, TRC concludes that the natural soils below six CCR impoundment units at four sites in southeast Michigan perform better than composite liners. In summary:

- TRC calculated leakage rates for six Southeast Michigan CCR units and compared these to the anticipated leakage rates for a single composite liner system. For all six units, the leakage rates were generally within an order of magnitude of the composite liner system. These data show that anticipated leakage rates between the natural soil barriers and the single composite liners are comparable. Data are summarized on Table 1. Data also show that other site specific factors contribute more significantly to the protectiveness of natural soil barriers when compared to single composite liner system, including thickness of the natural soil barrier, hydraulic conductivity of the soil barrier, and the hydraulic gradient between the CCR unit and the underlying aquifer, which can result in significantly greater times of travel to the uppermost aquifer. The results of the time of travel calculations are summarized on Table 1. As shown, all the six evaluated Southeast Michigan CCR units have natural clay liners that are more protective than single composite liner system.

- The travel time results from this study show times that exceed the USEPA's vulnerability criterion demonstrating that site-specific evaluation can demonstrate protectiveness. The sites presented in this study and the methods and criteria used to evaluate the competency of the liner systems meet the regulatory standard "does not pose a reasonable probability of adverse effects on health or the environment."

- Additionally, all of the studied CCR units have been in operation for decades. Although not the focus of this study, groundwater monitoring is currently being performed at all six of the CCR units that are the subject of this study. Based on review of this data, CCR-affected groundwater is not present at these facilities, which further supports the conclusions of this study. Groundwater data supporting this statement are available at:

Consumers Energy
https://www.consumersenergy.com/community/sustainability/environment/waste-management/coal-combustion-residuals

DTE Energy
https://newlook.dteenergy.com/wps/wcm/connect/dte-web/home/community-and-news/common/environment/coal-combustion-residual

Section 6
References

AECOM. 2009. Potential Failure Mode Analysis (PFMA) Report, J.R. Whiting Generating Facility Ash Dike Risk Assessment, Erie, Michigan. December 2009.

Bonaparte, R., Daniel, D.E., and Koerner, R.M. 2002. Assessment and Recommendations for Improving the Performance of Waste Containment Systems, EPA Cooperative Agreement Number CR-821448-01-0. December 2002.

EPA. 1986. Criteria for Identifying Areas of Vulnerable Hydrogeology Under the Resource Conservation and Recovery Act, Statutory Interpretive Guidance, July 1986.

Giroud, J.P., Soderman, K.L, Khire, M.V., and Badu-Tweneboah, K. 1998. New Developments in Landfill Liner Leakage Evaluation, in Proceedings of the Sixth International Conference on Geosynthetics, Vol. 1, ed: R.K. Rowe. March 1998.

Golder Associates. 2016. J.R. Whiting Generating Facility, Ash Pond Material Characterization. September 2016.

Golder Associates. 2017. J.R. Whiting Generating Facility, Ash Ponds 1 and 2 Liquefaction Assessment Report, Erie, Michigan. October 2017.

Rowe, R. K. 2012. Short- and long-term leakage through composite liners, the 7th Arthur Casagrande Lecture, Canadian Geotechnical Journal 49: 141-169, doi: 10.1139/T11-092.

STS Consultants. 1993. Monitor Well Installation and Hydrogeologic Report, J.R. Whiting Power Plant, Erie, Michigan. August 1993.

TRC. 2016. 2016 Monitoring Well Design, Installation, Development, and Decommissioning, JR Whiting Electric Generation Facility, Erie, Michigan. December 2016.

TRC. 2017a. Groundwater Monitoring Systems Summary Report, DTE Electric Company, Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units. October 2017.

TRC. 2017b. Groundwater Monitoring System Summary Report, DTE Electric Company, St. Claire Power Plant Bottom Ash Basins Coal Combustion Residual Unit. October 2017.

TRC. 2017c. Groundwater Monitoring System Summary Report, DTE Electric Company, Monroe Power Plant Fly Ash Basin Coal Combustion Residual Unit. October 2017.

TRC. 2018a. Annual Groundwater Monitoring Report, DTE Electric Company, Belle River Power Plant Bottom Ash Basins. January 2018.

TRC. 2018b. Annual Groundwater Monitoring Report, DTE Electric Company, Belle River Power Plant Diversion Basin. January 2018.

TRC. 2018c. Annual Groundwater Monitoring Report, DTE Electric Company, St. Clair Power Plant Bottom Ash Basins. January 2018.

TRC. 2018d. Annual Groundwater Monitoring Report, DTE Electric Company, Monroe Power Plant Fly Ash Basin Coal Combustion Residual Unit. January 2018.

TRC. 2018e. Annual Groundwater Monitoring Report, Former JR Whiting Power Plant Ponds 1 and 2 CCR Unit. January 2018.

Tables

Table 1
Summary of Velocity and Travel Time Calculations
Natural Clay Liner Equivalency Evaluation

CCR Units	Basin head (ft amsl)	Aquifer head (ft amsl)	dh	Basin Bottom (ft amsl)	Bottom of Clay (ft amsl)	Clay Thickness (dl, ft)	Vertical Hydraulic Gradient	Max K (cm/s)*	Q (lphd)	Velocity (ft/d)**	Travel time (yrs)
Two feet of clay***	--	--	3	--	--	2	1.5	1.0E-07	--	1.1E-03	5
Belle River PP BABs	590	574	16	580	500	80	0.20	2.9E-08	50	4.1E-05	5,329
Belle River PP DB	580	575	5	576	459	117	0.043	2.9E-08	11	8.8E-06	36,474
St. Clair PP BABs	580	579	1	572	462	110	0.009	3.1E-08	2	2.0E-06	150,800
Monroe PP FAB	609	580	29	563	533	30	0.97	2.7E-08	227	1.9E-04	441
Whiting Ponds 1&2	586	575	11	555	520	35	0.31	2.2E-08	61	5.0E-05	1,929
Whiting Pond 6	597	575	22	560	520	40	0.55	2.2E-08	106	8.7E-05	1,260

Created by: S. Sellwood 11/27/2018
Checked by: C. Olson 12/3/2018

Notes:
ft = feet
ft/d = feet per day
cm/s = centimeters per second
yrs = years
lphd = liters per hectare per day
amsl = above mean sea level
dh = difference between basin head and aquifer head
K = vertical hydraulic conductivity
Q = leakage rate
*The geometric mean of 33 available K values used for Monroe PP FAB, maximum K used for all other CCR units
**Velocity assumes effective porosity of 0.4
***Represents migration of leachate through a composite liner after passing through holes in the geomembrane, assumes 1 foot of head above the liner and head of zero below the liner

Table 2
Calculated Composite Liner Leakage Rates
Natural Clay Liner Equivalency Evaluation

			Size of Liner Defects		Quality of Contact				Q (lphd)		
h (m)	T (m)	K (m/s)	d_{sml} (m)	d_{lrg} (m)	$C_{qo(good)}$	$C_{qo(poor)}$	Q (m^3/s)	Q (L/day)	2.5 defects/hc	5 defects/hc	Assumptions
0.305	0.61	1.00E-09	0.001		0.21		4.07E-09	0.35	0.9	1.8	small defects, liner in good contact with clay
0.305	0.61	1.00E-09		0.00564	0.21		5.75E-09	0.50	1.2	2.5	large defects, liner in good contact with clay
0.305	0.61	1.00E-09	0.001			1.15	2.23E-08	1.92	4.8	9.6	small defects, liner in poor contact with clay
0.305	0.61	1.00E-09		0.00564		1.15	3.15E-08	2.72	6.8	14	large defects, liner in poor contact with clay

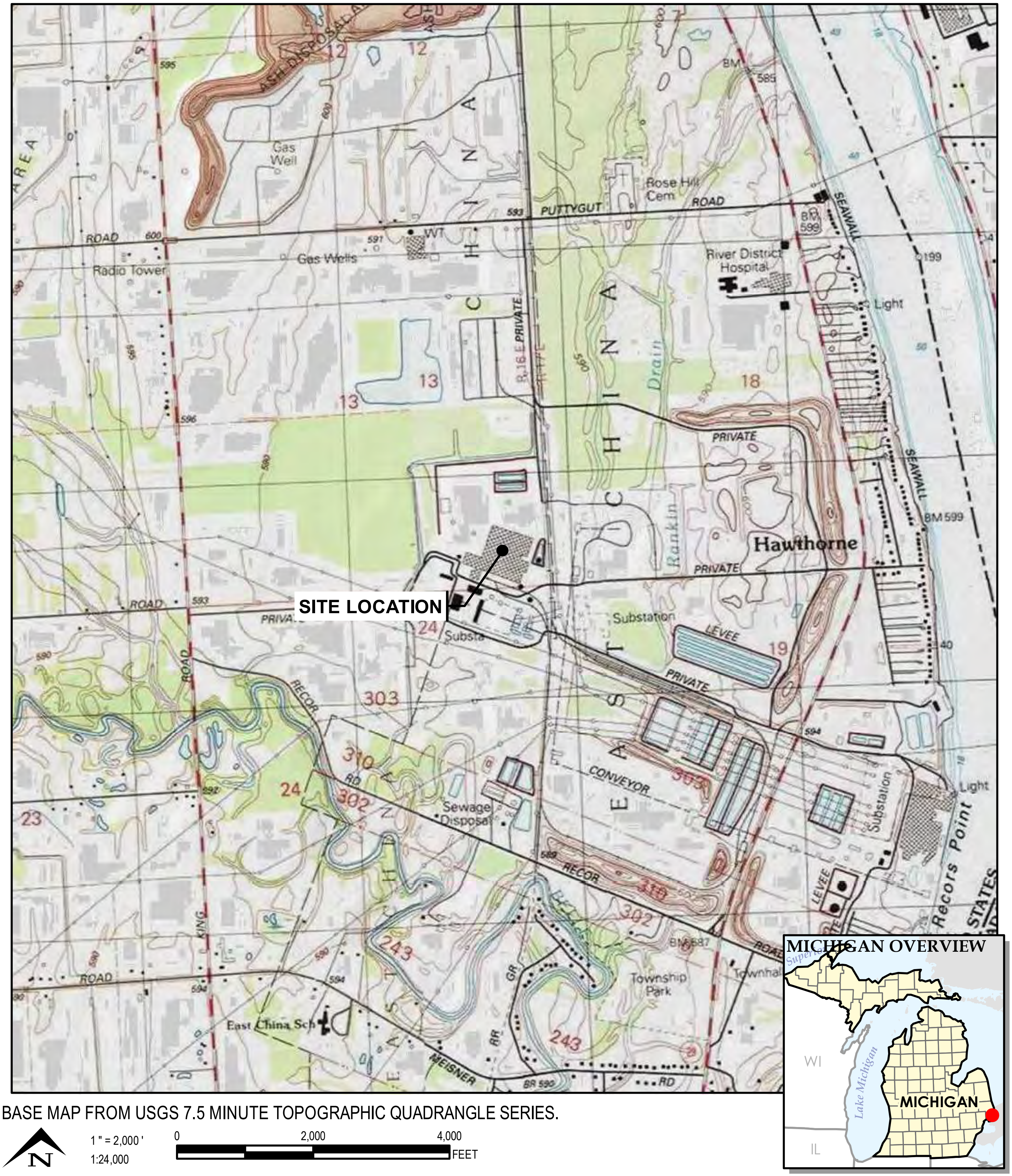
Notes:
h = height of water above the geomembrane
T = thickness of the compacted clay liner
K = hydraulic conductivity of the compacted clay liner
d = diameter of geomembrane defects
C_{qo} = dimensionless coefficient characterizing the quality of the contact between the geomembrane and the underlying compacted clay liner (Giroud et al. 1998)
Q = leakage rate, calculated in accordance with Giroud et al. 1998
m = meter
s = second
L = liter
lphd = liter per hectare per day
hc = hectare

Created by: S. Sellwood 11/27/2018
Checked by: C. Olson 12/3/2018

Appendix A
Site Data (Four Southeast MI CCR Unit Sites)

Table of Contents

BRPP BABs and DB CCR Units Site



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0003
FILE:	265996-SLMMB.mxd

FIGURE 1

LEGEND

● SOIL BORING

⊕ MONITORING WELL

⊘ DECOMMISSIONED MONITORING WELL

NOTES

1. BASE MAP IMAGERY FROM ST. CLAIR COUNTY INFORMATION TECHNOLOGY DEPARTMENT WEBMAP, 2015.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
SITE PLAN

DRAWN BY:	R SUEMNICHT	PROJ NO.:	265996.0003
CHECKED BY:	S HOLMSTROM	**FIGURE 2**	
APPROVED BY:	V BUENING		
DATE:	OCTOBER 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-002.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:18:14 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-002.mxd

Table 1

Groundwater Elevation Summary
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	16.21	573.85	15.30	573.64	16.53	574.13	16.89	573.62	16.70	574.10
9/19/2016	16.25	573.81	23.33	565.61	16.54	574.12	16.90	573.61	16.70	574.10
11/7/2016	16.58	573.48	19.91	569.03	16.82	573.84	17.15	573.36	16.95	573.85
1/9/2017	16.39	573.67	17.90	571.04	16.66	574.00	17.02	573.49	16.90	573.90
2/27/2017	16.11	573.95	16.65	572.29	16.43	574.23	16.75	573.76	16.56	574.24
4/17/2017	16.05	574.01	15.71	573.23	16.31	574.35	16.63	573.88	16.45	574.35
5/18/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
6/5/2017	15.67	574.39	14.80	574.14	15.98	574.68	16.31	574.20	16.18	574.62
6/30/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
7/24/2017	15.82	574.24	14.45	574.49	16.12	574.54	16.44	574.07	16.29	574.51

Notes:

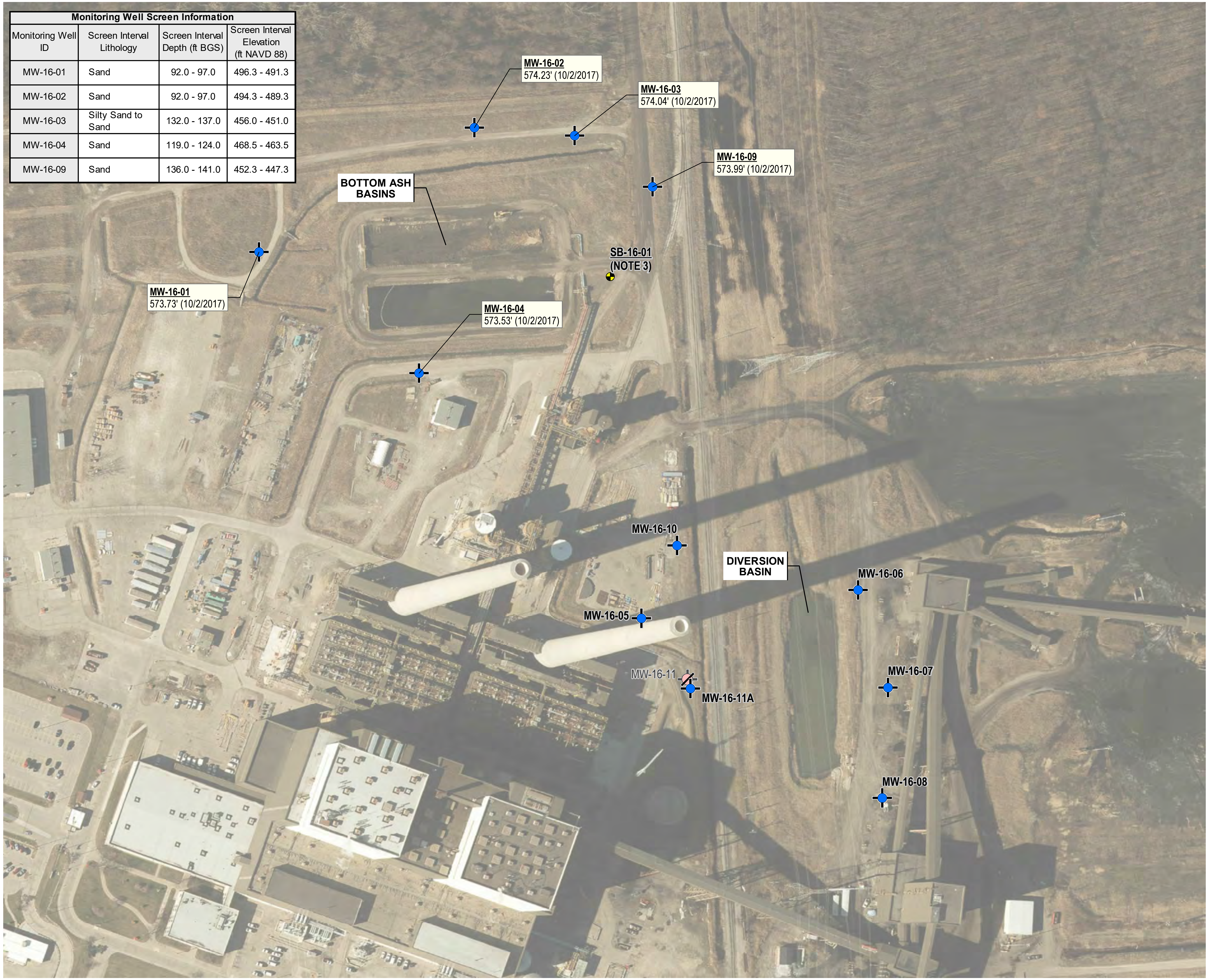
Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

NM - Not Measured

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

●	SOIL BORING
✚	MONITORING WELL
⊘	DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, “WORLD IMAGERY”, WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY OCTOBER 2017

DRAWN BY: S. MAJOR
PROJ NO.: 265996.0003
CHECKED BY: C. SCIESZKA
APPROVED BY: V. BUENING
DATE: JANUARY 2018

FIGURE 3

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-014.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/12/2018, 09:54:28 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-014.mxd

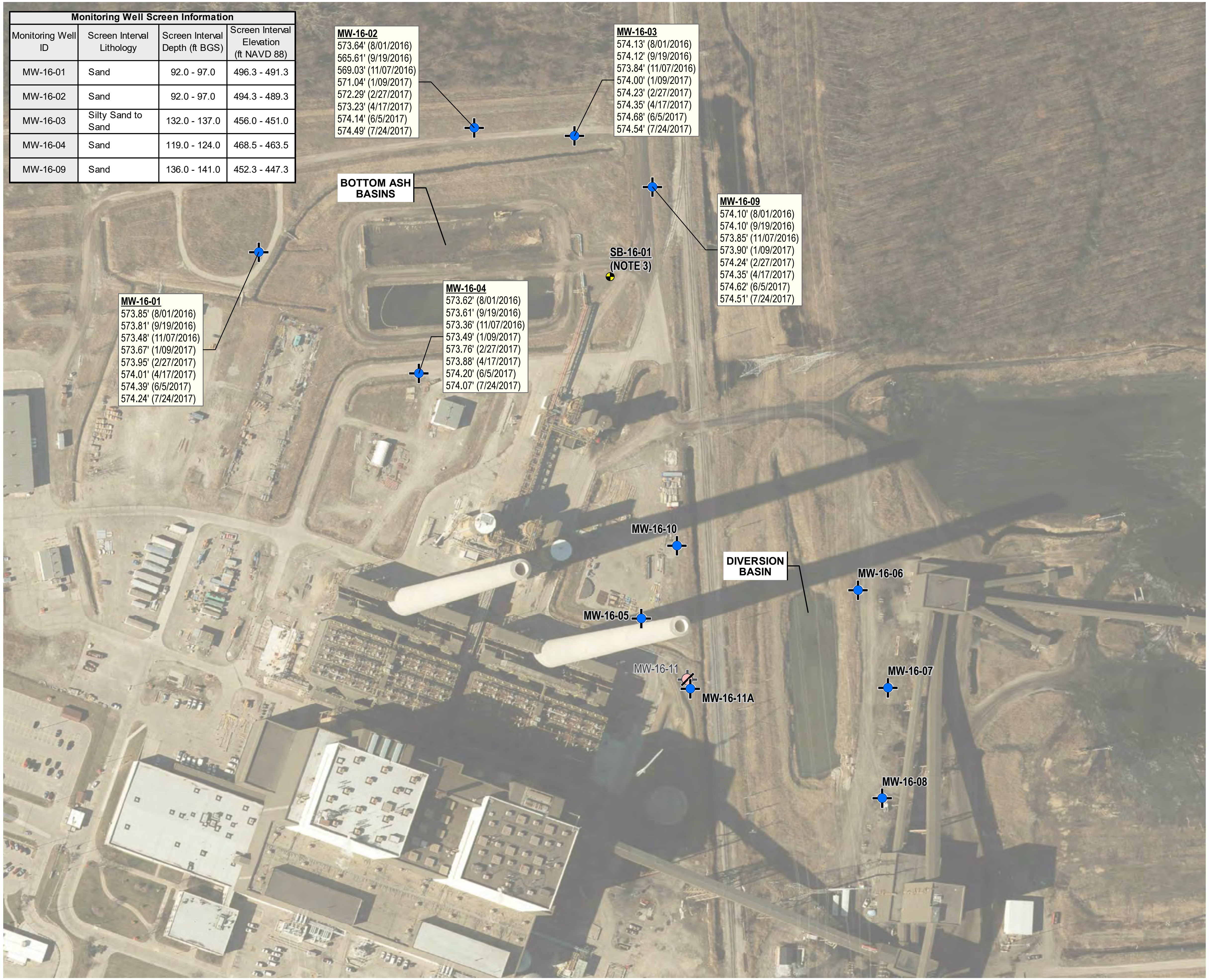
TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/15/2018, 10:06:08 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-003A.mxd

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS
GROUNDWATER POTENTIOMETRIC
ELEVATION SUMMARY

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA	**FIGURE 1**	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-003A.mxd

Table 1

Groundwater Elevation Summary
Belle River Power Plant Diversion Basin – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-05		MW-16-06		MW-16-07		MW-16-08		MW-16-10		MW-16-11 (1)		MW-16-11A	
Date Installed	3/4/2016		3/11/2016		3/9/2016		3/10/2016		6/6/2016		6/7/2016		5/12/2017	
TOC Elevation	590.82		593.21		592.58		591.88		592.26		591.54		591.66	
Geologic Unit of Screened Interval	Clayey Silt/Shale Interface		Silt/Shale Interface		Silt/Shale Interface		Silt/Shale Interface		Gravelly Silt and Silty Clay		Sandy Clay		Silt and Silty Clay	
Screened Interval Elevation	449.3 to 444.3		455.0 to 450.0		456.9 to 451.9		456.3 to 451.3		444.3 to 439.3		452.0 to 447.0		452.5 to 447.5	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	16.95	573.87	17.74	575.47	16.84	575.74	15.74	576.14	17.88	574.38	16.86	574.68	Not Installed	
9/19/2016	17.00	573.82	17.85	575.36	17.00	575.58	15.90	575.98	17.98	574.28	16.96	574.58		
11/7/2016	17.13	573.69	17.59	575.62	16.70	575.88	15.70	576.18	18.06	574.20	16.99	574.55		
1/9/2017	17.11	573.71	17.51	575.70	16.60	575.98	15.58	576.30	17.94	574.32	16.87	574.67		
2/27/2017	16.74	574.08	17.36	575.85	16.56	576.02	15.50	576.38	17.72	574.54	NU	NU		
4/17/2017	16.77	574.05	17.71	575.50	16.84	575.74	15.70	576.18	17.81	574.45	NU	NU		
5/18/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	Decommissioned		16.69	574.97
6/5/2017	16.61	574.21	17.66	575.55	16.83	575.75	15.72	576.16	17.73	574.53			16.71	574.95
6/30/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM			16.83	574.83
7/24/2017	16.74	574.08	18.01	575.20	17.13	575.45	15.99	575.89	17.93	574.33			16.91	574.75

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

NU - Not Used; monitoring well was damaged at the time of data collection.

