



A CMS Energy Company

Date: October 17, 2017

To: Operating Record

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

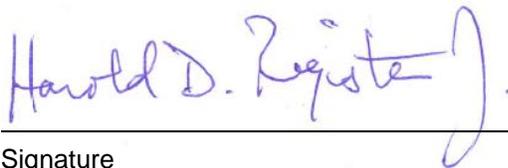
**“Groundwater Monitoring System Certification
JR Whiting Pond 1&2”
October 17, 2017
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Provided herein, as required by §257.91(f), is certification from a qualified professional engineer that the groundwater monitoring system at Consumers Energy JR Whiting 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.



Signature

October 17, 2017

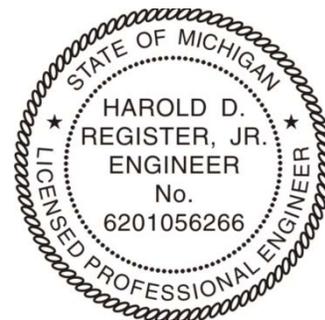
Date of Certification

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

Name

6201056266

Professional Engineer Certification Number



10/17/2017

ENCLOSURES

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

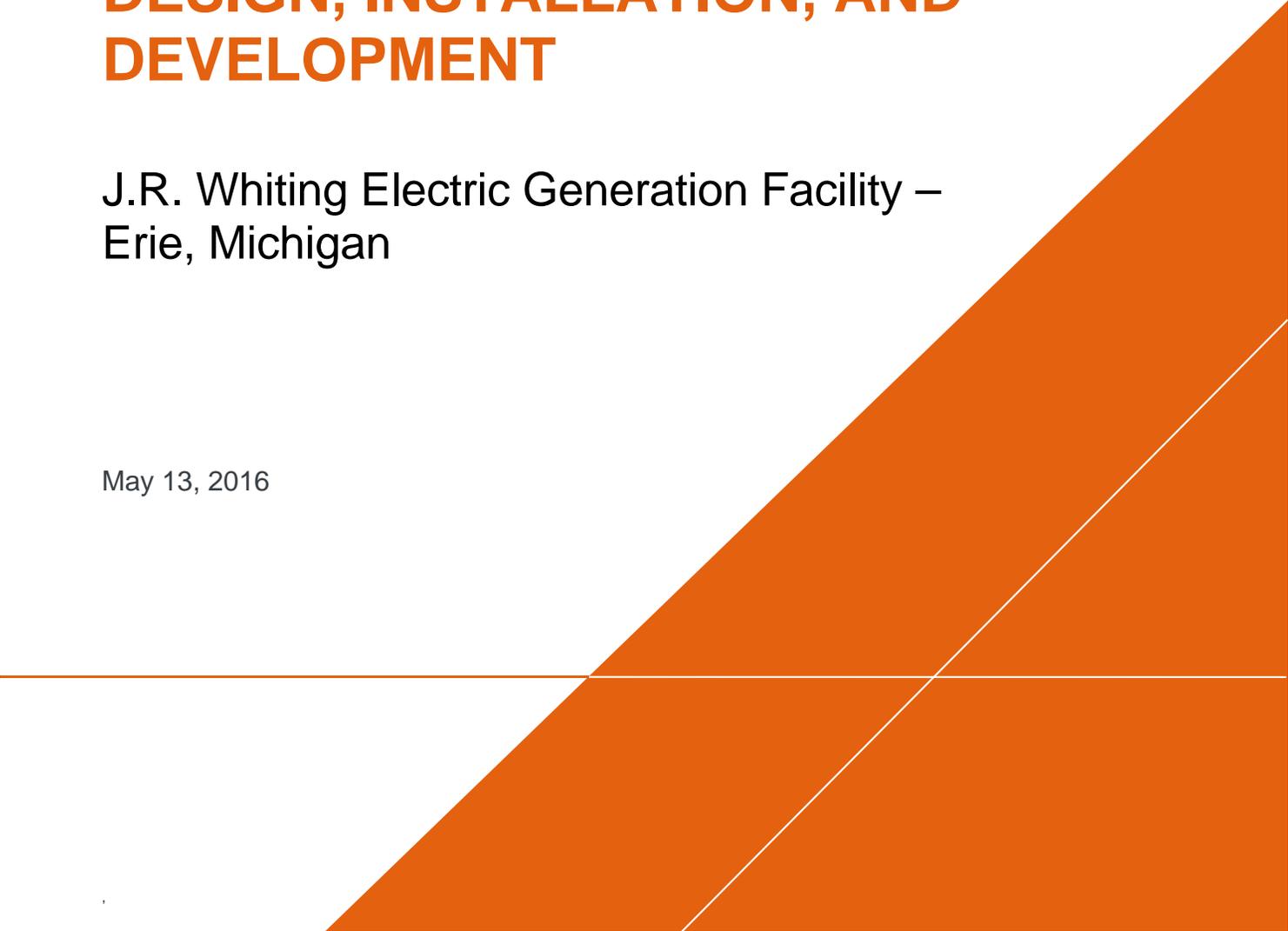
TRC (2016). *“2016 Monitoring Well Design, Installation, Development, and Decommissioning”*