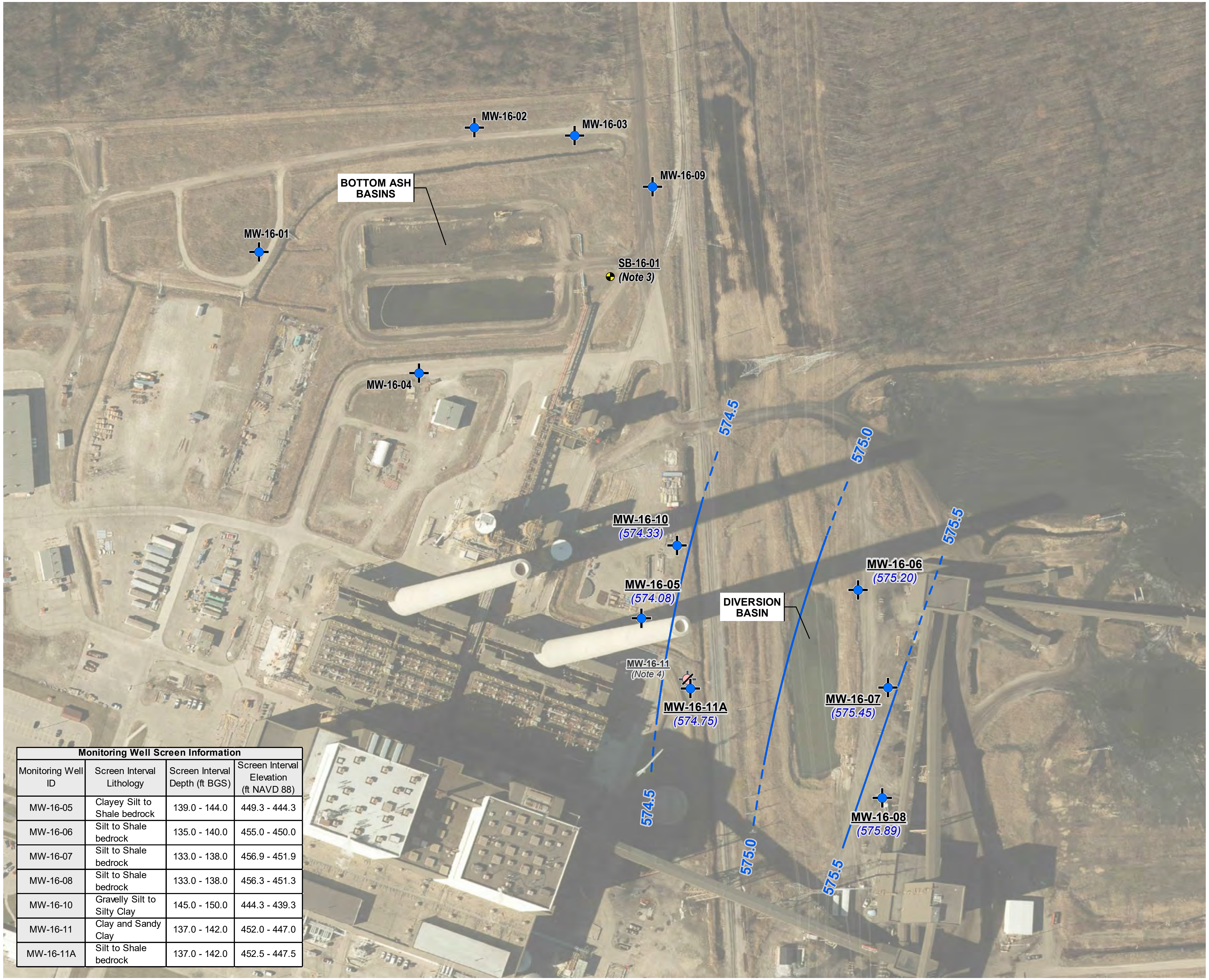
NM - Not Measured

(1) MW-16-11 decomissioned on 5/11/2017 and replaced with MW-16-11A.

TRC - GIS

Plot Date: 1/12/2018, 10:17:40 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-012.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0



Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-05	Clayey Silt to Shale bedrock	139.0 - 144.0	449.3 - 444.3
MW-16-06	Silt to Shale bedrock	135.0 - 140.0	455.0 - 450.0
MW-16-07	Silt to Shale bedrock	133.0 - 138.0	456.9 - 451.9
MW-16-08	Silt to Shale bedrock	133.0 - 138.0	456.3 - 451.3
MW-16-10	Gravelly Silt to Silty Clay	145.0 - 150.0	444.3 - 439.3
MW-16-11	Clay and Sandy Clay	137.0 - 142.0	452.0 - 447.0
MW-16-11A	Silt to Shale bedrock	137.0 - 142.0	452.5 - 447.5

LEGEND

●	SOIL BORING
⊕	MONITORING WELL
⊘	DECOMMISSIONED MONITORING
(575.47)	GROUNDWATER ELEVATION (FT NAVD 88)
∼	GROUNDWATER ELEVATION CONTOUR (0.5-FT INTERVAL, DASHED WHERE INFERRED)

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, AND JUNE 2016 BY BMJ ENGINEERS AND SURVEYORS. INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.
4. MONITORING WELL MW-16-11 WAS DECOMMISSIONED AND REPLACED BY MW-16-11A IN MAY 2017.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988.

0 200 400
Feet

1 " = 200 '
1:2,400

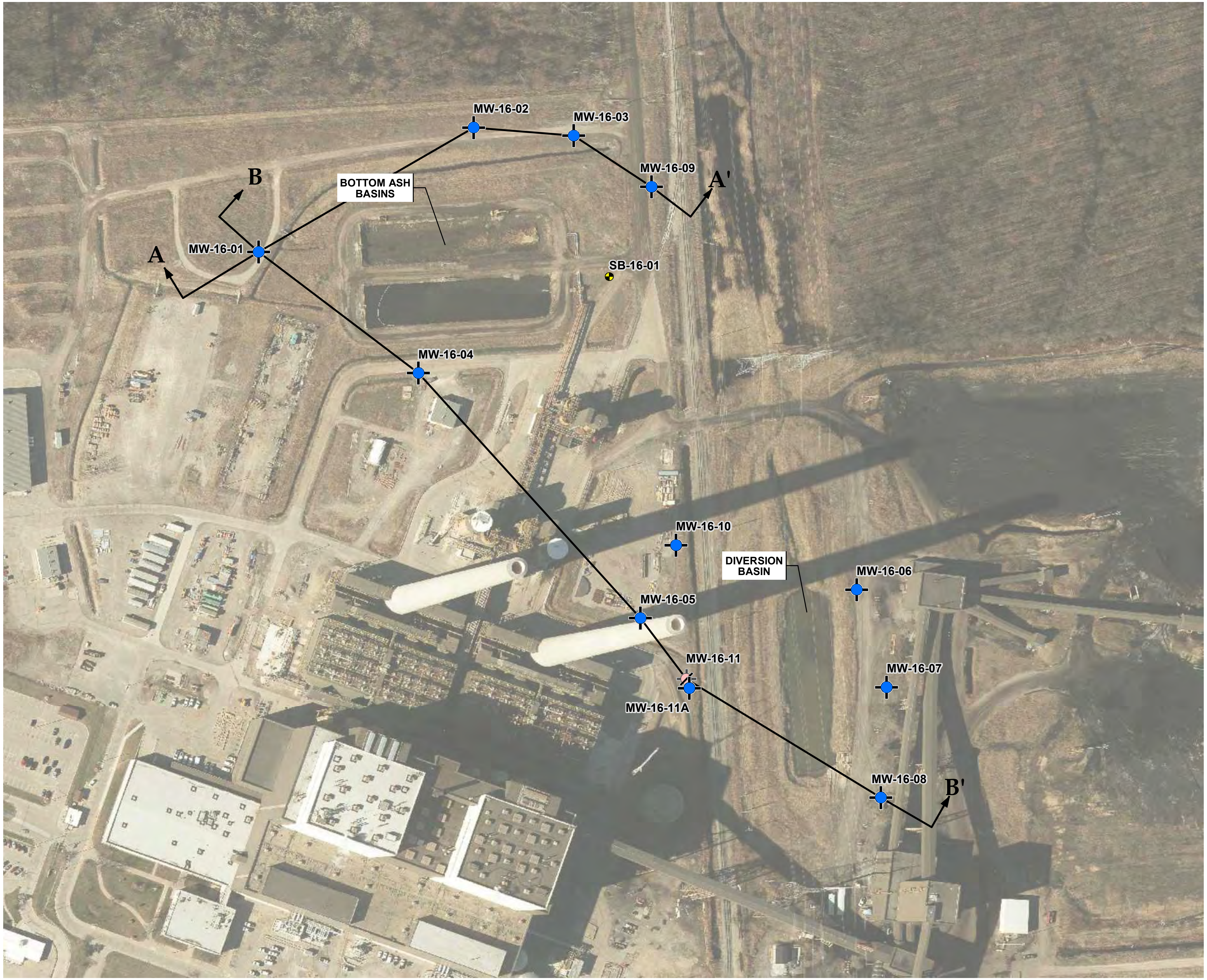
PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
DIVERSION BASIN GROUNDWATER POTENTIOMETRIC SURFACE MAP JULY 2017

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA	FIGURE 8	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-012.mxd



LEGEND

- ● SOIL BORING
- ⌖ MONITORING WELL
- ⊘ DECOMMISSIONED MONITORING WELL
- ⌐ CROSS SECTIONS

NOTES

1. BASE MAP IMAGERY FROM ST. CLAIR COUNTY INFORMATION TECHNOLOGY DEPARTMENT WEBMAP, 2015.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017.

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:

CROSS SECTION LOCATOR MAP

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

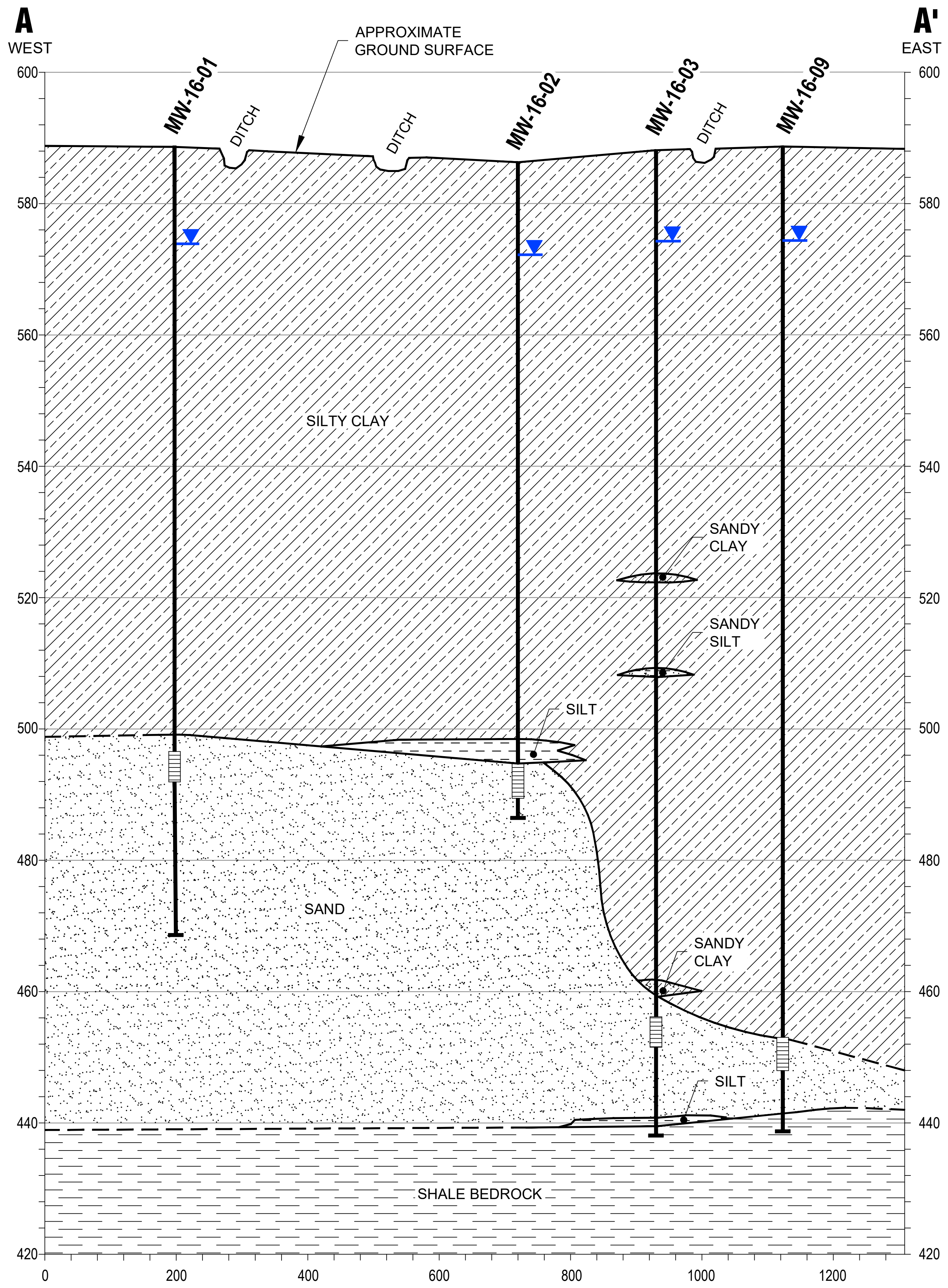
FILE NO.: 265996-0003-011.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:20:19 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-011.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

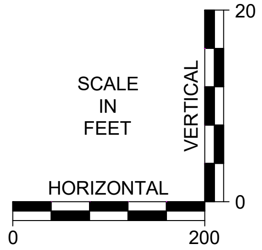


LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- ▼ GROUNDWATER ELEVATION (COLLECTED 02/27/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

- ▨ SILTY CLAY
- ░ SAND
- ☰ SILT
- ▨ SANDY CLAY
- ░ SANDY SILT
- ☰ SHALE BEDROCK



PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:

GENERALIZED
GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0003.01
CHECKED BY:	S.HOLMSTROM	FIGURE 4	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

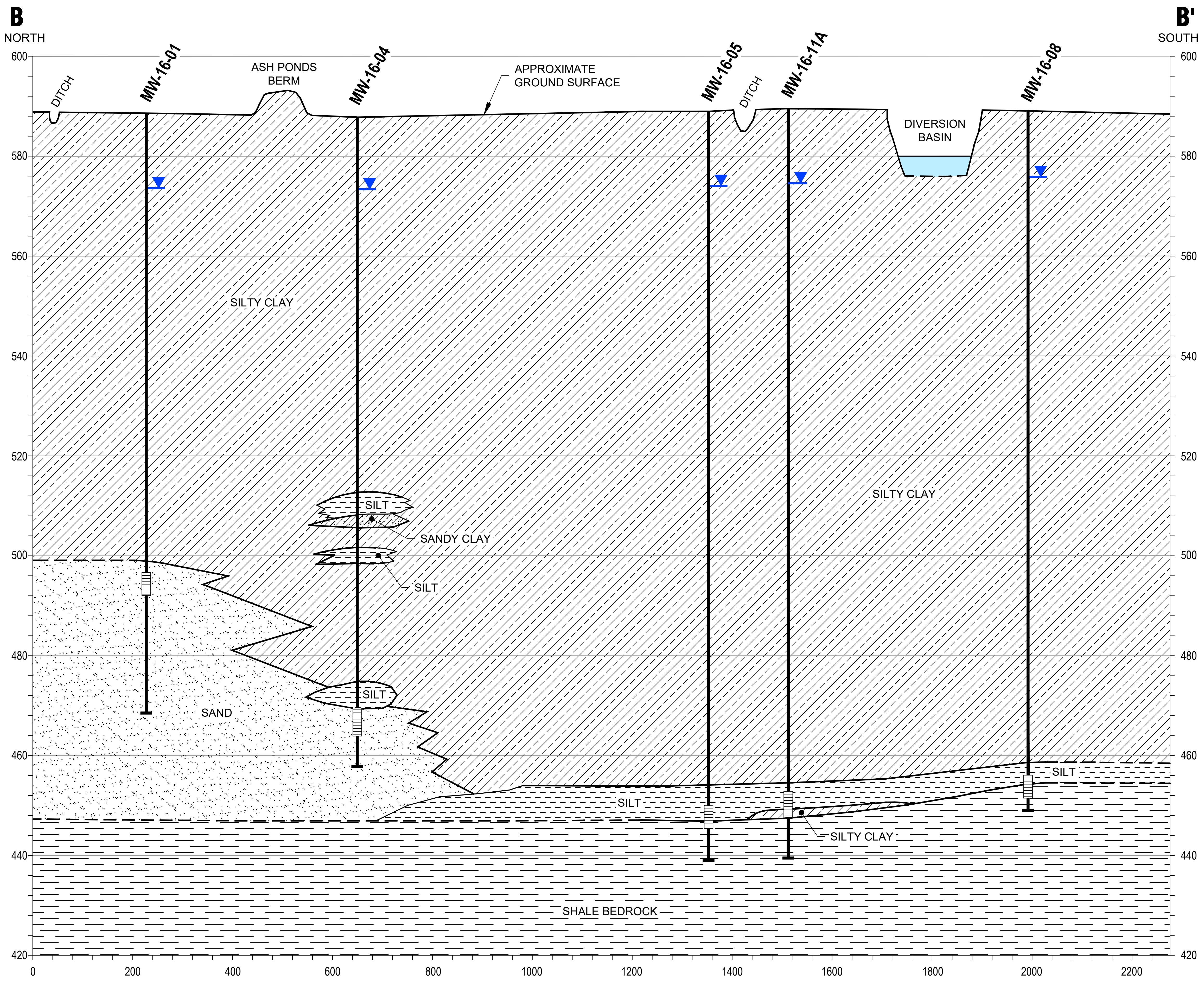
TRC

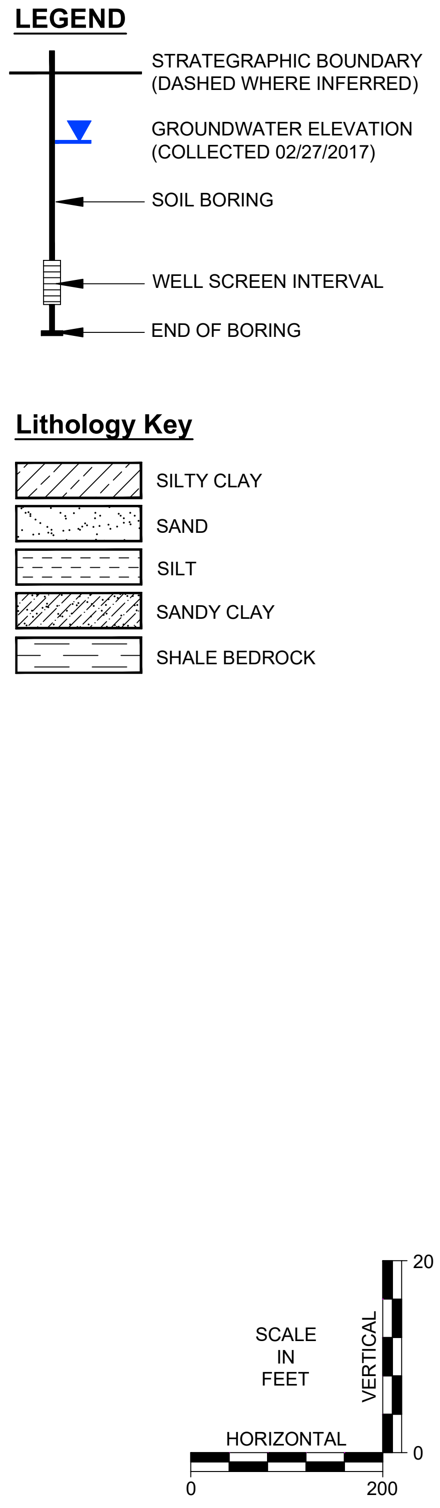
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0003.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES: DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_1; DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_2; XS aa wells; XS cc wells; XS DD wells;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'





PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:

GENERALIZED
GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0003
CHECKED BY:	S.HOLMSTROM	FIGURE 5	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0003.01.04-05.dwg

11x17 --- ATTACHED XREF'S: --- ATTACHED IMAGES: DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_1; DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_2; XS aa wells; XS cc wells; XS DD wells;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG05 XS BB

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	8
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray lean clay	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.87	2.87	Permeant:	Water	
Sample Ht. (in)	3.02	3.02	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	775.10	649.20	Sample Specific Gravity:	2.70	Est.
Tare & Dry (g)	562.60	471.50	Confining Pressure (psi):	100.0	
Tare (g)	88.86	88.64	Burette Diameter (in):	0.250	
Sample Wt. (g)	563.65	560.56	Burette Zero (cm):	100.0	

Moisture (%)	44.9	46.4	Maximum Gradient:	7.0
Wet Density (pcf)	109.9	109.5	Average Gradient:	6.5
Dry Density (pcf)	75.9	74.8	Max. Effect. Stress (psi):	5.7
Saturation (%)	99.2	100.0	Min. Effect. Stress (psi):	4.3
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	15	8	10.00		0.0	95	95	55.40		3.45		102.60				
2	2016	3	15	11	15.00	11100	23.0	95	95	56.10	0.70	4.05	0.60	101.30	1.30	-36.8	4.7E-08	
3	2016	3	15	14	16.00	10860	23.0	95	95	57.00	0.90	4.75	0.70	100.60	0.70	0.0	3.6E-08	
4	2016	3	15	18	15.00	14340	23.0	95	95	57.75	0.75	5.55	0.80	99.75	0.85	-3.0	3.3E-08	
5	2016	3	16	4	55.00	38400	22.0	95	95	59.30	1.55	7.65	2.10	97.50	2.25	-3.4	3.4E-08	
6	2016	3	16	8	38.00	13380	23.0	95	95	59.80	0.50	8.35	0.70	96.80	0.70	0.0	3.2E-08	
7	2016	3	16	11	56.00	11880	23.0	95	95	60.35	0.55	9.05	0.70	96.30	0.50	16.7	3.1E-08	
8	2016	3	16	15	1.00	11100	23.0	95	95	60.40	0.05	9.60	0.55	95.70	0.60	-4.3	3.2E-08	
9	2016	3	17	5	14.00	51180	22.0	95	95	61.30	0.90	12.10	2.50	93.20	2.50	0.0	3.2E-08	
10	2016	3	17	8	17.00	10980	24.0	95	95	62.05	0.75	12.65	0.55	92.75	0.45	10.0	3.0E-08	
11	2016	3	17	12	19.00	14520	23.0	95	95	62.15	0.10	13.25	0.60	92.05	0.70	-7.7	3.0E-08	
12	2016	3	17	17	49.00	19800	23.0	95	95	62.60	0.45	14.15	0.90	91.30	0.75	9.1	2.9E-08	
13	2016	3	18	5	23.00	41640	22.0	95	95	63.15	0.55	16.00	1.85	89.40	1.90	-1.3	3.3E-08	
14	2016	3	18	8	58.00	12900	24.0	95	95	63.60	0.45	16.55	0.55	88.90	0.50	4.8	3.0E-08	
15	2016	3	18	12	55.00	14220	23.0	95	95	63.80	0.20	17.10	0.55	88.30	0.60	-4.3	3.0E-08	
16	2016	3	18	16	30.00	12900	23.0	95	95	64.10	0.30	17.65	0.55	87.90	0.40	15.8	2.8E-08	
17	2016	3	21	4	58.00	217680	22.0	95	95	67.20	3.10	25.35	7.70	80.20	7.70	0.0	3.1E-08	
18	2016	3	21	8	1.00	10980	24.0	95	95	67.60	0.40	25.70	0.35	79.85	0.35	0.0	3.1E-08	
19	2016	3	21	12	10.00	14940	23.0	95	95	67.60	0.00	26.15	0.45	79.40	0.45	0.0	3.0E-08	
20	2016	3	21	15	12.00	10920	23.0	95	95	67.70	0.10	26.40	0.25	79.15	0.25	0.0	2.3E-08	1
21	2016	3	21	19	36.00	15840	23.0	95	95	68.30	0.60	26.90	0.50	78.70	0.45	5.3	3.1E-08	1
22	2016	3	21	21	31.00	6900	23.0	95	95	68.10	-0.20	27.10	0.20	78.50	0.20	0.0	3.0E-08	1
23	2016	3	22	5	52.00	30060	25.0	95	95	68.90	0.80	28.05	0.95	77.65	0.85	5.6	3.1E-08	1
24	2016	3	22	10	31.00	16740	23.0	95	95	68.85	-0.05	28.45	0.40	77.20	0.45	-5.9	2.8E-08	1
25	2016	3	22	15	59.00	19680	24.0	95	95	69.40	0.55	29.00	0.55	76.70	0.50	4.8	2.9E-08	1
26	2016	3	22	22	32.00	23580	24.0	95	95	69.80	0.40	29.55	0.55	76.10	0.60	-4.3	2.7E-08	1

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name: DTE - BRPP BAB and DB
Project #: 231828.0003.0000
Sample Name: MW-16-05, 50-52'
Visual Descript: Gray lean clay

Cell #: 9
USCS Description: N/A
USCS Classification: N/A
Average Kv = 2.7E-08 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values
Sample Dia. (in)	2.87	2.84
Sample Ht. (in)	3.25	3.20
Tare & Wet (g)	536.11	691.40
Tare & Dry (g)	403.90	517.10
Tare (g)	93.83	91.24
Sample Wt. (g)	610.40	600.16

Permeant: Water
Permeant Specific Gravity: 1.00
Sample Specific Gravity: 2.70 Est.
Confining Pressure (psi): 100.0
Burette Diameter (in): 0.250
Burette Zero (cm): 100.0

Moisture (%)	42.6	40.9
Wet Density (pcf)	110.6	112.8
Dry Density (pcf)	77.5	80.0
Saturation (%)	98.2	100.0

Maximum Gradient: 7.3
Average Gradient: 6.9
Max. Effect. Stress (psi): 6.1
Min. Effect. Stress (psi): 4.6
Ave. Effect. Stress (psi): 5.1

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	15	8	11.00		0.0	95	95	25.20		1.95		101.75				
2	2016	3	15	11	15.00		0.0	95	95	27.70		1.80		99.60				
3	2016	3	15	14	17.00	10920	23.0	95	95	29.40	1.70	2.00	0.20	98.65	0.95	-65.2	3.2E-08	
4	2016	3	15	18	16.00	14340	23.0	95	95	30.65	1.25	2.40	0.40	97.60	1.05	-44.8	3.1E-08	
5	2016	3	16	4	56.00	38400	22.0	95	95	32.20	1.55	3.85	1.45	95.40	2.20	-20.5	3.1E-08	
6	2016	3	16	8	39.00	13380	23.0	95	95	32.40	0.20	4.40	0.55	94.85	0.55	0.0	2.6E-08	
7	2016	3	16	11	57.00	11880	23.0	95	95	33.85	1.45	4.95	0.55	94.40	0.45	10.0	2.7E-08	
8	2016	3	16	15	2.00	11100	23.0	95	95	34.00	0.15	5.35	0.40	93.90	0.50	-11.1	2.7E-08	
9	2016	3	17	5	15.00	51180	22.0	95	95	35.20	1.20	7.35	2.00	91.80	2.10	-2.4	2.8E-08	
10	2016	3	17	8	17.00	10920	24.0	95	95	35.80	0.60	7.80	0.45	91.45	0.35	12.5	2.5E-08	
11	2016	3	17	12	20.00	14580	23.0	95	95	35.90	0.10	8.30	0.50	89.85	1.60	-52.4	5.1E-08	
12	2016	3	17	17	50.00	19800	23.0	95	95	36.40	0.50	9.10	0.80	89.25	0.60	14.3	2.6E-08	
13	2016	3	18	5	23.00	41580	22.0	95	95	37.00	0.60	10.65	1.55	88.60	0.65	40.9	2.0E-08	
14	2016	3	18	8	58.00	12900	24.0	95	95	37.50	0.50	11.15	0.50	88.15	0.45	5.3	2.7E-08	
15	2016	3	18	12	55.00	14220	23.0	95	95	37.70	0.20	11.65	0.50	87.60	0.55	-4.8	2.8E-08	
16	2016	3	18	16	31.00	12960	23.0	95	95	38.00	0.30	12.10	0.45	87.20	0.40	5.9	2.5E-08	
17	2016	3	21	4	59.00	217680	22.0	95	95	41.00	3.00	19.25	7.15	79.85	7.35	-1.4	3.0E-08	
18	2016	3	21	8	2.00	10980	24.0	95	95	41.40	0.40	19.55	0.30	79.60	0.25	9.1	2.4E-08	
19	2016	3	21	12	10.00	14880	23.0	95	95	41.40	0.00	19.95	0.40	79.15	0.45	-5.9	2.8E-08	
20	2016	3	21	15	13.00	10980	23.0	95	95	41.60	0.20	20.25	0.30	78.85	0.30	0.0	2.7E-08	1
21	2016	3	21	19	37.00	15840	23.0	95	95	42.00	0.40	20.80	0.55	78.55	0.30	29.4	2.7E-08	1
22	2016	3	21	21	32.00	6900	23.0	95	95	41.80	-0.20	20.90	0.10	78.30	0.25	-42.9	2.6E-08	1
23	2016	3	22	5	53.00	30060	25.0	95	95	42.75	0.95	21.75	0.85	77.55	0.75	6.3	2.6E-08	1
24	2016	3	22	10	32.00	16740	23.0	95	95	42.75	0.00	22.20	0.45	77.10	0.45	0.0	2.8E-08	1
25	2016	3	22	16	0.00	19680	24.0	95	95	43.25	0.50	22.75	0.55	76.65	0.45	10.0	2.7E-08	1
26	2016	3	22	22	33.00	23580	24.0	95	95	43.60	0.35	23.35	0.60	76.10	0.55	4.3	2.6E-08	1

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.7E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	9
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-07, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.50	3.48	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	512.00	737.80	Sample Specific Gravity:	2.68	Est.
Tare & Dry (g)	387.40	552.10	Confining Pressure (psi):	100.0	
Tare (g)	92.18	89.22	Burette Diameter (in):	0.250	
Sample Wt. (g)	666.40	648.58	Burette Zero (cm):	100.0	

Moisture (%)	42.2	40.1		
Wet Density (pcf)	112.9	112.9		
Dry Density (pcf)	79.4	80.6	Max. Effect. Stress (psi):	6.2
Saturation (%)	102.4	100.0	Min. Effect. Stress (psi):	4.5
			Ave. Effect. Stress (psi):	5.0

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	21	11	16.00		0.0	95	95	16.80		2.50		102.25				
2	2016	4	21	20	32.00	33360	27.0	95	95	27.60	10.80	1.25	-1.25	96.40	5.85	-154.3	4.1E-08	
3	2016	4	22	9	22.00	46200	24.0	95	95	32.50	4.90	2.40	1.15	93.40	3.00	-44.6	3.0E-08	
4	2016	4	22	12	18.00	10560	24.0	95	95	33.50	1.00	2.85	0.45	92.90	0.50	-5.3	3.1E-08	
5	2016	4	22	18	33.00	22500	25.0	95	95	35.05	1.55	3.80	0.95	91.95	0.95	0.0	2.9E-08	
6	2016	4	25	11	30.00	233820	23.0	95	95	44.30	9.25	12.75	8.95	83.10	8.85	0.6	3.1E-08	
7	2016	4	25	17	41.00	22260	24.0	95	95	45.35	1.05	13.50	0.75	82.40	0.70	3.4	2.9E-08	
8	2016	4	25	20	39.00	10680	24.0	95	95	45.30	-0.05	13.80	0.30	82.00	0.40	-14.3	3.0E-08	
9	2016	4	25	23	15.00	9360	24.0	95	95	45.35	0.05	14.10	0.30	81.70	0.30	0.0	3.0E-08	
10	2016	4	26	4	59.00	20640	25.0	95	95	46.00	0.65	14.75	0.65	81.00	0.70	-3.7	3.0E-08	
11	2016	4	26	8	19.00	12000	24.0	95	95	45.95	-0.05	15.10	0.35	80.60	0.40	-6.7	3.0E-08	
12	2016	4	26	13	18.00	17940	24.0	95	95	46.40	0.45	15.70	0.60	80.10	0.50	9.1	3.0E-08	
13	2016	4	27	4	57.00	56340	23.0	95	95	47.60	1.20	17.40	1.70	78.60	1.50	6.2	2.9E-08	
14	2016	4	27	12	47.00	28200	23.0	95	95	47.95	0.35	18.20	0.80	77.90	0.70	6.7	2.8E-08	
15	2016	4	27	15	8.00	8460	23.0	95	95	47.90	-0.05	18.45	0.25	77.65	0.25	0.0	3.2E-08	
16	2016	4	28	5	1.00	49980	22.0	95	95	48.80	0.90	19.80	1.35	76.35	1.30	1.9	3.0E-08	
17	2016	4	28	8	5.00	11040	24.0	95	95	49.40	0.60	20.15	0.35	76.15	0.20	27.3	2.8E-08	
18	2016	4	28	14	56.00	24660	23.0	95	95	49.60	0.20	20.75	0.60	75.55	0.60	0.0	2.8E-08	
19	2016	4	28	20	48.00	21120	23.0	95	95	49.90	0.30	21.30	0.55	75.10	0.45	10.0	2.8E-08	
20	2016	4	29	5	31.00	31380	26.0	95	95	51.05	1.15	22.10	0.80	74.35	0.75	3.2	2.8E-08	
21	2016	4	29	10	27.00	17760	23.0	95	95	50.90	-0.15	22.50	0.40	73.90	0.45	-5.9	3.0E-08	
22	2016	4	29	14	41.00	15240	23.0	95	95	51.25	0.35	22.90	0.40	73.60	0.30	14.3	2.9E-08	
23	2016	4	29	18	0.00	11940	23.0	95	95	51.55	0.30	23.20	0.30	73.40	0.20	20.0	2.7E-08	
24	2016	5	1	16	23.00	166980	22.0	95	95	54.25	2.70	26.95	3.75	70.05	3.35	5.6	3.0E-08	
25	2016	5	2	4	58.00	45300	23.0	95	95	55.05	0.80	27.85	0.90	69.25	0.80	5.9	2.9E-08	
26	2016	5	2	8	4.00	11160	23.0	95	95	55.30	0.25	28.10	0.25	69.05	0.20	11.1	3.1E-08	

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column.

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name: DTE - BRPP BAB and DB

Project #: 231828.0003.0000

Sample Name: MW-16-07, 50-52'

Visual Descript: Gray sandy lean clay, with gravel

Cell #: 9

USCS Description: N/A

USCS Classification: N/A

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.50	3.48	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	512.00	737.80	Sample Specific Gravity:	2.68	Est.
Tare & Dry (g)	387.40	552.10	Confining Pressure (psi):	100.0	
Tare (g)	92.18	89.22	Burette Diameter (in):	0.250	
Sample Wt. (g)	666.40	648.58	Burette Zero (cm):	100.0	

Moisture (%)	42.2	40.1	Maximum Gradient:	3.8
Wet Density (pcf)	112.9	112.9	Average Gradient:	3.6
Dry Density (pcf)	79.4	80.6	Max. Effect. Stress (psi):	5.2
Saturation (%)	102.4	100.0	Min. Effect. Stress (psi):	4.6
			Ave. Effect. Stress (psi):	4.9

	Date Yr.	Mo.	Day	Time Hr.	Min.	Run Time (s)	Temp C°**	Pressure (psi) Bot	Top	Cham (cm)	Cham. Dif.(cm)	Bot (cm)	Bot. Dif.(cm)	Top (cm)	Top Dif.(cm)	Flow Dif.(%)	Kv *** cm/s	Ave.* 0,1
1	2016	5	2	8	4.00		0.0	95	95	55.30		28.10		69.05				
2	2016	5	2	13	15.00	18660	23.0	95	95	55.65	0.35	28.50	0.40	68.80	0.25	23.1	2.8E-08	
3	2016	5	2	20	45.00	27000	26.0	95	95	56.30	0.65	29.00	0.50	68.35	0.45	5.3	2.6E-08	
4	2016	5	3	4	50.00	29100	23.0	95	95	56.00	-0.30	29.50	0.50	67.75	0.60	-9.1	3.1E-08	
5	2016	5	3	8	0.00	11400	25.0	95	95	56.35	0.35	29.70	0.20	67.60	0.15	14.3	2.5E-08	
6	2016	5	3	11	10.00	11400	23.0	95	95	56.30	-0.05	29.90	0.20	67.35	0.25	-11.1	3.4E-08	
7	2016	5	3	14	12.00	10920	23.0	95	95	56.40	0.10	30.15	0.25	67.25	0.10	42.9	2.8E-08	
8	2016	5	3	19	36.00	19440	24.0	95	95	57.20	0.80	30.55	0.40	67.05	0.20	33.3	2.6E-08	
9	2016	5	4	5	24.00	35280	23.0	95	95	57.60	0.40	31.15	0.60	66.50	0.55	4.3	2.9E-08	
10	2016	5	4	9	48.00	15840	23.0	95	95	57.60	0.00	31.40	0.25	66.25	0.25	0.0	2.9E-08	
11	2016	5	4	14	50.00	18120	23.0	95	95	57.70	0.10	31.70	0.30	66.00	0.25	9.1	2.8E-08	
12	2016	5	4	20	0.00	18600	25.0	95	95	58.25	0.55	32.10	0.40	65.80	0.20	33.3	2.9E-08	
13	2016	5	5	5	24.00	33840	24.0	95	95	58.35	0.10	32.60	0.50	65.30	0.50	0.0	2.8E-08	1
14	2016	5	5	10	25.00	18060	24.0	95	95	58.60	0.25	32.90	0.30	65.10	0.20	20.0	2.7E-08	1
15	2016	5	5	14	42.00	15420	24.0	95	95	58.90	0.30	33.20	0.30	64.85	0.25	9.1	3.5E-08	1
16	2016	5	6	4	52.00	51000	23.0	95	95	59.50	0.60	34.00	0.80	64.25	0.60	14.3	2.8E-08	1
17	2016	5	6	9	32.00	16800	23.0	95	95	59.70	0.20	34.25	0.25	64.05	0.20	11.1	2.9E-08	1
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name: DTE - BRPP BAB and DB
Project #: 231828.0003.0000
Sample Name: SB-16-01, 50-52'
Visual Descript: Gray lean clay

Cell #: 10
USCS Description: N/A
USCS Classification: N/A
Average Kv = 2.1E-08 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values
Sample Dia. (in)	2.87	2.82
Sample Ht. (in)	2.88	2.86
Tare & Wet (g)	534.46	607.60
Tare & Dry (g)	400.40	448.80
Tare (g)	98.45	86.36
Sample Wt. (g)	532.36	521.24

Permeant: Water
Permeant Specific Gravity: 1.00
Sample Specific Gravity: 2.70 Est.
Confining Pressure (psi): 100.0
Burette Diameter (in): 0.250
Burette Zero (cm): 100.0

Moisture (%)	44.4	43.8
Wet Density (pcf)	109.0	111.0
Dry Density (pcf)	75.5	77.2
Saturation (%)	97.4	100.0

Maximum Gradient: 8.9
Average Gradient: 8.4
Max. Effect. Stress (psi): 6.1
Min. Effect. Stress (psi): 4.5
Ave. Effect. Stress (psi): 5.1

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	15	8	11.00		0.0	95	95	24.00		1.65		102.30				
2	2016	3	15	11	16.00		0.0	95	95	27.35		1.15		99.70				
3	2016	3	15	14	17.00		0.0	95	95	29.50		1.15		98.60				
4	2016	3	15	18	17.00	14400	23.0	95	95	30.90	1.40	1.35	0.20	97.50	1.10	-69.2	2.5E-08	
5	2016	3	16	4	56.00	38340	22.0	95	95	34.75	3.85	2.00	0.65	95.00	2.50	-58.7	2.4E-08	
6	2016	3	16	8	39.00	13380	23.0	95	95	35.00	0.25	2.50	0.50	94.55	0.45	5.3	2.0E-08	
7	2016	3	16	11	58.00	11940	23.0	95	95	35.45	0.45	3.00	0.50	94.10	0.45	5.3	2.3E-08	
8	2016	3	16	15	3.00	11100	23.0	95	95	35.80	0.35	3.35	0.35	93.60	0.50	-17.6	2.2E-08	
9	2016	3	17	5	15.00	51120	22.0	95	95	38.75	2.95	4.55	1.20	91.10	2.50	-35.1	2.2E-08	
10	2016	3	17	8	18.00	10980	24.0	95	95	38.25	-0.50	5.25	0.70	90.95	0.15	64.7	2.3E-08	
11	2016	3	17	12	21.00	14580	23.0	95	95	38.60	0.35	5.65	0.40	90.35	0.60	-20.0	2.1E-08	
12	2016	3	17	17	51.00	19800	23.0	95	95	38.50	-0.10	6.45	0.80	89.85	0.50	23.1	2.1E-08	
13	2016	3	18	5	24.00	41580	22.0	95	95	40.80	2.30	7.40	0.95	87.95	1.90	-33.3	2.3E-08	
14	2016	3	18	8	59.00	12900	24.0	95	95	40.40	-0.40	8.05	0.65	87.70	0.25	44.4	2.3E-08	
15	2016	3	18	12	56.00	14220	23.0	95	95	40.70	0.30	8.40	0.35	87.25	0.45	-12.5	1.9E-08	
16	2016	3	18	16	32.00	12960	23.0	95	95	40.70	0.00	8.95	0.55	86.90	0.35	22.2	2.4E-08	
17	2016	3	21	4	59.00	217620	22.0	95	95	45.25	4.55	15.10	6.15	80.30	6.60	-3.5	2.2E-08	
18	2016	3	21	8	2.00	10980	24.0	95	95	45.25	0.00	15.50	0.40	80.10	0.20	33.3	2.2E-08	
19	2016	3	21	12	11.00	14940	23.0	95	95	45.40	0.15	15.90	0.40	79.65	0.45	-5.9	2.4E-08	1
20	2016	3	21	15	13.00	10920	23.0	95	95	45.70	0.30	16.10	0.20	79.35	0.30	-20.0	1.9E-08	1
21	2016	3	21	19	38.00	15900	23.0	95	95	45.70	0.00	16.65	0.55	79.10	0.25	37.5	2.1E-08	1
22	2016	3	21	21	33.00	6900	23.0	95	95	46.10	0.40	16.70	0.05	78.80	0.30	-71.4	2.2E-08	1
23	2016	3	22	5	53.00	30000	25.0	95	95	47.20	1.10	17.35	0.65	78.00	0.80	-10.3	2.0E-08	1
24	2016	3	22	10	32.00	16740	23.0	95	95	47.10	-0.10	17.80	0.45	77.60	0.40	5.9	2.2E-08	1
25	2016	3	22	16	0.00	19680	24.0	95	95	47.40	0.30	18.35	0.55	77.15	0.45	10.0	2.2E-08	1
26	2016	3	22	22	34.00	23640	24.0	95	95	47.10	-0.30	19.10	0.75	76.80	0.35	36.4	2.1E-08	1