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

Summary of Monitoring Well Design, Installation, and Development

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

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

Prepared for:
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May 13, 2016

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Appendix A – Soil Boring and Monitoring Well Construction Logs

Appendix B – Photographic Log

Appendix C – Hydraulic Test Results

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

rotasonic 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 Turbidity (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
 H⁰ = 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. Papadopoulos, 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



APPENDIX A

Soil Boring and Monitoring Well Construction Logs

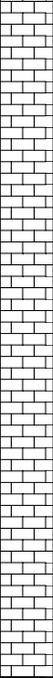


Date Start: 10/23/15 Date Finish: 10/26/15 Drilling Company: Stock Drilling Driller's Name: Austin G. Drilling Method: Hydrovac/Sonic Sampling Method: Continuous Rig Type: Sonic Water Level Start (ft. bgs.): 11.0 Water Level Finish (ft. btoc.): NA	Northing: 108330.83 Easting: 13374236.18 Casing Elevation: 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
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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							(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).		Cement/Bentonite (0.0-72.0' bgs) 2" PVC Well Casing (-3.0-78.0' bgs)
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.		
55	-55	8	51.0-61.0'	6.4	NA			NOTE: Clay is very stiff to hard at 59.0' bgs.		

	Remarks: bgs = below ground surface Hydrovac to 6.0' bgs. Groundwater encountered at 11.0' bgs. No odor or staining observed.
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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
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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	-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.		Bentonite Pellets (72.0-76.0' bgs)
80	-80									
85	-85	11	81.0-86.0'	3.7	NA					Sand Pack K&E WP1 (76.0-88.0' bgs)
		12	86.0-88.0'	0.0	NA					2" PVC 10 Slot Well Screen (78.0-88.0' bgs)
90	-90							End of boring 88.0' bgs.		

	Remarks: bgs = below ground surface Hydrovac to 6.0' bgs. Groundwater encountered at 11.0' bgs. No odor or staining observed.
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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

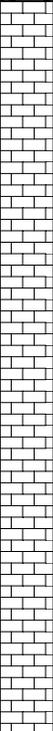
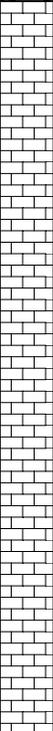
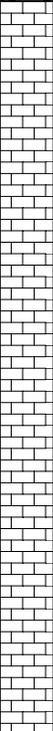
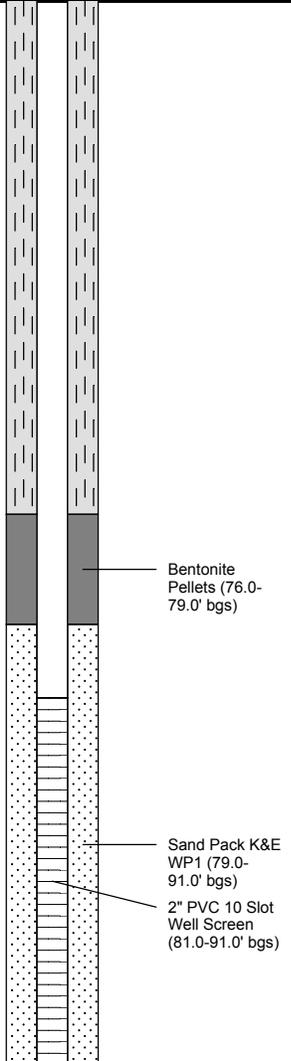
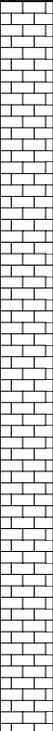
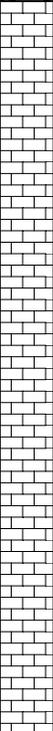
DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
30	-30									
		5	31.0-41.0'	12.0	NA			NOTE: Color change to dark gray (10YR 4/1) at 31.0' bgs.		
35	-35									
40	-40							NOTE: Clay is stiff at 41.0' bgs.		Cement/Bentonite (0.0-76.0' bgs) 2" PVC Well Casing (-3.0-81.0' 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									