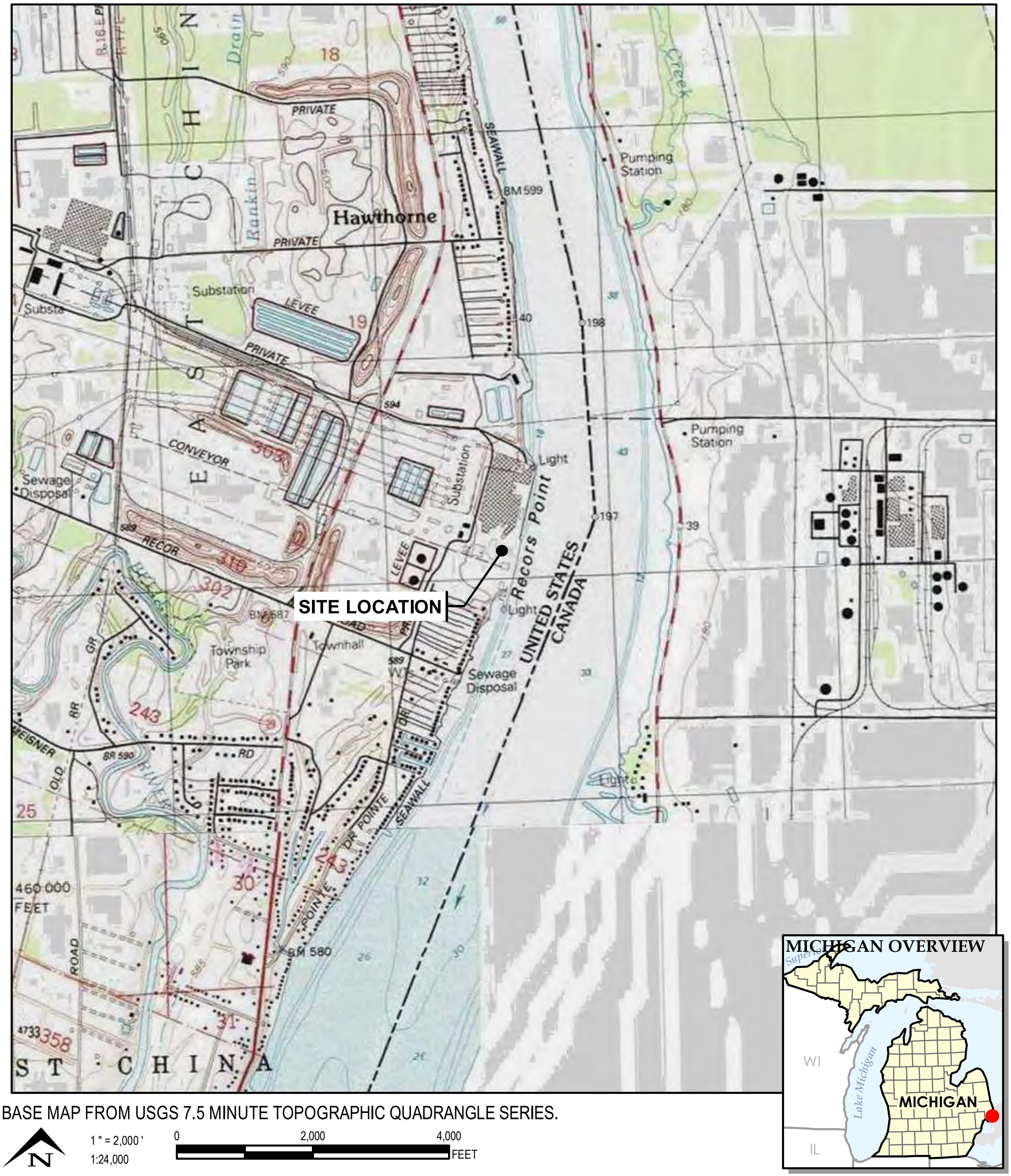
**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 2.1E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

MONPP FAB CCR Unit Site



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
EAST CHINA TOWNSHIP, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0004
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:51:49 PM

LEGEND

✦	MONITORING WELLS
⊟	SURFACE WATER MEASURING POINT
(579.85)	GROUNDWATER ELEVATION (FT NAVD88)
∼	GROUNDWATER ELEVATION CONTOUR (0.5-FT INTERVAL, DASHED WHERE INFERRED)

NOTES

1. BASE MAP IMAGERY FROM ST. CLAIR COUNTY INFORMATION TECHNOLOGY DEPARTMENT WEBMAP, 2015.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN APRIL 2016.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988.
4. GROUNDWATER ELEVATION DATA FOR MW-16-02 WAS NOT USED. GROUNDWATER LEVEL WAS NOT FULLY RECOVERED AT THE TIME OF DATA COLLECTION.

0 100 200
Feet

1 " = 100 '
1:1,200

PROJECT:
DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
CHINA TOWNSHIP, MICHIGAN

TITLE:
GROUNDWATER POTENTIOMETRIC SURFACE MAP
OCTOBER 2017

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0004
CHECKED BY:	S. SCIESZKA	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0004-012.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/12/2018, 10:19:44 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0004-012.mxd

Table 1

Groundwater Elevation Summary
St. Clair Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
East China Township, Michigan

Well ID	**MP-01**		**MW-16-01**		**MW-16-02**		**MW-16-03**		**MW-16-04**	
Date Installed	3/23/2016		3/31/2016		3/29/2016		3/25/2016		3/23/2016	
TOC Elevation	580.84(1)		584.74		581.43		581.39		580.95	
Geologic Unit of Screened Interval	NA		Silty Clay Shale Interface		Silty Clay Shale Interface		Silty Clay/Hardpan Shale Interface		Silty Clay/Hardpan Shale Interface	
Screened Interval Elevation	NA		458.1 to 453.1		456.2 to 451.2		455.1 to 450.1		455.0 to 450.0	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	NM	NM	3.16	581.58	1.32	580.11	1.39	580.00	1.10	579.85
10/3/2016	4.25	576.58	3.63	581.09	5.25	579.49	1.70	579.69	3.22	578.98
11/11/2016	4.72	576.11	3.25	581.49	1.85	579.58	2.00	579.39	1.43	579.52
1/13/2017	4.95	575.88	3.38	581.36	1.82	579.61	1.85	579.54	1.84	579.11
2/28/2017	5.00	575.83	3.42	581.32	2.10	579.33	3.08	578.31	1.60	579.35
4/21/2017	4.21	576.62	3.44	581.30	2.42	579.01	2.06	579.33	1.24	579.71
6/9/2017	4.12	576.71	3.16	581.58	1.30	580.13	1.40	579.99	1.01	579.94
7/27/2017	4.68	576.15	2.31	582.43	1.41	580.02	1.39	580.00	1.28	579.67

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet below top of casing

NA - not applicable

NM - not measured

1) Elevation represents the point of reference used to collect surface water level measurements.

LEGEND

✦	MONITORING WELLS
⊟	SURFACE WATER MEASURING POINT

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, APRIL 2015.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN APRIL 2016.

N

0 100 200 Feet

1 " = 100 '
1:1,200

PROJECT:
DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
CHINA TOWNSHIP, MICHIGAN

TITLE:
CROSS SECTION LOCATOR MAP

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0004
CHECKED BY:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

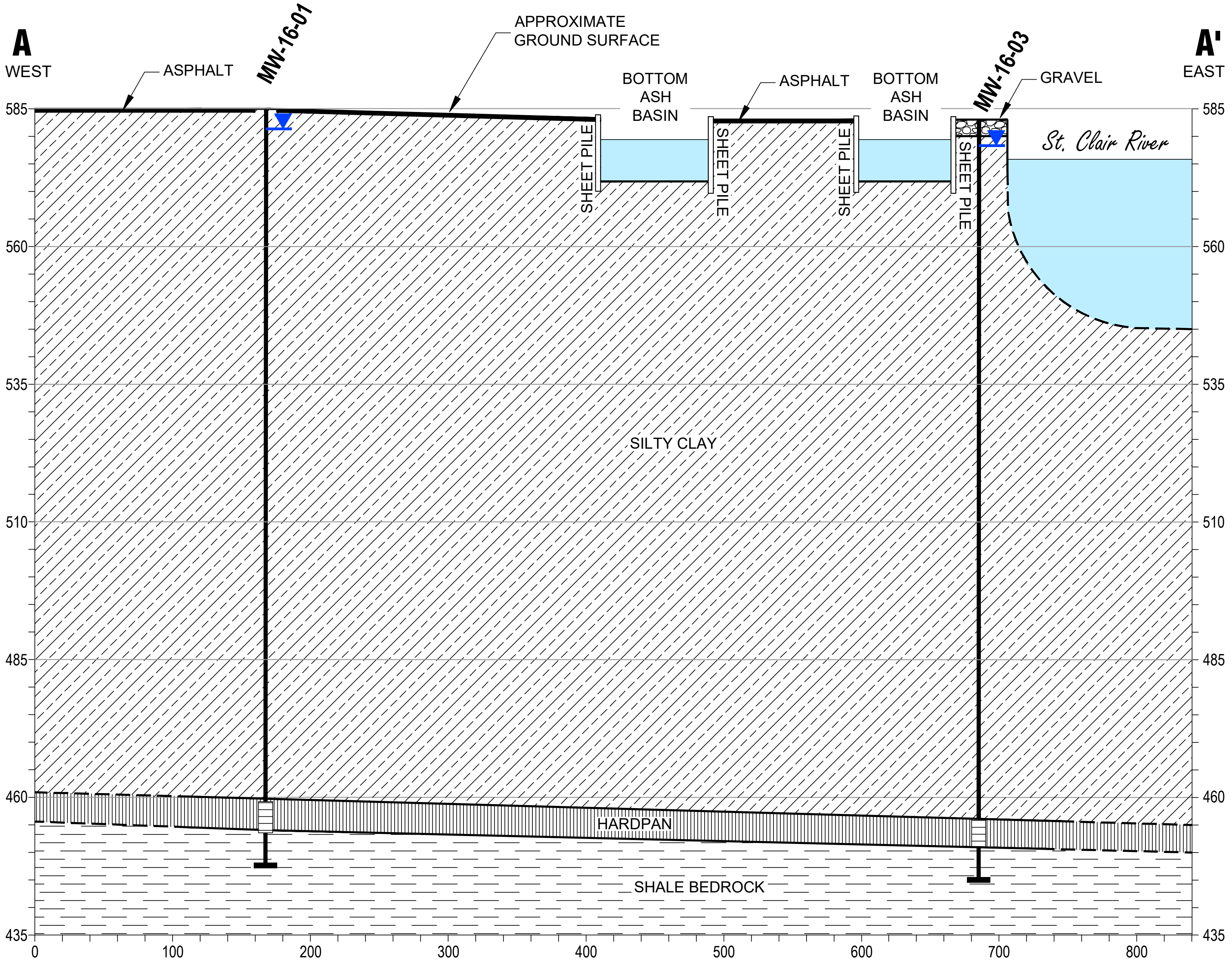
FILE NO.: 265996-0004-010.mxd

TRC - GIS

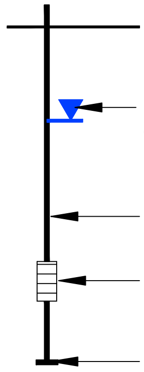
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:36:52 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0004-010.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

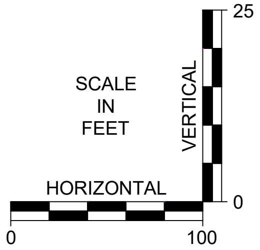


LEGEND



Lithology Key

▥	HARDPAN
▨	SILTY CLAY
☰	SHALE BEDROCK



PROJECT:
DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
EAST CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED
GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0004.01.01
CHECKED BY:	S.HOLMSTROM	FIGURE 4	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

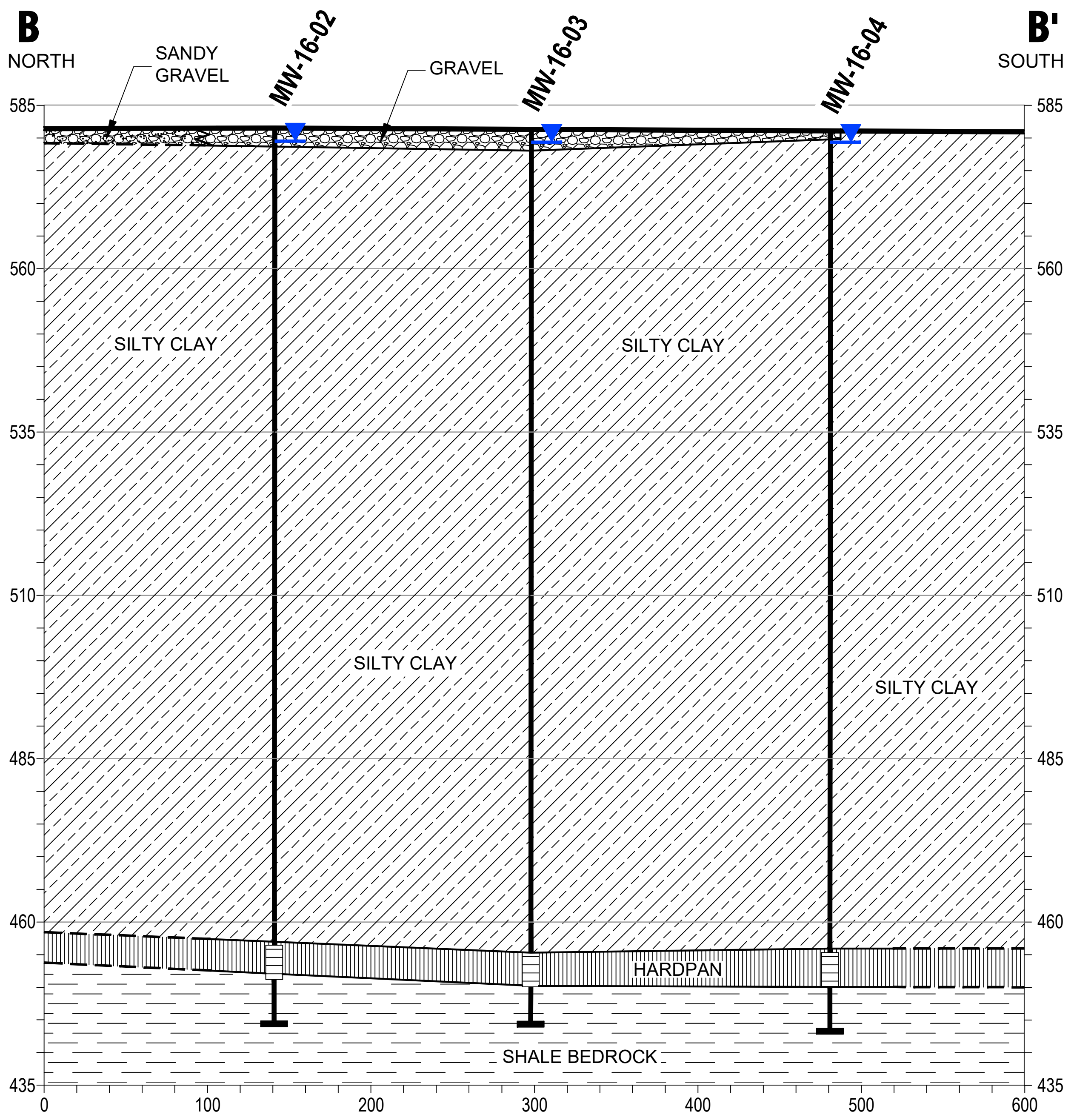
TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

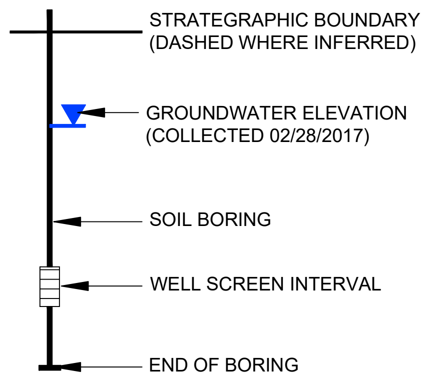
FILE NO.: 265996.0004.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\St Clair PP\265996\0004\01\ 265996.0004.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 12:02PM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'

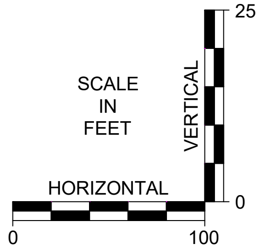


LEGEND



Lithology Key

- ▥ HARDPAN
- ▨ SILTY CLAY
- ▤ SHALE BEDROCK
- ▩ GRAVEL
- ▩ SANDY GRAVEL



PROJECT:
DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
EAST CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED
GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.STEHLE
CHECKED BY:	S.HOLMSTROM
APPROVED BY:	V.BUENING
DATE:	SEPTEMBER 2017

PROJ NO.: 265996.0004.01.01

FIGURE 5

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0004.01.01.04-05.dwg

11x17 --- ATTACHED XREF'S: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\St Clair PP\265996\0004\01\ 265996.0004.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 12:03PM --- LAYOUT: FIG05 XS BB

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	10
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.3E-08 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values
Sample Dia. (in)	2.86	2.83
Sample Ht. (in)	3.62	3.47
Tare & Wet (g)	470.27	763.70
Tare & Dry (g)	373.66	604.00
Tare (g)	88.45	89.44
Sample Wt. (g)	703.30	674.26

Permeant:	Water	
Permeant Specific Gravity:	1.00	
Sample Specific Gravity:	2.60	Est.
Confining Pressure (psi):	100.0	
Burette Diameter (in):	0.250	
Burette Zero (cm):	100.0	

Moisture (%)	33.9	31.0
Wet Density (pcf)	115.2	117.7
Dry Density (pcf)	86.1	89.8
Saturation (%)	99.4	100.0

Max. Effect. Stress (psi):	6.2
Min. Effect. Stress (psi):	4.1
Ave. Effect. Stress (psi):	4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	22	9	23.00		0.0	95	95	13.65		2.80		101.50				
2	2016	4	22	18	33.00	33000	25.0	95	95	31.40	17.75	1.00	-1.80	91.35	10.15	-143.1	8.2E-08	
3	2016	4	25	11	31.00	233880	23.0	95	95	54.55	23.15	2.00	1.00	79.25	12.10	-84.7	2.1E-08	
4	2016	4	25	17	43.00	22320	24.0	95	95	55.40	0.85	2.75	0.75	78.55	0.70	3.4	2.7E-08	
5	2016	4	25	20	40.00	10620	24.0	95	95	55.85	0.45	2.95	0.20	78.15	0.40	-33.3	2.3E-08	
6	2016	4	25	23	16.00	9360	24.0	95	95	56.35	0.50	3.20	0.25	77.80	0.35	-16.7	2.7E-08	
7	2016	4	26	5	0.00	20640	25.0	95	95	56.65	0.30	3.85	0.65	77.25	0.55	8.3	2.4E-08	
8	2016	4	26	8	19.00	11940	24.0	95	95	57.55	0.90	4.00	0.15	76.70	0.55	-57.1	2.5E-08	
9	2016	4	26	13	18.00	17940	24.0	95	95	58.40	0.85	4.45	0.45	76.10	0.60	-14.3	2.5E-08	
10	2016	4	27	4	58.00	56400	23.0	95	95	61.65	3.25	5.45	1.00	74.05	2.05	-34.4	2.5E-08	
11	2016	4	27	12	48.00	28200	23.0	95	95	62.00	0.35	6.10	0.65	73.35	0.70	-3.7	2.3E-08	
12	2016	4	27	15	9.00	8460	23.0	95	95	62.00	0.00	6.30	0.20	73.05	0.30	-20.0	2.8E-08	
13	2016	4	28	5	2.00	49980	22.0	95	95	65.10	3.10	6.95	0.65	71.35	1.70	-44.7	2.4E-08	
14	2016	4	28	8	6.00	11040	24.0	95	95	64.75	-0.35	7.40	0.45	71.25	0.10	63.6	2.4E-08	
15	2016	4	28	14	57.00	24660	23.0	95	95	65.30	0.55	7.85	0.45	70.60	0.65	-18.2	2.3E-08	
16	2016	4	28	20	48.00	21060	23.0	95	95	66.25	0.95	8.30	0.45	70.00	0.60	-14.3	2.6E-08	
17	2016	4	29	5	31.00	31380	26.0	95	95	68.05	1.80	8.70	0.40	69.05	0.95	-40.7	2.1E-08	
18	2016	4	29	10	27.00	17760	23.0	95	95	67.10	-0.95	9.25	0.55	68.80	0.25	37.5	2.4E-08	
19	2016	4	29	14	42.00	15300	23.0	95	95	67.70	0.60	9.55	0.30	68.50	0.30	0.0	2.1E-08	
20	2016	4	29	18	0.00	11880	23.0	95	95	67.50	-0.20	9.90	0.35	68.35	0.15	40.0	2.3E-08	
21	2016	5	1	16	24.00	167040	22.0	95	95	72.80	5.30	12.75	2.85	64.50	3.85	-14.9	2.4E-08	
22	2016	5	2	4	59.00	45300	23.0	95	95	74.50	1.70	13.35	0.60	63.50	1.00	-25.0	2.2E-08	
23	2016	5	2	8	5.00	11160	23.0	95	95	74.15	-0.35	13.65	0.30	63.35	0.15	33.3	2.6E-08	
24	2016	5	2	13	16.00	18660	23.0	95	95	74.45	0.30	14.00	0.35	63.10	0.25	16.7	2.1E-08	
25	2016	5	2	20	46.00	27000	26.0	95	95	73.50	-0.95	14.75	0.75	62.90	0.20	57.9	2.2E-08	
26	2016	5	3	4	50.00	29040	23.0	95	95	74.70	1.20	15.05	0.30	62.10	0.80	-45.5	2.5E-08	

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column.