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
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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 - 65	-65	8	61.0-71.0'	10.3	NA					
70 - 70	-70							(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).		
75 - 75	-75	9	71.0-81.0'	5.0	NA					
80 - 80	-80							NOTE: Very low recovery from 81.0 to 91.0' bgs.		
85 - 85	-85	10	81.0-91.0'	1.0	NA					
90 - 90	-90							End of boring 91.0' bgs.		
95 - 95	-95									

	Remarks: bgs = below ground surface Hydrovac to 6.0' bgs. Groundwater encountered at 6.0' bgs. No odor or staining observed.
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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

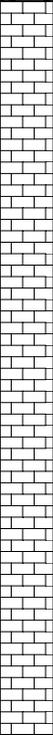
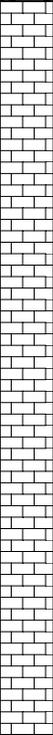
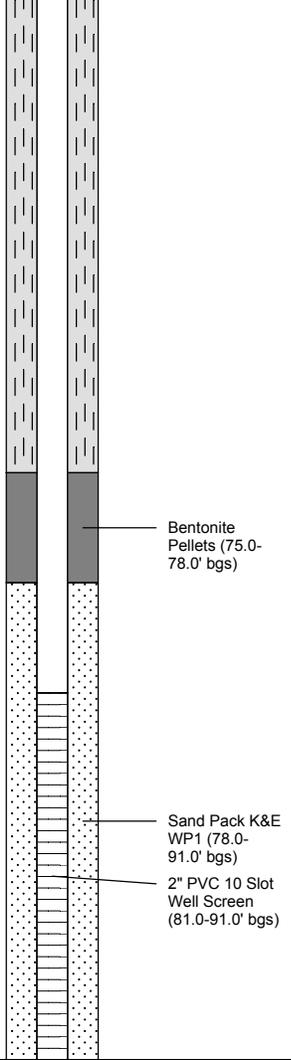
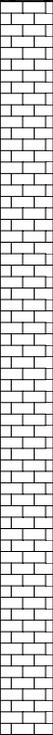
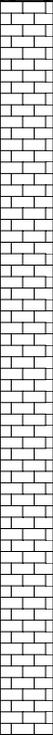
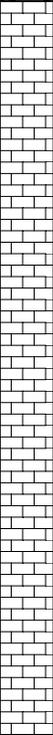
Well/Boring ID: JRW MW-15003
Client: Consumers Energy
Location: JR Whiting Facility
 4525 East Erie Road
 Erie, MI 48133
Weather Conditions: 60 F Cloudy, rain

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
30	-30						[Hatched Pattern]	NOTE: Clay is stiff at 33.0' bgs.		Cement/Bentonite (0.0-75.0' bgs) 2" PVC Well Casing (-3.0-81.0' 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		[Hatched Pattern]			
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		[Hatched Pattern]			
60	-60							NOTE: Clay is stiff at 60.5' bgs.		

Remarks: bgs = below ground surface
 Hydrovac to 6.0' bgs.
 Groundwater encountered at 6.0' bgs.
 No odor or staining observed.



Date Start: 10/28/15 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
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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 -65		8	61.0-71.0'	10.1	NA					
70 -70								(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.		
75 -75		9	71.0-81.0'	4.0	NA					
80 -80										
85 -85		10	81.0-91.0'	7.0	NA					
90 -90										
								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.
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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
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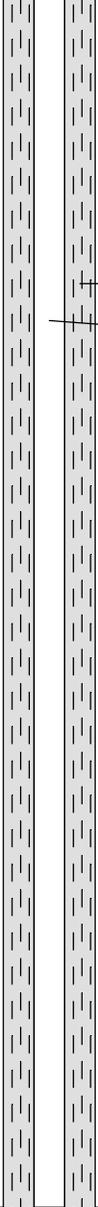
DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	0							(0.0 - 6.0') Hydrovac; no lithology recorded.		
5	-5	1	0.0-6.0'	0.0	NA				▼	
10	-10	2	6.0-11.0'	7.0	NA	X X X		(6.0 - 9.0') Fly ASH; trace bottom ash; wet; black (10YR 2/1).		
								(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 silt; 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.		

	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			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.		
40	-40									
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					



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
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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										
75 -75		9	71.0-81.0'	6.0	NA					
80 -80										
85 -85		10	81.0-91.0'	5.2	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 sample was pulverized from 81.0 to 96.0' bgs.		Bentonite Pellets (81.0-84.0' bgs)
90 -90										
95 -95		11	91.0-96.0'	4.0	NA					Sand Pack K&E WP1 (84.0-96.0' bgs) 2" PVC 10 Slot Well Screen (86.0-96.0' bgs)
100-100								End of boring 96.0' bgs.		

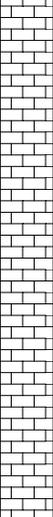
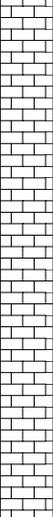
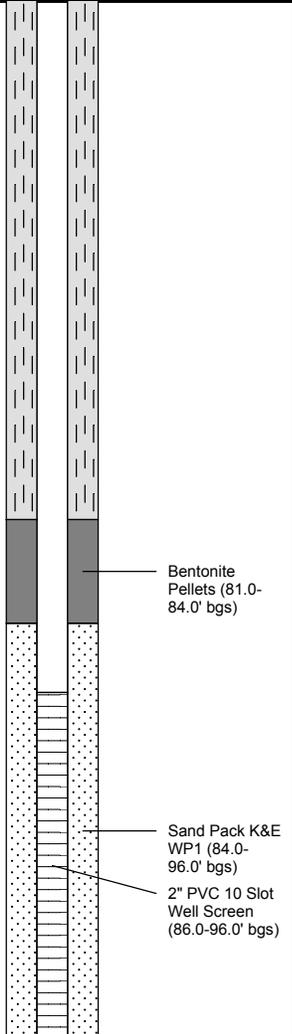
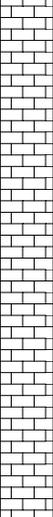
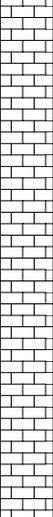
	Remarks: bgs = below ground surface Hydrovac to 6.0' bgs. Groundwater encountered at 6.0' bgs. No odor or staining observed.
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Date Start: 11/02/15 Date Finish: 11/03/15 Drilling Company: Stock Drilling Driller's Name: Austin G. Drilling Method: Hydrovac/Sonic 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
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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'	10.2	NA			(31.0 - 33.0') PEAT and SILT; trace organics, roots; moist to wet; dark grayish brown (10YR 3/2).		
40	-40							(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).		
45	-45	6	41.0-51.0'	12.2	NA			NOTE: Trace very large pebbles to large cobbles, subrounded to subangular; clay becomes hard from 41.0 to 49.0' bgs.		Cement/Bentonite (0.0-81.0' bgs) 2" PVC Well Casing (-3.0-86.0' bgs)
50	-50							(49.0 - 54.0') SILT and SAND, rapid dilatancy, very fine; wet; medium stiff to soft; very dark gray (10YR 3/1).		
55	-55	7	51.0-61.0'	10.0	NA			(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).		
60	-60									
65	-65									

	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
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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	-70	8	61.0-71.0'	12.3	NA					
75 - 75	-75	9	71.0-81.0'	7.3	NA					
80 - 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).		
85 - 85	-85	10	81.0-91.0'	5.1	NA			NOTE: Limestone is porous with calcite crystals infilling in openings at 89.0' bgs.		
90 - 90	-90									
95 - 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	-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.
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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

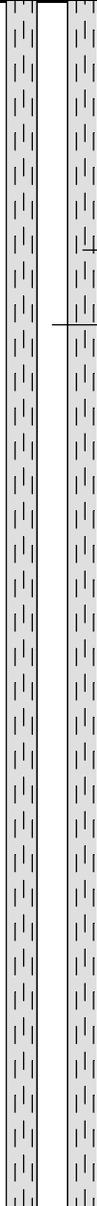
Borehole Depth (ft. bgs.): 91.0
Surface Elevation: 590.3