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	10
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel		

	Initial Values	Final Values			
Sample Type: Undisturbed					
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.62	3.47	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	470.27	763.70	Sample Specific Gravity:	2.60	Est.
Tare & Dry (g)	373.66	604.00	Confining Pressure (psi):	100.0	
Tare (g)	88.45	89.44	Burette Diameter (in):	0.250	
Sample Wt. (g)	703.30	674.26	Burette Zero (cm):	100.0	

Moisture (%)	33.9	31.0	Maximum Gradient:	4.7
Wet Density (pcf)	115.2	117.7	Average Gradient:	4.5
Dry Density (pcf)	86.1	89.8	Max. Effect. Stress (psi):	4.8
Saturation (%)	99.4	100.0	Min. Effect. Stress (psi):	4.1
			Ave. Effect. Stress (psi):	4.4

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	5	3	4	50.00		0.0	95	95	74.70		15.05		62.10				
2	2016	5	3	8	1.00	11460	25.0	95	95	75.05	0.35	15.25	0.20	61.90	0.20	0.0	2.3E-08	
3	2016	5	3	11	11.00	11400	23.0	95	95	75.60	0.55	15.30	0.05	61.65	0.25	-66.7	1.8E-08	
4	2016	5	3	14	13.00	10920	23.0	95	95	76.00	0.40	15.50	0.20	61.45	0.20	0.0	2.5E-08	
5	2016	5	3	19	37.00	19440	24.0	95	95	76.30	0.30	15.95	0.45	61.25	0.20	38.5	2.3E-08	
6	2016	5	4	5	24.00	35220	23.0	95	95	76.70	0.40	16.45	0.50	60.65	0.60	-9.1	2.2E-08	
7	2016	5	4	9	49.00	15900	23.0	95	95	76.85	0.15	16.75	0.30	60.35	0.30	0.0	2.8E-08	
8	2016	5	4	14	51.00	18120	23.0	95	95	77.40	0.55	16.90	0.15	60.00	0.35	-40.0	2.0E-08	
9	2016	5	4	20	1.00	18600	25.0	95	95	76.85	-0.55	17.40	0.50	59.90	0.10	66.7	2.3E-08	
10	2016	5	5	5	25.00	33840	24.0	95	95	78.30	1.45	17.75	0.35	59.15	0.75	-36.4	2.4E-08	
11	2016	5	5	10	26.00	18060	24.0	95	95	78.30	0.00	18.10	0.35	58.90	0.25	16.7	2.5E-08	1
12	2016	5	5	14	42.00	15360	24.0	95	95	78.60	0.30	18.30	0.20	58.70	0.20	0.0	2.0E-08	1
13	2016	5	6	4	53.00	51060	23.0	95	95	79.30	0.70	19.10	0.80	58.00	0.70	6.7	2.4E-08	1
14	2016	5	6	9	33.00	16800	23.0	95	95	79.90	0.60	19.25	0.15	57.70	0.30	-33.3	2.2E-08	1
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 2.3E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation	QC: JPH
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	11
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-02, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.7E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.85	2.84	Permeant:	Water
Sample Ht. (in)	2.69	2.68	Permeant Specific Gravity:	1.00
Tare & Wet (g)	482.10	587.40	Sample Specific Gravity:	2.68 Est.
Tare & Dry (g)	371.38	440.90	Confining Pressure (psi):	100.0
Tare (g)	87.03	88.43	Burette Diameter (in):	0.250
Sample Wt. (g)	507.56	498.97	Burette Zero (cm):	100.0

Moisture (%)	38.9	41.6	Maximum Gradient:	9.0
Wet Density (pcf)	112.8	112.0	Average Gradient:	8.3
Dry Density (pcf)	81.2	79.1	Max. Effect. Stress (psi):	5.5
Saturation (%)	98.4	100.0	Min. Effect. Stress (psi):	4.0
			Ave. Effect. Stress (psi):	4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	29	5	36.00		0.0	95	95	65.15		2.65		103.70				
2	2016	4	29	10	28.00	17520	23.0	95	95	67.50	2.35	3.50	0.85	102.35	1.35	-22.7	3.1E-08	
3	2016	4	29	14	45.00	15420	23.0	95	95	69.50	2.00	4.40	0.90	102.40	-0.05	111.8	1.4E-08	
4	2016	4	29	17	58.00	11580	23.0	95	95	70.70	1.20	5.05	0.65	102.00	0.40	23.8	2.3E-08	
5	2016	5	1	16	20.00	166920	22.0	95	95	80.70	10.00	13.65	8.60	96.80	5.20	24.6	2.3E-08	
6	2016	5	2	5	0.00	45600	23.0	95	95	82.70	2.00	15.70	2.05	94.70	2.10	-1.2	2.8E-08	
7	2016	5	2	8	7.00	11220	23.0	95	95	83.25	0.55	16.20	0.50	94.25	0.45	5.3	2.6E-08	
8	2016	5	2	13	7.00	18000	23.0	95	95	84.00	0.75	17.05	0.85	93.55	0.70	9.7	2.7E-08	
9	2016	5	2	20	40.00	27180	26.0	95	95	85.60	1.60	18.20	1.15	92.50	1.05	4.5	2.5E-08	
10	2016	5	3	4	51.00	29460	23.0	95	95	85.85	0.25	19.35	1.15	91.10	1.40	-9.8	2.9E-08	
11	2016	5	3	8	3.00	11520	25.0	95	95	86.60	0.75	19.85	0.50	90.65	0.45	5.3	2.7E-08	
12	2016	5	3	11	8.00	11100	23.0	95	95	86.60	0.00	20.30	0.45	90.15	0.50	-5.3	3.0E-08	
13	2016	5	3	14	13.00	11100	23.0	95	95	87.30	0.70	20.75	0.45	89.70	0.45	0.0	2.9E-08	
14	2016	5	3	19	34.00	19260	24.0	95	95	88.25	0.95	21.55	0.80	89.15	0.55	18.5	2.5E-08	
15	2016	5	4	5	25.00	35460	23.0	95	95	89.35	1.10	22.85	1.30	87.75	1.40	-3.7	2.8E-08	
16	2016	5	4	9	50.00	15900	23.0	95	95	89.70	0.35	23.45	0.60	87.20	0.55	4.3	2.8E-08	
17	2016	5	4	14	52.00	18120	23.0	95	95	90.20	0.50	24.10	0.65	86.55	0.65	0.0	2.8E-08	
18	2016	5	4	19	58.00	18360	25.0	95	95	91.10	0.90	24.80	0.70	86.00	0.55	12.0	2.6E-08	
19	2016	5	5	5	26.00	34080	24.0	95	95	91.75	0.65	25.95	1.15	84.75	1.25	-4.2	2.8E-08	1
20	2016	5	5	10	27.00	18060	24.0	95	95	92.40	0.65	26.50	0.55	84.20	0.55	0.0	2.5E-08	1
21	2016	5	5	14	43.00	15360	24.0	95	95	92.80	0.40	27.05	0.55	83.70	0.50	4.8	2.9E-08	1
22	2016	5	6	4	53.00	51000	23.0	95	95	84.30	-8.50	28.70	1.65	82.15	1.55	3.1	2.8E-08	1
23	2016	5	6	9	34.00	16860	23.0	95	95	94.70	10.40	29.20	0.50	81.65	0.50	0.0	2.8E-08	1
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.7E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	2
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-03, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	2.90	2.85	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	474.40	611.40	Sample Specific Gravity:	2.70	Est.
Tare & Dry (g)	351.87	453.40	Confining Pressure (psi):	100.0	
Tare (g)	86.27	88.02	Burette Diameter (in):	0.250	
Sample Wt. (g)	535.23	523.38	Burette Zero (cm):	100.0	

Moisture (%)	46.1	43.2	Maximum Gradient:	7.7
Wet Density (pcf)	109.4	111.2	Average Gradient:	7.3
Dry Density (pcf)	74.9	77.6	Max. Effect. Stress (psi):	5.5
Saturation (%)	99.8	100.0	Min. Effect. Stress (psi):	3.8
			Ave. Effect. Stress (psi):	4.3

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	29	5	39.00		0.0	95	95	71.90		3.05		103.70				
2	2016	4	29	10	29.00	17400	23.0	95	95	74.80	2.90	3.25	0.20	100.00	3.70	-89.7	6.0E-08	
3	2016	4	29	14	46.00	15420	23.0	95	95	77.30	2.50	3.70	0.45	98.60	1.40	-51.4	3.3E-08	
4	2016	4	29	17	59.00	11580	23.0	95	95	78.70	1.40	4.15	0.45	97.75	0.85	-30.8	3.1E-08	
5	2016	5	1	16	21.00	166920	22.0	95	95	90.30	11.60	11.25	7.10	89.20	8.55	-9.3	3.0E-08	
6	2016	5	2	5	1.00	45600	23.0	95	95	92.75	2.45	13.05	1.80	87.30	1.90	-2.7	2.8E-08	
7	2016	5	2	8	7.00	11160	23.0	95	95	93.70	0.95	13.40	0.35	86.80	0.50	-17.6	2.7E-08	
8	2016	5	2	13	8.00	18060	23.0	95	95	94.25	0.55	14.20	0.80	86.20	0.60	14.3	2.8E-08	
9	2016	5	2	20	42.00	27240	26.0	95	95	96.15	1.90	15.25	1.05	85.20	1.00	2.6	2.6E-08	
10	2016	5	3	4	52.00	29400	23.0	95	95	95.60	-0.55	16.20	0.95	83.85	1.35	-17.5	3.0E-08	
11	2016	5	3	8	3.00	11460	25.0	95	95	96.60	1.00	16.60	0.40	83.45	0.40	0.0	2.6E-08	
12	2016	5	3	11	9.00	11160	23.0	95	95	96.20	-0.40	17.10	0.50	82.95	0.50	0.0	3.6E-08	
13	2016	5	3	14	14.00	11100	23.0	95	95	97.05	0.85	17.35	0.25	82.55	0.40	-23.1	2.4E-08	
14	2016	5	3	19	34.00	19200	24.0	95	95	98.70	1.65	18.10	0.75	82.00	0.55	15.4	2.7E-08	
15	2016	5	4	5	26.00	35520	23.0	95	95	99.75	1.05	19.25	1.15	80.70	1.30	-6.0	2.9E-08	
16	2016	5	4	9	50.00	15840	23.0	95	95	100.30	0.55	19.80	0.55	80.20	0.50	4.5	2.9E-08	
17	2016	5	4	14	52.00	18120	23.0	95	95	100.60	0.30	20.30	0.50	79.55	0.65	-13.0	2.8E-08	
18	2016	5	4	19	59.00	18420	25.0	95	95	101.75	1.15	21.00	0.70	79.10	0.45	21.7	2.7E-08	
19	2016	5	5	5	26.00	34020	24.0	95	95	102.60	0.85	21.90	0.90	77.85	1.25	-16.3	2.8E-08	
20	2016	5	5	10	27.00	18060	24.0	95	95	103.20	0.60	22.50	0.60	77.35	0.50	9.1	2.8E-08	1
21	2016	5	5	14	43.00	15360	24.0	95	95	103.50	0.30	22.95	0.45	76.85	0.50	-5.3	2.9E-08	1
22	2016	5	6	4	54.00	51060	23.0	95	95	104.00	0.50	24.35	1.40	75.40	1.45	-1.8	2.8E-08	1
23	2016	5	6	9	35.00	16860	23.0	95	95	105.00	1.00	24.80	0.45	74.90	0.50	-5.3	2.9E-08	1
24																		
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	3
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-04, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	3.1E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.85	2.82	Permeant:	Water	
Sample Ht. (in)	2.88	2.84	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	561.80	656.70	Sample Specific Gravity:	2.63	Est.
Tare & Dry (g)	460.60	537.10	Confining Pressure (psi):	100.0	
Tare (g)	95.90	87.80	Burette Diameter (in):	0.250	
Sample Wt. (g)	580.00	568.90	Burette Zero (cm):	100.0	

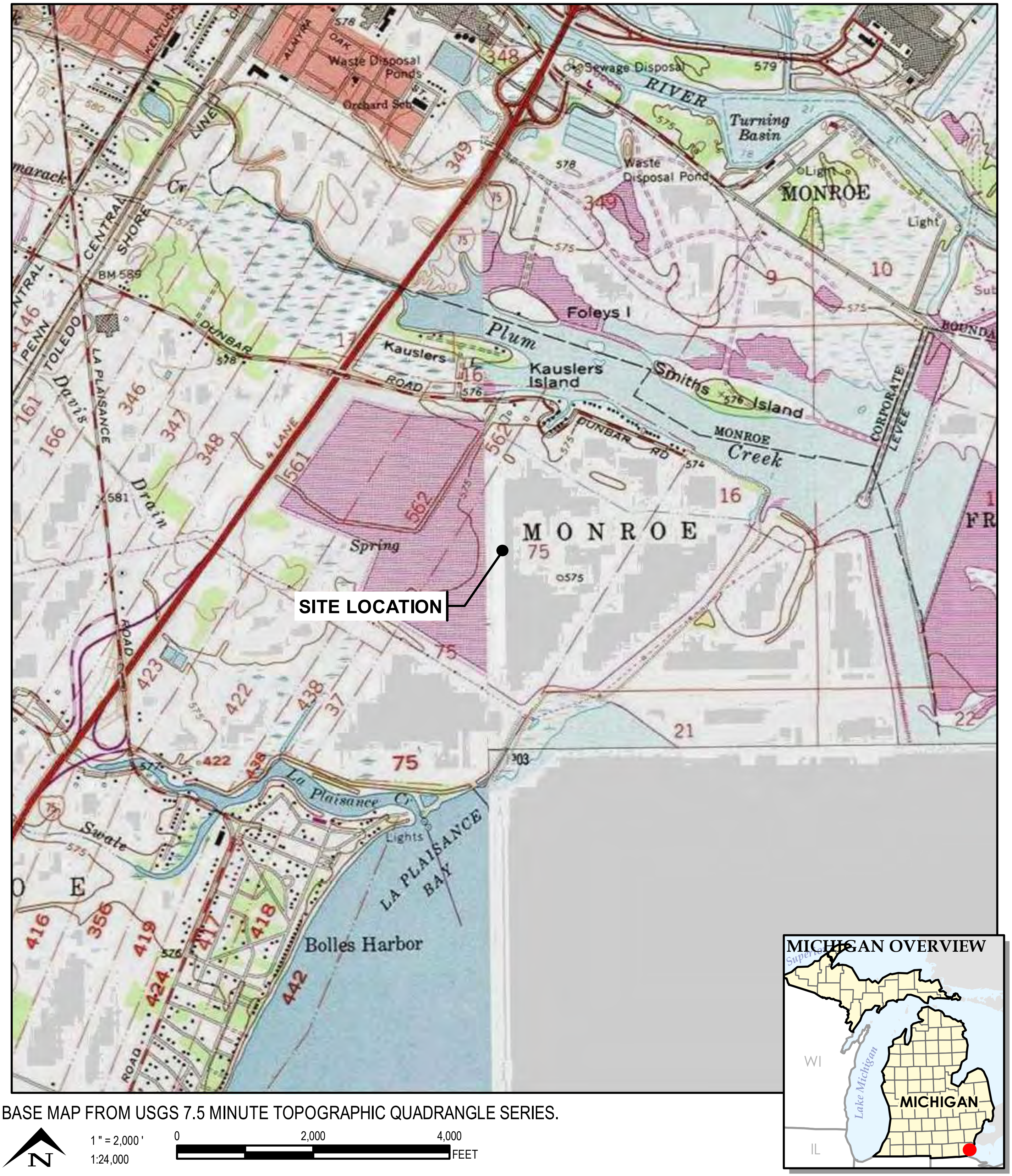
Moisture (%)	27.7	26.6	Maximum Gradient:	7.7
Wet Density (pcf)	120.5	122.2	Average Gradient:	7.3
Dry Density (pcf)	94.3	96.5	Max. Effect. Stress (psi):	5.5
Saturation (%)	98.7	100.0	Min. Effect. Stress (psi):	4.0
			Ave. Effect. Stress (psi):	4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	29	5	41.00		0.0	95	95	66.60		1.60		104.80				
2	2016	4	29	10	30.00	17340	23.0	95	95	68.30	1.70	2.15	0.55	101.80	3.00	-69.0	5.3E-08	
3	2016	4	29	14	47.00	15420	23.0	95	95	69.60	1.30	2.90	0.75	100.80	1.00	-14.3	3.0E-08	
4	2016	4	29	17	59.00	11520	23.0	95	95	70.60	1.00	3.50	0.60	100.15	0.65	-4.0	2.9E-08	
5	2016	5	1	16	21.00	166920	22.0	95	95	77.85	7.25	11.95	8.45	91.30	8.85	-2.3	3.2E-08	
6	2016	5	2	5	2.00	45660	23.0	95	95	79.40	1.55	13.95	2.00	89.10	2.20	-4.8	3.1E-08	
7	2016	5	2	8	8.00	11160	23.0	95	95	80.15	0.75	14.40	0.45	88.65	0.45	0.0	2.8E-08	
8	2016	5	2	13	9.00	18060	23.0	95	95	80.40	0.25	15.25	0.85	88.00	0.65	13.3	3.0E-08	
9	2016	5	2	20	43.00	27240	26.0	95	95	81.60	1.20	16.40	1.15	86.95	1.05	4.5	2.8E-08	
10	2016	5	3	4	52.00	29340	23.0	95	95	80.60	-1.00	17.50	1.10	85.50	1.45	-13.7	3.3E-08	
11	2016	5	3	8	2.00	11400	25.0	95	95	81.25	0.65	18.00	0.50	85.10	0.40	11.1	2.9E-08	
12	2016	5	3	11	9.00	11220	23.0	95	95	80.75	-0.50	18.40	0.40	84.60	0.50	-11.1	3.2E-08	
13	2016	5	3	14	15.00	11160	23.0	95	95	81.55	0.80	18.85	0.45	84.15	0.45	0.0	3.2E-08	
14	2016	5	3	19	35.00	19200	24.0	95	95	82.95	1.40	19.60	0.75	83.60	0.55	15.4	2.7E-08	
15	2016	5	4	5	26.00	35460	23.0	95	95	83.40	0.45	20.90	1.30	82.20	1.40	-3.7	3.2E-08	
16	2016	5	4	9	50.00	15840	23.0	95	95	83.70	0.30	21.40	0.50	81.60	0.60	-9.1	3.0E-08	
17	2016	5	4	14	53.00	18180	23.0	95	95	83.80	0.10	22.05	0.65	80.95	0.65	0.0	3.2E-08	
18	2016	5	4	19	59.00	18360	25.0	95	95	84.80	1.00	22.80	0.75	80.50	0.45	25.0	2.8E-08	
19	2016	5	5	5	27.00	34080	24.0	95	95	85.10	0.30	23.85	1.05	79.20	1.30	-10.6	3.1E-08	
20	2016	5	5	10	28.00	18060	24.0	95	95	85.60	0.50	24.45	0.60	78.65	0.55	4.3	3.0E-08	1
21	2016	5	5	14	44.00	15360	24.0	95	95	85.80	0.20	25.00	0.55	78.25	0.40	15.8	3.0E-08	1
22	2016	5	6	4	55.00	51060	23.0	95	95	86.70	0.90	26.50	1.50	76.75	1.50	0.0	3.0E-08	1
23	2016	5	6	9	35.00	16800	23.0	95	95	87.20	0.50	27.00	0.50	76.15	0.60	-9.1	3.5E-08	1
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 3.1E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

SCPP BABs CCR Unit Site



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

DTE ELECTRIC COMPANY
MONROE POWER PLANT
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0001
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

- ✛ MONITORING WELLS
- APPROXIMATE BOUNDARY OF FLY ASH BASIN

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.

N

0 600 1,200
Feet

1 " = 600 '
1:7,200

PROJECT:

DTE ELECTRIC COMPANY
MONROE POWER PLANT FLY ASH BASIN
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:

MONITORING NETWORK AND SITE PLAN

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0001
CHECKED BY:	S. HOLMSTROM	**FIGURE 2**	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0001-000.mxd

TRC - GIS

Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

Plot Date: 1/29/2018, 09:45:57 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-000.mxd

LEGEND

✛	MONITORING WELL
〰	APPROXIMATE BOUNDARY OF FLY ASH BASIN
↗	INFERRED GROUNDWATER FLOW DIRECTION
〰	POTENTIOMETRIC SURFACE CONTOUR LINE (5-FT INTERVAL,DASHED WHERE INFERRED)
(582.69)	STATIC WATER ELEVATION IN FEET (NAVD, 1988)

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, “WORLD IMAGERY”, WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988

0 600 1,200 Feet

1 " = 600 '

1:7,200

PROJECT:

DTE ELECTRIC COMPANY
MONROE POWER PLANT FLY ASH BASIN
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:

POTENTIOMETRIC SURFACE MAP
SEPTEMBER 2017

DRAWN BY:	S MAJOR	PROJ NO.:	265996.0001
CHECKED BY:	C. SCIESZKA	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0001-011a.mxd

TRC - GIS

Plot Date: 1/12/2018, 08:54:41 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-011a.mxd

Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

Table 1

Groundwater Elevation Summary
Range Road Landfill – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-05		MW-16-06		MW-16-07	
Date Installed	1/13/2016		1/27/2016		2/1/2016		5/24/2016		5/13/2016		5/10/2016		5/13/2016	
TOC Elevation	595.35		598.44		597.69		596.87		601.97		600.68		589.34	
Geologic Unit of Screened interval	Sand with Silt		Silty Sand with Gravel		Silty Gravel with Sand		Silty Sand		Gravel with Sand		Sand		Sand	
Screened Interval Elevation	390.7 to 385.7		393.8 to 388.8		432.1 to 427.1		414.1 to 409.1		476.6 to 471.6		508.0 to 503.0		494.4 to 489.4	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/11/2016	22.77	572.58	21.10	577.34	20.24	577.45	19.54	577.33	27.73	574.24	23.89	576.79	16.13	573.21
9/22/2016	21.41	573.94	21.04	577.40	20.23	577.46	20.92	575.95	27.74	574.23	23.90	576.78	16.40	572.94
11/10/2016	21.07	574.28	20.96	577.48	20.17	577.52	19.55	577.32	27.72	574.25	23.80	576.88	16.20	573.14
1/11/2017	19.63	575.72	20.87	577.57	20.10	577.59	19.38	577.49	27.53	574.44	23.71	576.97	15.80	573.54
1/3/2017	19.05	576.30	20.30	578.14	19.49	578.20	18.85	578.02	26.91	575.06	23.08	577.60	15.74	573.60
4/19/2017	19.11	576.24	20.75	577.69	19.94	577.75	19.32	577.55	27.41	574.56	23.56	577.12	16.19	573.15
6/7/2017	19.00	576.35	20.79	577.65	20.03	577.66	19.32	577.55	27.50	574.47	23.65	577.03	15.82	573.52
7/26/2017	18.90	576.45	20.45	577.99	20.05	577.64	19.45	577.42	27.60	574.37	23.75	576.93	16.30	573.04

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet below top of casing.