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

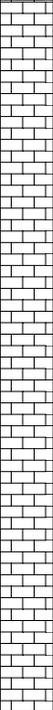
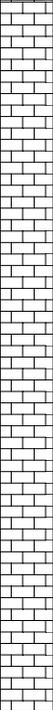
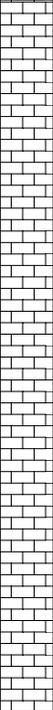
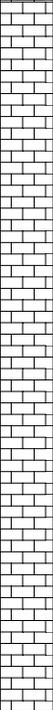
DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
35	-35	5	31.0-41.0'	8.3	NA			NOTE: Clay becomes medium stiff to soft; color change to very dark gray (10YR 3/1) at 31.0' bgs. NOTE: Clay becomes stiff at 38.0' bgs. NOTE: trace very large pebbles to small cobbles, subrounded to subangular at 41.0' bgs.		 Cement/Bentonite (0.0-74.0' bgs) 2" PVC Well Casing (-3.0-81.0' 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).		
50	-50							(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).		
55	-55	7	51.0-61.0'	10.3	NA					

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
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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	-65	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.		
70	-70							(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).		
75	-75	9	71.0-81.0'	4.0	NA					Bentonite Pellets (74.0-78.0' bgs)
80	-80									
85	-85	10	81.0-91.0'	5.0	NA					Sand Pack K&E WP1 (78.0-91.0' bgs) 2" PVC 10 Slot Well Screen (81.0-91.0' bgs)
90	-90							End of boring 91.0' bgs.		
95	-95									

	Remarks: bgs = below ground surface Hydrovac to 6.0' bgs. Groundwater encountered at 6.0' bgs. No odor or staining observed.
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SOIL DESCRIPTION

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.09+	
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:
October 23, 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



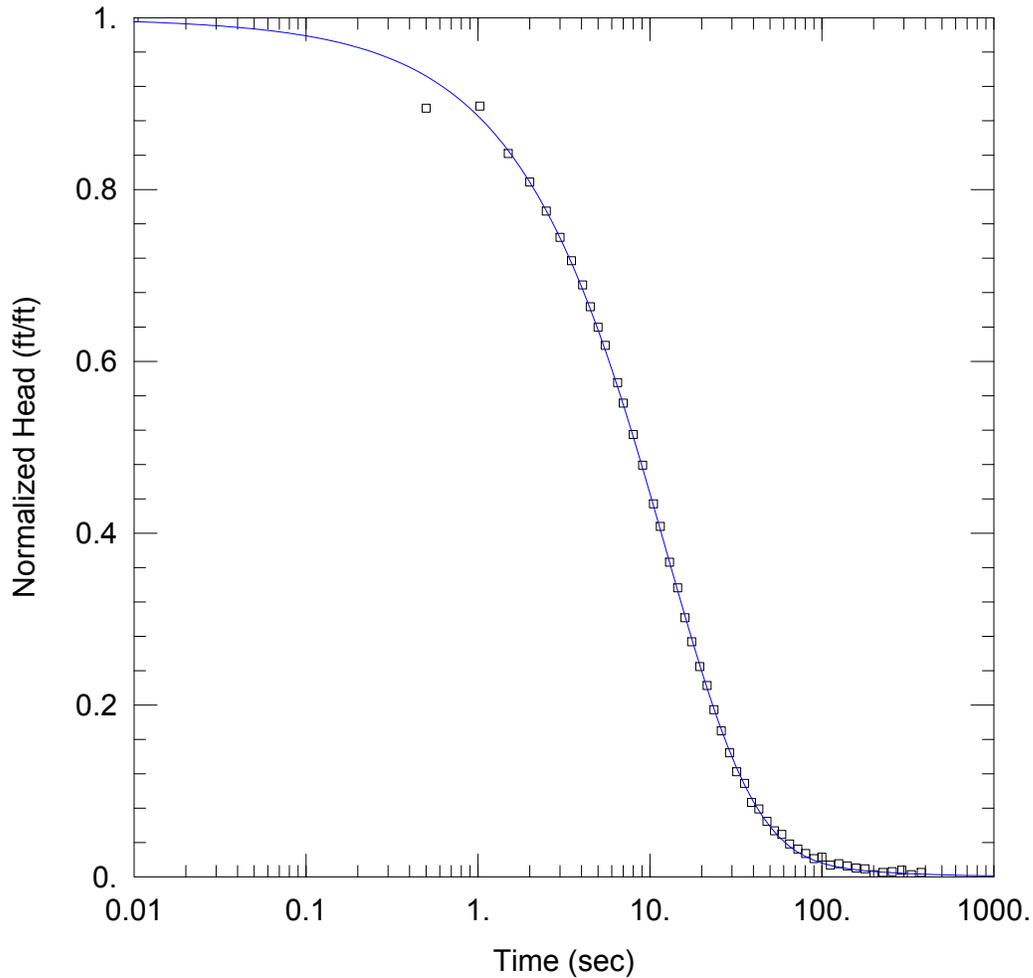
Slug Test Analysis Results for JRW MW-15001 -Test 2