LEGEND

- ✦ MONITORING WELLS
- APPROXIMATE BOUNDARY OF FLY ASH
- CROSS SECTIONS

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.

N

0 600 1,200 Feet

1 " = 600 '

1:7,200

PROJECT:

DTE ELECTRIC COMPANY
MONROE POWER PLANT FLY ASH BASIN
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:

CROSS SECTION LOCATOR MAP

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0001
CHECKED BY:	S. HOLMSTROM	FIGURE 3	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

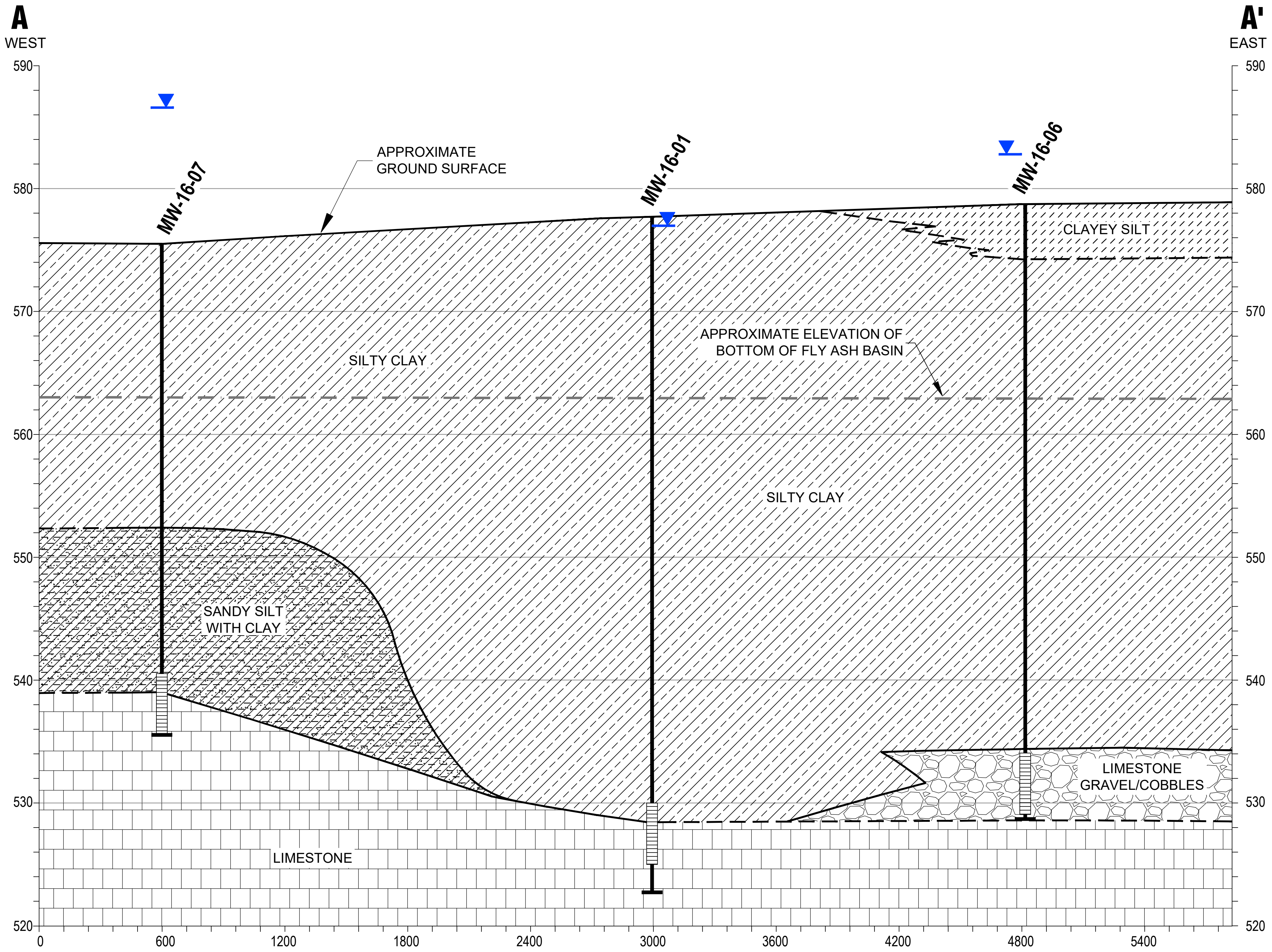
FILE NO.: 265996-0001-008.mxd

TRC - GIS

Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

Plot Date: 10/9/2017, 14:56:26 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-008.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



LEGEND

STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)

▼ GROUNDWATER ELEVATION (COLLECTED ON 03/06/2017)

SOIL BORING

WELL SCREEN INTERVAL

END OF BORING

Lithology Key

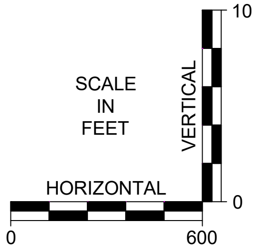
▨ CLAYEY SILT

▨ SILTY CLAY

▨ SANDY SILT WITH CLAY

▨ LIMESTONE GRAVEL / COBBLES

▨ LIMESTONE BEDROCK



PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT - FLY ASH BASIN
MONROE, MICHIGAN

TITLE:
GENERALIZED
GEOLOGIC CROSS-SECTION A-A'

DRAWN BY: D.STEHLE
CHECKED BY: S.HOLMSTROM
APPROVED BY: V.BUENING
DATE: SEPTEMBER 2017

PROJ NO.: 265996.0001.01

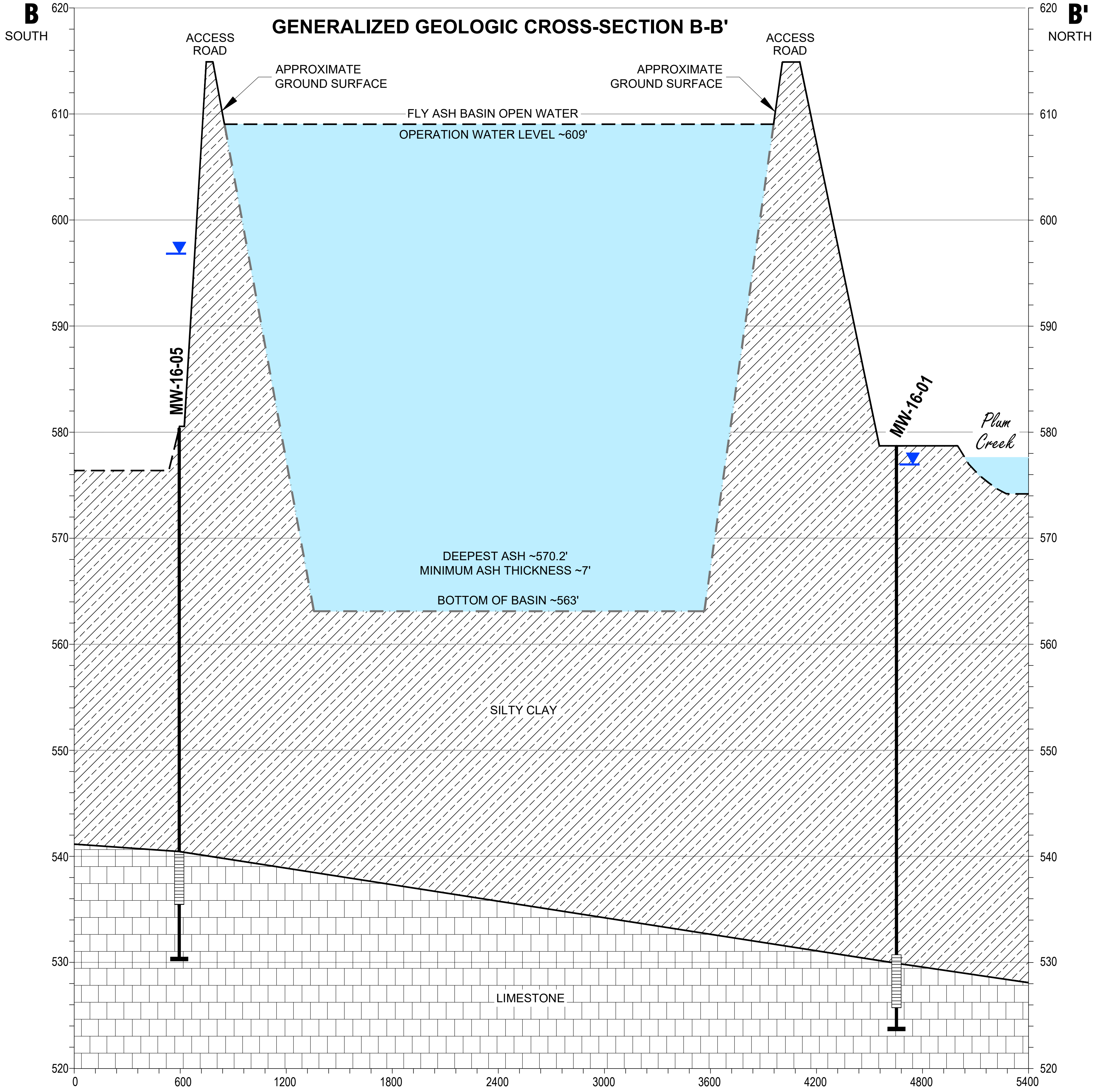
FIGURE 4

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0001.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\Monroe PP\265996\0001\01\ 265996.0001.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 11:17AM --- LAYOUT: FIG04 XS AA

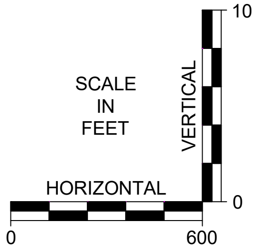


LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 03/06/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

- ▨ SILTY CLAY
- ▦ LIMESTONE BEDROCK



PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT - FLY ASH BASIN
MONROE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.Stehle	PROJ NO.:	265996.0001.01.01
CHECKED BY:	S.HOLMSTROM		**FIGURE 5**
APPROVED BY:	V.BUENING		
DATE:	MAY 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0001.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\Monroe PP\265996\0001\01\ 265996.0001.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 11:17AM --- LAYOUT: FIG05 XS BB

TRC Environmental Corporation	QC: JPH
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	8
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.6E-08 cm/s

Sample Type:	Undisturbed	Initial Values	Final Values			
Sample Dia. (in)		2.87	2.87	Permeant:	Water	
Sample Ht. (in)		3.31	3.31	Permeant Specific Gravity:	1.00	
Tare & Wet (g)		542.53	912.90	Sample Specific Gravity:	2.81	Est.
Tare & Dry (g)		495.80	821.70	Confining Pressure (psi):	100.0	
Tare (g)		90.23	91.36	Burette Diameter (in):	0.250	
Sample Wt. (g)		816.00	821.54	Burette Zero (cm):	100.0	

Moisture (%)	11.5	12.5	Maximum Gradient:	6.7
Wet Density (pcf)	145.1	146.0	Average Gradient:	6.5
Dry Density (pcf)	130.1	129.8	Max. Effect. Stress (psi):	5.8
Saturation (%)	92.9	100.0	Min. Effect. Stress (psi):	4.4
			Ave. Effect. Stress (psi):	4.9

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	6.00		0.0	95	95	45.70		2.90		102.20				
2	2016	3	2	9	13.00	14820	24.0	95	95	46.50	0.80	4.15	1.25	100.65	1.55	-10.7	5.6E-08	
3	2016	3	2	12	8.00	10500	22.0	95	95	46.70	0.20	4.95	0.80	99.85	0.80	0.0	4.8E-08	
4	2016	3	2	20	42.00	30840	22.0	95	95	48.30	1.60	7.20	2.25	97.85	2.00	5.9	4.5E-08	
5	2016	3	3	14	8.00	62760	23.0	95	95	50.95	2.65	10.90	3.70	94.55	3.30	5.7	3.8E-08	
6	2016	3	3	18	52.00	17040	24.0	95	95	51.50	0.55	11.80	0.90	93.80	0.75	9.1	3.4E-08	
7	2016	3	4	13	27.00	66900	22.0	95	95	53.20	1.70	14.70	2.90	91.15	2.65	4.5	3.2E-08	
8	2016	3	4	18	53.00	19560	22.0	95	95	53.80	0.60	15.45	0.75	90.45	0.70	3.4	3.0E-08	
9	2016	3	7	5	14.00	210060	22.0	95	95	58.95	5.15	21.05	5.60	85.35	5.10	4.7	2.2E-08	
10	2016	3	7	8	14.00	10800	23.0	95	95	59.30	0.35	21.30	0.25	85.15	0.20	11.1	1.9E-08	
11	2016	3	7	13	26.00	18720	22.0	95	95	59.75	0.45	21.65	0.35	84.80	0.35	0.0	1.8E-08	
12	2016	3	7	18	47.00	19260	21.0	95	95	60.50	0.75	22.05	0.40	84.55	0.25	23.1	1.7E-08	
13	2016	3	8	5	5.00	37080	25.0	95	95	61.50	1.00	22.75	0.70	83.85	0.70	0.0	1.7E-08	
14	2016	3	8	13	23.00	29880	22.0	95	95	62.20	0.70	23.30	0.55	83.30	0.55	0.0	1.8E-08	
15	2016	3	8	19	23.00	21600	22.0	95	95	63.10	0.90	23.70	0.40	83.10	0.20	33.3	1.4E-08	
16	2016	3	9	5	30.00	36420	24.0	95	95	63.80	0.70	24.30	0.60	82.40	0.70	-7.7	1.8E-08	
17	2016	3	9	11	14.00	20640	24.0	95	95	64.30	0.50	24.65	0.35	82.15	0.25	16.7	1.5E-08	
18	2016	3	9	20	22.00	32880	22.0	95	95	64.70	0.40	25.25	0.60	81.70	0.45	14.3	1.7E-08	
19	2016	3	10	4	59.00	31020	23.0	95	95	65.20	0.50	25.70	0.45	81.20	0.50	-5.3	1.6E-08	1
20	2016	3	10	8	24.00	12300	23.0	95	95	65.40	0.20	25.90	0.20	81.00	0.20	0.0	1.7E-08	1
21	2016	3	10	11	23.00	10740	23.0	95	95	65.40	0.00	26.05	0.15	80.85	0.15	0.0	1.5E-08	1
22	2016	3	10	20	45.00	33720	23.0	95	95	66.20	0.80	26.65	0.60	80.45	0.40	20.0	1.6E-08	1
23	2016	3	11	4	53.00	29280	22.0	95	95	66.20	0.00	27.05	0.40	79.95	0.50	-11.1	1.8E-08	1
24	2016	3	11	7	57.00	11040	24.0	95	95	66.60	0.40	27.20	0.15	79.80	0.15	0.0	1.5E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.6E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	9
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-02, 30-32'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.3E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.87	2.86	Permeant:	Water
Sample Ht. (in)	3.06	3.03	Permeant Specific Gravity:	1.00
Tare & Wet (g)	392.27	822.40	Sample Specific Gravity:	2.80 Est.
Tare & Dry (g)	353.20	733.00	Confining Pressure (psi):	100.0
Tare (g)	89.98	90.41	Burette Diameter (in):	0.250
Sample Wt. (g)	733.20	731.99	Burette Zero (cm):	100.0

Moisture (%)	14.8	13.9	Maximum Gradient:	9.2
Wet Density (pcf)	141.0	143.2	Average Gradient:	9.0
Dry Density (pcf)	122.8	125.7	Max. Effect. Stress (psi):	5.7
Saturation (%)	98.2	100.0	Min. Effect. Stress (psi):	4.2
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	7.00		0.0	95	95	55.10		2.10		101.90				
2	2016	3	2	9	14.00	14820	24.0	95	95	55.90	0.80	2.65	0.55	101.15	0.75	-15.4	2.4E-08	
3	2016	3	2	12	9.00	10500	22.0	95	95	56.20	0.30	2.95	0.30	100.75	0.40	-14.3	1.9E-08	
4	2016	3	2	20	43.00	30840	22.0	95	95	57.75	1.55	4.05	1.10	99.90	0.85	12.8	1.8E-08	
5	2016	3	3	14	9.00	62760	23.0	95	95	60.30	2.55	5.95	1.90	98.50	1.40	15.2	1.5E-08	
6	2016	3	3	18	53.00	17040	24.0	95	95	60.85	0.55	6.50	0.55	98.00	0.50	4.8	1.8E-08	
7	2016	3	4	13	28.00	66900	22.0	95	95	62.50	1.65	8.30	1.80	96.55	1.45	10.8	1.5E-08	
8	2016	3	4	18	54.00	19560	22.0	95	95	63.10	0.60	8.80	0.50	96.15	0.40	11.1	1.5E-08	
9	2016	3	7	5	15.00	210060	22.0	95	95	67.80	4.70	13.70	4.90	92.40	3.75	13.3	1.4E-08	
10	2016	3	7	8	14.00	10740	23.0	95	95	68.30	0.50	13.95	0.25	92.20	0.20	11.1	1.5E-08	
11	2016	3	7	13	26.00	18720	21.0	95	95	68.60	0.30	14.35	0.40	92.00	0.20	33.3	1.2E-08	
12	2016	3	7	18	48.00	19320	21.0	95	95	69.35	0.75	14.80	0.45	91.75	0.25	28.6	1.3E-08	
13	2016	3	8	5	5.00	37020	25.0	95	95	70.40	1.05	15.60	0.80	91.15	0.60	14.3	1.3E-08	
14	2016	3	8	13	48.00	31380	22.0	95	95	70.40	0.00	16.15	0.55	90.70	0.45	10.0	1.2E-08	
15	2016	3	8	19	24.00	20160	22.0	95	95	71.75	1.35	16.60	0.45	90.55	0.15	50.0	1.1E-08	
16	2016	3	9	5	31.00	36420	24.0	95	95	72.40	0.65	17.25	0.65	90.15	0.40	23.8	1.1E-08	
17	2016	3	9	11	15.00	20640	24.0	95	95	72.80	0.40	17.65	0.40	89.85	0.30	14.3	1.3E-08	
18	2016	3	9	20	23.00	32880	22.0	95	95	73.20	0.40	18.35	0.70	89.55	0.30	40.0	1.2E-08	
19	2016	3	10	4	59.00	30960	23.0	95	95	73.60	0.40	18.85	0.50	89.10	0.45	5.3	1.2E-08	1
20	2016	3	10	8	23.00	12240	23.0	95	95	73.80	0.20	19.10	0.25	88.90	0.20	11.1	1.4E-08	1
21	2016	3	10	11	23.00	10800	23.0	95	95	73.80	0.00	19.30	0.20	88.70	0.20	0.0	1.5E-08	1
22	2016	3	10	20	46.00	33780	23.0	95	95	74.50	0.70	20.00	0.70	88.45	0.25	47.4	1.1E-08	1
23	2016	3	11	4	54.00	29280	22.0	95	95	74.40	-0.10	20.45	0.45	87.85	0.60	-14.3	1.5E-08	1
24	2016	3	11	7	58.00	11040	24.0	95	95	74.80	0.40	20.70	0.25	87.75	0.10	42.9	1.3E-08	1
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 1.3E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QC: JPH QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	10
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-03, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.2E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.87	2.87	Permeant:	Water	
Sample Ht. (in)	3.00	3.01	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	563.98	834.70	Sample Specific Gravity:	2.82	Est.
Tare & Dry (g)	512.90	750.80	Confining Pressure (psi):	100.0	
Tare (g)	88.99	90.55	Burette Diameter (in):	0.250	
Sample Wt. (g)	740.10	744.15	Burette Zero (cm):	100.0	

Moisture (%)	12.0	12.7	Maximum Gradient:	9.8
Wet Density (pcf)	145.3	145.8	Average Gradient:	9.4
Dry Density (pcf)	129.7	129.4	Max. Effect. Stress (psi):	5.7
Saturation (%)	95.6	100.0	Min. Effect. Stress (psi):	4.2
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	8.00		0.0	95	95	50.70		2.00		101.60				
2	2016	3	2	9	14.00	14760	24.0	95	95	50.40	-0.30	2.65	0.65	100.90	0.70	-3.7	2.4E-08	
3	2016	3	2	12	9.00	10500	22.0	95	95	51.00	0.60	2.95	0.30	100.50	0.40	-14.3	1.9E-08	
4	2016	3	2	20	44.00	30900	22.0	95	95	52.65	1.65	3.85	0.90	99.75	0.75	9.1	1.5E-08	
5	2016	3	3	14	10.00	62760	23.0	95	95	55.10	2.45	5.50	1.65	98.30	1.45	6.5	1.4E-08	
6	2016	3	3	18	54.00	17040	24.0	95	95	55.30	0.20	6.00	0.50	97.90	0.40	11.1	1.5E-08	
7	2016	3	4	13	29.00	66900	22.0	95	95	57.20	1.90	7.55	1.55	96.50	1.40	5.1	1.3E-08	
8	2016	3	4	18	55.00	19560	22.0	95	95	57.70	0.50	8.00	0.45	96.00	0.50	-5.3	1.5E-08	
9	2016	3	7	5	15.00	210000	22.0	95	95	63.25	5.55	12.30	4.30	92.10	3.90	4.9	1.3E-08	
10	2016	3	7	8	15.00	10800	23.0	95	95	63.40	0.15	12.60	0.30	91.90	0.20	20.0	1.6E-08	
11	2016	3	7	13	27.00	18720	21.0	95	95	63.80	0.40	12.85	0.25	91.60	0.30	-9.1	1.1E-08	
12	2016	3	7	18	49.00	19320	21.0	95	95	64.65	0.85	13.35	0.50	91.35	0.25	33.3	1.4E-08	
13	2016	3	8	5	6.00	37020	25.0	95	95	65.15	0.50	14.00	0.65	90.75	0.60	4.0	1.1E-08	
14	2016	3	8	13	48.00	31320	22.0	95	95	66.90	1.75	14.40	0.40	90.15	0.60	-20.0	1.2E-08	
15	2016	3	8	19	25.00	20220	22.0	95	95	67.60	0.70	14.80	0.40	89.95	0.20	33.3	1.1E-08	
16	2016	3	9	5	31.00	36360	24.0	95	95	67.70	0.10	15.50	0.70	89.35	0.60	7.7	1.3E-08	1
17	2016	3	9	11	15.00	20640	24.0	95	95	68.40	0.70	15.85	0.35	89.00	0.35	0.0	1.2E-08	1
18	2016	3	9	20	24.00	32940	22.0	95	95	69.10	0.70	16.40	0.55	88.60	0.40	15.8	1.1E-08	1
19	2016	3	10	5	0.00	30960	23.0	95	95	70.20	1.10	16.75	0.35	88.05	0.55	-22.2	1.1E-08	1
20	2016	3	10	8	24.00	12240	23.0	95	95	69.90	-0.30	17.00	0.25	87.80	0.25	0.0	1.6E-08	1
21	2016	3	10	11	24.00	10800	23.0	95	95	70.20	0.30	17.20	0.20	87.70	0.10	33.3	1.1E-08	1
22	2016	3	10	20	47.00	33780	23.0	95	95	70.40	0.20	17.80	0.60	87.40	0.30	33.3	1.0E-08	1
23	2016	3	11	4	54.00	29220	22.0	95	95	71.40	1.00	18.15	0.35	86.75	0.65	-30.0	1.4E-08	1
24	2016	3	11	7	58.00	11040	24.0	95	95	71.25	-0.15	18.35	0.20	86.65	0.10	33.3	1.0E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.2E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	11
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-04, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.2E-08 cm/s

	Initial Values	Final Values			
Sample Type: Undisturbed					
Sample Dia. (in)	2.87	2.85	Permeant:	Water	
Sample Ht. (in)	3.55	3.51	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	869.30	961.20	Sample Specific Gravity:	2.80	Est.
Tare & Dry (g)	785.95	875.10	Confining Pressure (psi):	100.0	
Tare (g)	0.00	89.15	Burette Diameter (in):	0.250	
Sample Wt. (g)	869.30	872.05	Burette Zero (cm):	100.0	

Moisture (%)	10.6	11.0	Maximum Gradient:	8.4
Wet Density (pcf)	144.2	148.4	Average Gradient:	8.1
Dry Density (pcf)	130.4	133.7	Max. Effect. Stress (psi):	5.7
Saturation (%)	87.3	100.0	Min. Effect. Stress (psi):	4.1
			Ave. Effect. Stress (psi):	4.7

Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
2016	3	2	5	8.00		0.0	95	95	52.10		2.10		102.60				
2016	3	2	9	15.00	14820	24.0	95	95	53.45	1.35	2.75	0.65	101.85	0.75	-7.1	3.0E-08	
2016	3	2	12	10.00	10500	22.0	95	95	54.20	0.75	3.15	0.40	101.45	0.40	0.0	2.5E-08	
2016	3	2	20	40.00	30600	22.0	95	95	56.60	2.40	4.40	1.25	100.50	0.95	13.6	2.4E-08	
2016	3	3	14	6.00	62760	23.0	95	95	60.60	4.00	6.50	2.10	98.80	1.70	10.5	2.1E-08	
2016	3	3	18	50.00	17040	24.0	95	95	61.60	1.00	7.05	0.55	98.40	0.40	15.8	1.9E-08	
2016	3	4	13	25.00	66900	22.0	95	95	64.60	3.00	8.85	1.80	96.75	1.65	4.3	1.9E-08	
2016	3	4	18	51.00	19560	22.0	95	95	65.60	1.00	9.35	0.50	96.30	0.45	5.3	1.8E-08	
2016	3	7	5	16.00	210300	22.0	95	95	73.80	8.20	13.55	4.20	92.50	3.80	5.0	1.5E-08	
2016	3	7	8	15.00	10740	23.0	95	95	74.30	0.50	13.80	0.25	92.30	0.20	11.1	1.7E-08	
2016	3	7	13	27.00	18720	21.0	95	95	74.95	0.65	14.10	0.30	92.00	0.30	0.0	1.4E-08	
2016	3	7	18	46.00	19140	21.0	95	95	75.95	1.00	14.45	0.35	91.85	0.15	40.0	1.1E-08	
2016	3	8	5	6.00	37200	25.0	95	95	77.60	1.65	15.00	0.55	91.35	0.50	4.8	1.1E-08	
2016	3	8	13	50.00	31440	22.0	95	95	78.60	1.00	15.45	0.45	90.80	0.55	-10.0	1.4E-08	
2016	3	8	19	21.00	19860	22.0	95	95	79.60	1.00	15.80	0.35	90.70	0.10	55.6	9.9E-09	
2016	3	9	5	32.00	36660	24.0	95	95	80.80	1.20	16.30	0.50	90.20	0.50	0.0	1.1E-08	1
2016	3	9	11	16.00	20640	24.0	95	95	81.60	0.80	16.60	0.30	89.90	0.30	0.0	1.2E-08	1
2016	3	9	20	20.00	32640	22.0	95	95	82.25	0.65	17.10	0.50	89.60	0.30	25.0	1.1E-08	1
2016	3	10	5	0.00	31200	23.0	95	95	82.90	0.65	17.55	0.45	89.10	0.50	-5.3	1.4E-08	1
2016	3	10	8	24.00	12240	23.0	95	95	83.30	0.40	17.70	0.15	89.00	0.10	20.0	9.1E-09	1
2016	3	10	11	24.00	10800	23.0	95	95	83.50	0.20	17.85	0.15	88.85	0.15	0.0	1.2E-08	1
2016	3	10	20	43.00	33540	23.0	95	95	84.50	1.00	18.35	0.50	88.60	0.25	33.3	1.0E-08	1
2016	3	11	4	55.00	29520	22.0	95	95	84.70	0.20	18.65	0.30	88.05	0.55	-29.4	1.3E-08	1
2016	3	11	7	59.00	11040	24.0	95	95	85.30	0.60	18.85	0.20	88.00	0.05	60.0	1.0E-08	1

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.2E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

LABORATORY TEST RESULTS
VERIFICATION OF NATURAL SOIL BARRIER - MONROE ASH BASIN
SME PROJECT NO. PG-22087

BORING NO.	SAMPLE NO.	DEPTH (feet)	CLASSIFICATION SYMBOL	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO (calculated)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION (%)						COEFFICIENT OF PERMEABILITY (cm/sec)
								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	
B2	CS2	6.5	CL	21	108	2.73	0.58	42	17	25	0	0	2	5	36	57	3.3E-08
B2	CS4	11.5	CL	12	126	2.68	0.33	23	15	8	0	0	8	18	39	35	5.8E-08
B2	CS6	16.5	CL	12	126	2.72	0.35	23	14	9	0	0	8	16	40	36	1.3E-08
B2	CS8	21.5	CL	12	127	2.72	0.34	24	13	11	0	0	8	17	38	37	1.5E-08
B2	CS10	26.5	CL	10	131	2.75	0.31	20	11	9	0	0	9	24	34	33	2.0E-08
B2	CS12	31.5	CL	12	122	2.73	0.40	32	15	17	0	0	5	9	39	47	2.0E-08
B4	CS2	6.5	CL	18	111	2.73	0.53	45	19	26	0	0	2	8	37	53	6.6E-08
B4	CS4	11.5	CL	21	109	2.73	0.56	43	17	26	0	0	3	11	36	50	2.1E-08
B4	CS6	16.5	CL	12	126	2.71	0.34	24	13	11	0	0	8	17	41	34	4.7E-08
B4	CS8	21.5	CL	11	136	2.70	0.24	23	13	10	0	0	8	18	37	37	2.1E-08
B4	CS10	26.5	CL	11	130	2.73	0.31	23	14	9	0	0	8	17	38	37	3.0E-08
B4	CS12	31.5	CL	10	128	2.71	0.32	25	14	11	0	0	4	11	44	41	1.8E-08
B4	CS14	36.5	CL	8	118	2.73	0.44	24	13	11	0	0	13	23	44	20	*
B6	CS2	6.5	CL	12	123	2.70	0.37	27	15	12	0	0	8	17	39	36	7.4E-08
B6	CS4	11.5	CL	11	132	2.72	0.29	23	13	10	0	0	8	17	39	36	1.8E-08
B6	CS6	16.5	CL	8	134	2.72	0.27	21	12	9	0	0	7	22	38	33	4.0E-08
B6	CS8	21.5	CL	11	133	2.75	0.29	21	12	9	0	0	7	21	37	35	6.5E-08
B6	CS10	26.5	CL	9	125	2.71	0.35	26	14	12	0	0	5	13	39	43	*
B6	CS12	31.5	CL	10	128	2.74	0.34	26	15	11	0	0	11	17	33	39	*
B8	CS2	6.5	CL	13	118	2.73	0.44	41	15	26	0	0	3	12	35	50	1.5E-08
B8	CS4	11.5	CL	17	112	2.73	0.52	34	17	17	0	0	7	17	38	38	2.2E-08
B8	CS6	16.5	CL	13	127	2.73	0.34	26	15	11	0	0	9	19	38	34	4.8E-08
B8	CS8	21.5	CL	12	129	2.74	0.33	24	14	10	0	0	8	17	40	35	1.6E-08
B8	CS10	26.5	CL	13	130	2.76	0.32	25	14	11	0	0	7	18	36	39	1.7E-08
B8	CS12	31.5	CL	10	134	2.73	0.27	20	11	9	0	0	10	24	41	25	4.7E-08
B8	CS14	36.5	CL	11	135	2.75	0.27	23	12	11	0	0	11	24	31	34	3.8E-08
B8	CS16	41.5	CL	10	127	2.78	0.37	23	13	10	0	0	15	19	46	20	1.9E-07

LABORATORY TEST RESULTS
VERIFICATION OF NATURAL SOIL BARRIER - MONROE ASH BASIN
SME PROJECT NO. PG-22087

BORING NO.	SAMPLE NO.	DEPTH (feet)	CLASSIFICATION SYMBOL	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO (calculated)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION (%)						COEFFICIENT OF PERMEABILITY (cm/sec)
								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	
B10	CS2	6.5	CL	20	114	2.72	0.49	40	15	25	0	0	3	13	35	49	3.6E-08
B10	CS4	11.5	CL	18	112	2.75	0.53	35	15	20	0	0	2	9	39	50	1.2E-08
B10	CS6	16.5	CL	22	102	2.74	0.68	36	17	19	0	0	1	2	37	60	5.3E-08
B10	CS8	21.5	CL	13	127	2.71	0.33	25	14	11	0	0	8	17	37	38	3.7E-08
B10	CS10	26.5	CL	10	133	2.74	0.29	23	14	9	0	0	7	17	39	37	1.5E-08

NOTE:

* Sample too small or disturbed to run test.

JRW Ponds 1 & 2 CCR Unit and Pond 6 Inactive CCR Unit Site

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 3,000 '
1:36,000

0 3,000 6,000 FEET

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S. HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	269767-004
FILE:	269767-004-000SLM.mxd

FIGURE 1

E:\ConsumersEnergy\CCR_GW\2017_269767\269767-004-000SLM.mxd -- Saved By: JPAPEZ on 10/17/2017, 09:07:39 AM

LEGEND

✛ MONITORING WELL (STATIC WATER LEVEL ONLY)
● CCR UNIT MONITORING WELL

LABEL FORMAT

MONITORING WELL ID
GROUNDWATER ELEVATION FT MSL (MEASUREMENT DATE)
GROUNDWATER ELEVATION FT MSL (MEASUREMENT DATE)
etc...

NOTES

1. BASE MAP IMAGERY FROM NEARMAP, 4/12/2017.
2. WELL LOCATIONS SURVEYED BY SHERIDAN SURVEYING CO. ON 11/19/2015 AND 11/30/2016.

0 500 1,000 Feet

1 " = 500 '
1:6,000

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY

DRAWN BY:	J. PAPEZ	PROJ NO.:	297944-001
CHECKED BY:	J. LI		
APPROVED BY:		**FIGURE 3**	
DATE:	JULY 2018		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 297944-001-001.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 7/25/2018, 10:23:57 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\297944-001-001.mxd

Table 1

Summary of Groundwater Elevation Data
JR Whiting – RCRA CCR Monitoring Program
Erie, Michigan

Well Location	Ground Surface Elevation (ft)	TOC Elevation (ft)	Geologic Unit of Screen Interval	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Round 1				Round 2		Round 3		Round 4	
										November 21, 2016		December 19, 2016		January 24, 2017		March 8, 2017		April 12, 2017	
										Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background																			
JRW-MW-16007	579.47	582.32	Limestone	68.0	to	78.0	511.5	to	501.5	7.58	574.74	8.28	574.04	7.14	575.18	6.78	575.54	6.18	576.14
JRW-MW-16008	579.95	582.84	Limestone	68.0	to	73.0	512.0	to	507.0	7.93	574.91	8.77	574.07	7.70	575.14	7.34	575.50	6.82	576.02
JRW-MW-16009	579.90	582.59	Limestone	69.0	to	79.0	510.9	to	500.9	7.70	574.89	8.53	574.06	7.43	575.16	7.09	575.50	6.54	576.05
Ponds 1 & 2																			
JRW-MW-15001	589.6	590.71	Limestone	78.0	to	88.0	511.6	to	501.6	--	--	16.55	574.16	15.57	575.14	15.22	575.49	14.68	576.03
JRW-MW-15002	590.6	592.31	Limestone	81.0	to	91.0	509.6	to	499.6	--	--	18.13	574.18	17.11	575.20	16.77	575.54	16.25	576.06
JRW-MW-15003	589.6	591.36	Limestone	81.0	to	91.0	508.6	to	498.6	--	--	17.11	574.25	16.18	575.18	16.24	575.12	15.32	576.04
JRW-MW-15004	590.8	592.52	Limestone	86.0	to	96.0	504.8	to	494.8	--	--	18.24	574.28	17.36	575.16	17.07	575.45	16.51	576.01
JRW-MW-15005	592.7	594.25	Limestone	86.0	to	96.0	506.7	to	496.7	--	--	19.96	574.29	19.12	575.13	18.79	575.46	18.22	576.03
JRW-MW-15006	590.3	592.01	Limestone	81.0	to	91.0	509.3	to	499.3	--	--	17.80	574.21	16.91	575.10	16.56	575.45	15.98	576.03

Notes:

Survey conducted by Sheridan Surveying Co., November 2015 (2015 wells), and November 2016 (2016 wells)

Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).

TOC: Top of well casing.

ft BTOC: Feet below top of well casing.

ft BGS: Feet below ground surface.

Table 1

Summary of Groundwater Elevation Data
JR Whiting – RCRA CCR Monitoring Program
Erie, Michigan

Well Location	Ground Surface Elevation (ft)	TOC Elevation (ft)	Geologic Unit of Screen Interval	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Round 5		Round 6		Round 7		Round 8		Round 9	
										May 23, 2017		June 27, 2017		July 31, 2017		September 5, 2017		October 9, 2017	
										Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background																			
JRW-MW-16007	579.47	582.32	Limestone	68.0	to	78.0	511.5	to	501.5	6.14	576.18	7.33	574.99	6.87	575.45	7.14	575.18	7.93	574.39
JRW-MW-16008	579.95	582.84	Limestone	68.0	to	73.0	512.0	to	507.0	6.66	576.18	7.84	575.00	7.41	575.43	7.63	575.21	8.41	574.43
JRW-MW-16009	579.90	582.59	Limestone	69.0	to	79.0	510.9	to	500.9	6.40	576.19	7.59	575.00	7.15	575.44	7.35	575.24	8.18	574.41
Ponds 1 & 2																			
JRW-MW-15001	589.6	590.71	Limestone	78.0	to	88.0	511.6	to	501.6	14.45	576.26	15.65	575.06	15.27	575.44	15.38	575.33	16.18	574.53
JRW-MW-15002	590.6	592.31	Limestone	81.0	to	91.0	509.6	to	499.6	16.00	576.31	17.18	575.13	16.83	575.48	17.00	575.31	17.80	574.51
JRW-MW-15003	589.6	591.36	Limestone	81.0	to	91.0	508.6	to	498.6	15.02	576.34	16.14	575.22	15.89	575.47	16.00	575.36	16.80	574.56
JRW-MW-15004	590.8	592.52	Limestone	86.0	to	96.0	504.8	to	494.8	16.20	576.32	17.33	575.19	17.05	575.47	17.10	575.42	18.00	574.52
JRW-MW-15005	592.7	594.25	Limestone	86.0	to	96.0	506.7	to	496.7	17.89	576.36	19.04	575.21	18.79	575.46	18.84	575.41	19.70	574.55
JRW-MW-15006	590.3	592.01	Limestone	81.0	to	91.0	509.3	to	499.3	15.71	576.30	16.77	575.24	16.55	575.46	16.68	575.33	17.50	574.51

Notes:

Survey conducted by Sheridan Surveying Co., November 2015 (2015 wells), and November 2016 (2016 wells)

Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).

TOC: Top of well casing.

ft BTOC: Feet below top of well casing.

ft BGS: Feet below ground surface.

TRC - GIS

LEGEND

- BACKGROUND MONITORING WELL
- CCR UNIT MONITORING WELL
- CROSS SECTION LOCATION

NOTES

1. BASE MAP IMAGERY FROM NEARMAP, 4/12/2017.
2. WELL LOCATIONS SURVEYED BY SHERIDAN SURVEYING CO. ON 11/19/2015 AND 11/30/2016.

N

0 500 1,000 Feet

1 " = 500 '
1:6,000

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
SITE PLAN
WITH MONITORING WELL LOCATIONS

DRAWN BY:	J. PAPEZ	PROJ NO.:	269767-001
CHECKED BY:	S. HOLMSTROM	**FIGURE 1**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

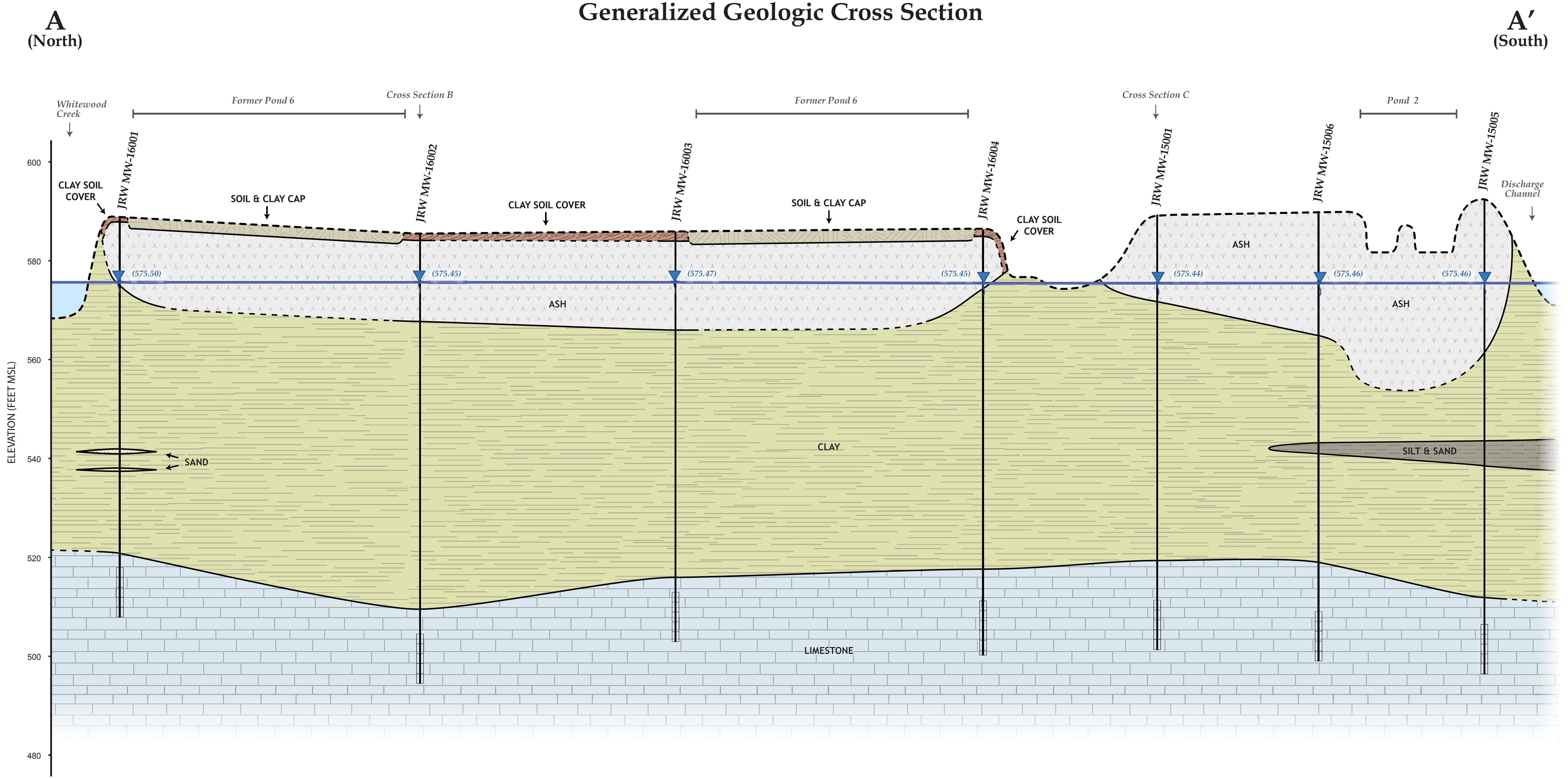
TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 269767-004-004.mxd

Plot Date: 10/17/2017, 09:08:10 AM by JPAPEZ -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\269767-004-004.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Generalized Geologic Cross Section



LEGEND

- GROUND SURFACE PROFILE, DASHED WHERE INFERRED
- STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED
- APPROXIMATE CONFINED GROUNDWATER POTENTIOMETRIC ELEVATION (JULY 31, 2017)

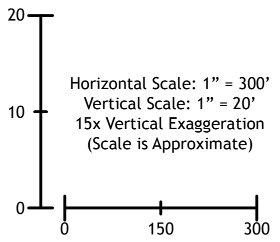
SOIL UNIT LITHOLOGY

- ▨ SOIL & CLAY CAP
- ▨ CLAY SOIL COVER
- ▨ ASH
- ▨ CLAY
- ▨ LIMESTONE
- ▨ SILT & SAND
- ▨ SAND

- WELL BOREHOLE
- WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM ASH POND MATERIAL CHARACTERIZATION (GOLDER, 2016), SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016), AND 2016 MONITORING WELL DESIGN, INSTALLATION, DEVELOPMENT, AND DECOMISSIONING (TRC, 2016).



Horizontal Scale: 1” = 300’
Vertical Scale: 1” = 20’
15x Vertical Exaggeration
(Scale is Approximate)

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC
CROSS SECTION A-A’

DRAWN BY: L. AUNER
CHECKED BY: S. HOLMSTROM
APPROVED BY: V. BUENING
DATE: OCTOBER 2017
PROJ NO.: 269767

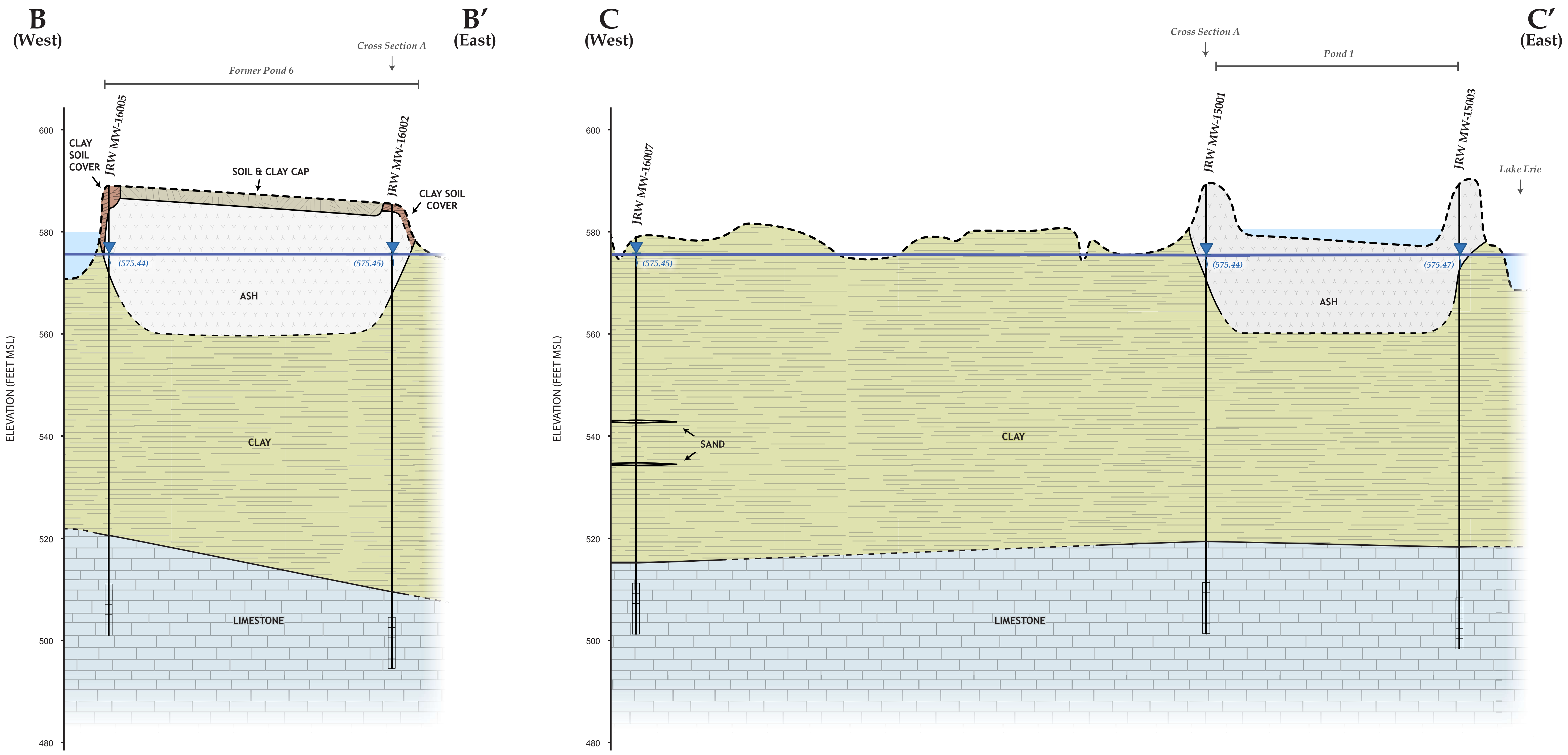
FIGURE 2

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 269767-004-ai01.ai

File Path: E:\WI_DOT\2015_229576\AI\269767-004-ai01.ai

Generalized Geologic Cross Sections



LEGEND

- GROUND SURFACE PROFILE, DASHED WHERE INFERRED
- STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED
- ▼ APPROXIMATE CONFINED GROUNDWATER POTENTIOMETRIC ELEVATION (JULY 31, 2017)

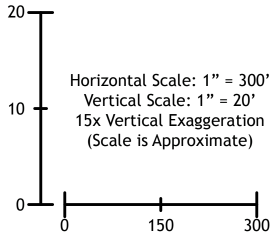
SOIL UNIT LITHOLOGY

▨ SOIL & CLAY CAP	▨ CLAY
▨ CLAY SOIL COVER	▨ LIMESTONE
▨ ASH	▨ SAND

- WELL BOREHOLE
- WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM ASH POND MATERIAL CHARACTERIZATION (GOLDER, 2016), SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016), AND 2016 MONITORING WELL DESIGN, INSTALLATION, DEVELOPMENT, AND DECOMISSIONING (TRC, 2016).



Horizontal Scale: 1” = 300’
Vertical Scale: 1” = 20’
15x Vertical Exaggeration
(Scale is Approximate)

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC
CROSS SECTIONS B-B’ AND C-C’

DRAWN BY:	L. AUNER	PROJ NO.:	269767
CHECKED BY:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 269767-004-ai02.ai

File Path: E:\WI_DOT\2015_229576\AI\269767-004-ai02.ai

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

Enclosed are the laboratory test results for the project shown above.

NUMBER	TEST
8	Permeability

We appreciate the opportunity to be of service to you on this project. If you have any questions, please feel free to contact our office.

Respectfully Submitted,

Malek Smadi, Ph.D., PE
Principal Engineer
GEOTILL, Inc.
Ph: (317) 449-0033 - Ext 101
e-mail: msmadi@geotill.com

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16007	Confining Pressure (psi):	75
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA
Depth (ft):	34.0'-35.0'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.14	4.22
Diameter (in)	4.21	4.14
Dry Unit Weight (pcf)	**130.1**	131.0
Moisture Content (%)	**10.5**	10.1
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	947	1027	1124	1740
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$1.21x10^{-8}$	$1.07x10^{-8}$	$9.14x10^{-9}$	$8.03x10^{-9}$

Average Hydraulic Conductivity (cm/sec) **$1.00x10^{-8}$** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16006	Confining Pressure (psi):	75
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA
Depth (ft):	34.5'-35.5	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.13	4.20
Diameter (in)	3.99	3.91
Dry Unit Weight (pcf)	**120.2**	123.0
Moisture Content (%)	**15.1**	12.8
B Value	98	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1015	1040	1106	1136
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$2.13x10^{-8}$	$1.90x10^{-8}$	$1.85x10^{-8}$	$1.62x10^{-8}$

Average Hydraulic Conductivity (cm/sec) **$1.88x10^{-8}$** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16005	Confining Pressure (psi):	75
Sample No.:	BS-7	Target Back Pressure Differential (psi):	NA
Depth (ft):	38.0'-39.0'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.18	4.20
Diameter (in)	4.11	4.08
Dry Unit Weight (pcf)	**128.2**	130.4
Moisture Content (%)	**11.9**	9.9
B Value	100	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1027	1105	1151	1242
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$1.55x10^{-8}$	$1.25x10^{-8}$	$1.13x10^{-8}$	$1.15x10^{-8}$

Average Hydraulic Conductivity (cm/sec) **$1.27x10^{-8}$** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16001	Confining Pressure (psi):	80
Sample No.:	BS-7	Target Back Pressure Differential (psi):	NA
Depth (ft):	44.0'-45.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.10	4.10
Diameter (in)	3.67	3.65
Dry Unit Weight (pcf)	**136.4**	137.0
Moisture Content (%)	**9.0**	8.5
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1357	1418	1442	1511
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.64x10^{-8}	1.28x10^{-8}	1.20x10^{-8}	1.17x10^{-8}

Average Hydraulic Conductivity (cm/sec) **1.32x10^{-8}** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16002	Confining Pressure (psi):	80
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA
Depth (ft):	33.0'-34.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	3.88	3.89
Diameter (in)	3.37	3.35
Dry Unit Weight (pcf)	**123.4**	123.7
Moisture Content (%)	**13.7**	13.1
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1346	1417	1445	1521
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.79×10^{-8}	1.38×10^{-8}	1.46×10^{-8}	1.31×10^{-8}

Average Hydraulic Conductivity (cm/sec) **1.50×10^{-8}** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16003	Confining Pressure (psi):	80
Sample No.:	BS-4C	Target Back Pressure Differential (psi):	NA
Depth (ft):	33.0'-34.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.11	4.11
Diameter (in)	3.88	3.90
Dry Unit Weight (pcf)	**124.3**	123.3
Moisture Content (%)	**10.5**	10.8
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1430	1534	1643	1614
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	6.65x10^{-9}	6.05x10^{-9}	5.07x10^{-9}	4.24x10^{-9}

Average Hydraulic Conductivity (cm/sec) **5.50x10^{-9}** **(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16007	Confining Pressure (psi):	75
Sample No.:	BS-10	Target Back Pressure Differential (psi):	NA
Depth (ft):	52.0'-53.0'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.17	4.17
Diameter (in)	4.14	4.11
Dry Unit Weight (pcf)	**115.3**	116.1
Moisture Content (%)	**15.6**	15.3
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	933	947	1009	1032
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	3.69x10^{-8}	3.15x10^{-8}	2.87x10^{-8}	2.14x10^{-8}

Average Hydraulic Conductivity (cm/sec)	**2.23x10^{-8}**	**(Temperature Corrected)**

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL
ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS

Boring No.:	MW-16004	Confining Pressure (psi):	75
Sample No.:	BS-4	Target Back Pressure Differential (psi):	NA
Depth (ft):	31.5'-32.3'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS

CHARACTERISTICS	INITIAL	FINAL
Length (in)	3.92	3.92
Diameter (in)	3.91	3.84
Dry Unit Weight (pcf)	**121.0**	123.5
Moisture Content (%)	**14.4**	13.3
B Value	104	

SUMMARY OF FINAL FOUR MEASUREMENTS

MEASUREMENT	1	2	3	4
Elapsed Time (sec)	951	1010	1030	1058
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	2.222.8x10^{-8}	1.78x10^{-8}	1.72x10^{-8}	1.58x10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.83x10^{-8}**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

Appendix B
Calculation Documentation

TRC Results you can rely on

SHEET NO. 1 OF 2
PROJECT NO. 319742
DATE 11-27-2018
BY S. Sellwood
SUBJECT Composite Liner Leakage
CHK'D A. Sellwood

Per Giroud et al. 1998, rate of leakage through a composite liner can be calculated by:

$$Q = 0.976\, C_{q_0}\left[1 + 0.1\left(h/T\right)^{0.95}\right] d^{0.2}\, h^{0.9}\, K^{0.74}$$

where Q = leakage rate, m^3/s
C_{q_0} = coefficient characterizing contact between geomembrane and underlying clay, dimensionless
C_{q_0} - good = 0.21
C_{q_0} - poor = 1.15
h = leachate head on top of liner, m
T = thickness of clay liner below geomembrane, m
d = defect diameter, m
K = hydraulic conductivity of clay liner, m/s

Assume:
h = 0.3 m T = 0.61 m K = 1×10^{-9} m/s

1. Assume:
d = 0.001 m $C_{q_0} = 0.21$

$$Q = 0.976(0.21)\left[1 + 0.1\left(\tfrac{0.3}{0.61}\right)^{0.95}\right](0.001)^{0.2}(0.3)^{0.9}(1 \times 10^{-9})^{0.74}$$

$$Q = 0.976(0.21)(1.05)(0.251)(0.338)(2.19 \times 10^{-7}) = 4 \times 10^{-9}\ m^3/s$$

$$4 \times 10^{-9}\ m^3/s \cdot 86400\ \tfrac{s}{day} \cdot \tfrac{1000\ L}{m^3} = 0.35\ \tfrac{L}{day}\ \text{per defect}$$

$$0.35\ \tfrac{L}{day}/\text{defect} \cdot 2.5\ \tfrac{\text{defects}}{hc} = \boxed{0.9\ \text{lphd}}$$

lphd = liters per hectare per day

$$0.35\ \tfrac{L}{day}/\text{defect} \cdot 5\ \tfrac{\text{defects}}{hc} = \boxed{1.8\ \text{lphd}}$$

hc = hectare

2. Assume:
d = 0.00564 m $C_{q_0} = 0.21$

$$Q = 0.976(0.21)\left[1 + 0.1\left(\tfrac{0.3}{0.61}\right)^{0.95}(0.00564)^{0.2}(0.3)^{0.9}(1 \times 10^{-9})^{0.74}\right.$$

$$Q = 0.976(0.21)(1.05)(0.355)(0.338)(2.19 \times 10^{-7}) = 5.7 \times 10^{-9}\ m^3/s$$

$$5.7 \times 10^{-9}\ m^3/s \cdot 86400\ \tfrac{s}{d} \cdot \tfrac{1000\ L}{m^3} = 0.5\ L/day\ \text{per defect}$$

$$0.5\ L/day \cdot \text{defect}\left(2.5\ \tfrac{\text{defects}}{hc}\right) = \boxed{1.2\ \text{lphd}}$$

$$0.5\ L/day \cdot \text{defect}\left(5\ \tfrac{\text{defects}}{hc}\right) = \boxed{2.5\ \text{lphd}}$$

A

3. Assume

$d = 0.001 \text{ m} \qquad C_{q0} = 1.15$

$$Q = 0.976(1.15)[1.05](0.001)^{0.2}(0.338)(2.19\times10^{-7}) = 2.2\times10^{-8}\ \text{m}^3/\text{s}$$

$$2.2\times10^{-8}\ \text{m}^3/\text{s} \cdot 86400\,\frac{\text{s}}{\text{day}} \cdot \frac{1000\,\text{L}}{\text{m}^3} = 1.9\,\frac{\text{L}}{\text{day}} \text{ per defect}$$

$$1.9\,\frac{\text{L}}{\text{day-defect}} \cdot \frac{2.5\text{ defects}}{\text{ha}} = \boxed{4.8\text{ lphd}}$$

$$1.9\,\frac{\text{L}}{\text{day}\cdot\text{defect}} \cdot 5\,\frac{\text{defects}}{\text{ha}} = \boxed{9.6\text{ lphd}}$$

4. Assume

$d = 0.00564 \text{ m} \qquad C_{q0} = 1.15$

$$Q = 0.976(1.15)[1.05](0.00564)^{0.2}(0.338)(2.19\times10^{-7}) = 3.1\times10^{-8}\ \text{m}^3/\text{s}$$

$$3.1\times10^{-8}\ \text{m}^3/\text{s} \cdot 86400\,\frac{\text{s}}{\text{day}} \cdot \frac{1000\,\text{L}}{\text{m}^3} = 2.7\,\frac{\text{L}}{\text{day}} \text{ per defect}$$

$$2.7\,\frac{\text{L}}{\text{day}} \cdot \frac{2.5\text{ defects}}{\text{ha}} = \boxed{6.7\text{ lphd}}$$

$$2.7\,\frac{\text{L}}{\text{day}} \cdot \frac{5\text{ defects}}{\text{ha}} = \boxed{14\text{ lphd}}$$

TRC
Results you can rely on

SHEET NO. 2 OF 2
PROJECT NO. 319742
DATE 11-27-2018
BY S. Sellwood
CHK'D A. Sellwood
SUBJECT Natural Clay Leakage

Leakage through a clay-only liner can be calculated using Darcy's Law assuming one-dimensional vertical flow:

$$Q = -KA\frac{dh}{dl}$$

where Q = leakage rate (units depend on inputs)
K = hydraulic conductivity of the clay
A = cross-sectional area of flow
dh = difference in head between the head above the clay and the head in the aquifer underlying the clay
dl = thickness of clay separating hydrogeologic units

CCR Unit	K	dh	dl	A
a. BRPP BABs	2.9×10^{-8} cm/s	16 ft	80 ft	assume 1 hectare (hc)
b. BRPP DB	2.9×10^{-8} cm/s	5 ft	117 ft	"
c. SCPP BABs	3.1×10^{-8} cm/s	1 ft	110 ft	"
d. Monroe PP FAB	6.5×10^{-8} cm/s	12 ft	23 ft	"
e. Whiting Ponds 1+2	2.23×10^{-8} cm/s	11 ft	35 ft	"
f. Whiting Pond 6	2.23×10^{-8} cm/s	22 ft	40 ft	"

a. $Q = -2.9 \times 10^{-8}\,cm/s\left(-\frac{16\,ft}{80\,ft}\right)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,\frac{L}{ft^3})(2834.6\,ft/d/cm/s) = 50$ lph
b. $Q = -2.9 \times 10^{-8}\,cm/s\left(\frac{-5\,ft}{117\,ft}\right)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,L/ft^3)(2834.6\,ft/d/cm/s) = 11$ lphd
c. $Q = -3.1 \times 10^{-8}\,cm/s(-1\,ft/110\,ft)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,L/ft^3)(2834.6\,ft/d/cm/s) = 2$ lphd
d. $Q = -6.5 \times 10^{-8}\,cm/s(-12\,ft/23\,ft)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,L/ft^3)(2834.6\,ft/d/cm/s) = 293$ lp
e. $Q = -2.23 \times 10^{-8}\,cm/s(-11\,ft/35\,ft)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,L/ft^3)(2834.6\,ft/d/cm/s) = 61$ lphd
f. $Q = -2.23 \times 10^{-8}\,cm/s(-22\,ft/40\,ft)(1\,hc)(107{,}639\,ft^2/hc)(28.317\,L/ft^3)(2834.6\,ft/d/cm/s) = 106$ lphd

Velocity: $V = \frac{-K}{n_e}\frac{dh}{dl}$ where n_e = clay effective porosity, assume 0.40 (dimensionless

a. $V = -2.9 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-16\,ft/80\,ft)(2834.6\,ft/d/cm/s) = 4.1 \times 10^{-5}\,ft/d$
b. $V = -2.9 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-5\,ft/117\,ft)(2834.6\,ft/d/cm/s) = 8.8 \times 10^{-6}\,ft/d$
c. $V = -3.1 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-10\,ft/110\,ft)(2834.6\,ft/d/cm/s) = 2 \times 10^{-6}\,ft/d$
d. $V = -6.5 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-12\,ft/23\,ft)(2834.6\,ft/d/cm/s) = 2.4 \times 10^{-4}\,ft/d$
e. $V = -2.23 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-11\,ft/35\,ft)(2834.6\,ft/d/cm/s) = 5 \times 10^{-5}\,ft/d$
f. $V = -2.23 \times 10^{-8}\,cm/s\left(\frac{1}{0.4}\right)(-22\,ft/40\,ft)(2834.6\,ft/d/cm/s) = 8.7 \times 10^{-5}\,ft/d$

* lphd = liters per hectare per day

travel time: $t = \frac{dl}{v}$

a. $t = \frac{80\text{ ft}}{4.1 \times 10^{-5}\text{ ft/d}} = 1.95 \times 10^{6}$ days

$\frac{1.95 \times 10^{6}\text{ days}}{365.25\text{ days/yr}} = 5{,}300$ yrs

b. $t = \frac{117\text{ ft}}{8.8 \times 10^{-6}\text{ ft/d}} = 1.33 \times 10^{7}$ days

$\frac{1.33 \times 10^{7}\text{ days}}{365.25\text{ days/yr}} = 36{,}400$ yrs

c. $t = \frac{110\text{ ft}}{2 \times 10^{-6}\text{ ft/d}\,(365.25\text{ d/yr})} = 151{,}000$ yrs

d. $t = \frac{23\text{ ft}}{2.4 \times 10^{-4}\text{ ft/d}\,(365.25\text{ d/yr})} = 260$ yrs

e. $t = \frac{35\text{ ft}}{5 \times 10^{-5}\text{ ft/d}\,(365.25\text{ d/yr})} = 1{,}900$ yrs

f. $t = \frac{40\text{ ft}}{8.7 \times 10^{-5}\text{ ft/d}\,(365.25\text{ d/yr})} = 1{,}260$ yrs

Monroe pp FAB assuming average K, steeper gradient, and clay thickness associated with the steeper gradient.

$K = 2.7 \times 10^{-8}$ cm/s $\quad dh = 29$ ft $\quad dl = 30$ ft

$Q = -2.7 \times 10^{-8}\text{ cm/s}\left(\frac{-29\text{ ft}}{30\text{ ft}}\right)(1\text{ ha})\left(107{,}639\ \frac{\text{ft}^2}{\text{ha}}\right)\left(28.317\ \frac{\text{L}}{\text{ft}^3}\right)\left(2834.6\ \frac{\text{ft/d}}{\text{cm/s}}\right) = 226$ lphd

$V = -2.7 \times 10^{-8}\text{ cm/s}\left(\frac{1}{0.4}\right)\left(\frac{-29\text{ ft}}{30\text{ ft}}\right)\left(2834.6\ \frac{\text{ft/d}}{\text{cm/s}}\right) = 1.85 \times 10^{-4}$ ft/d

$t = \frac{30\text{ ft}}{1.85 \times 10^{-4}\text{ ft/d}\,(365.25\text{ d/yr})} = 440$ yrs