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

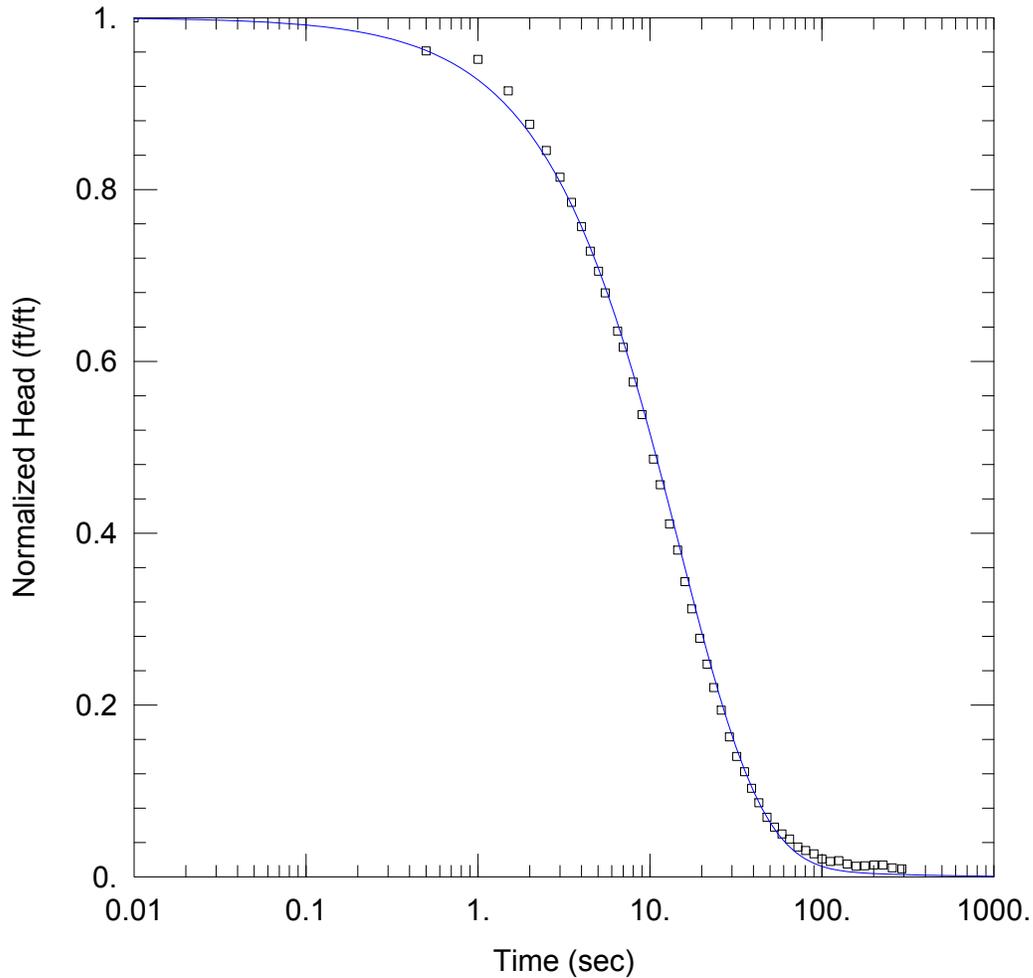
Slug Test Analysis Results for JRW MW-15001 -Test 3

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

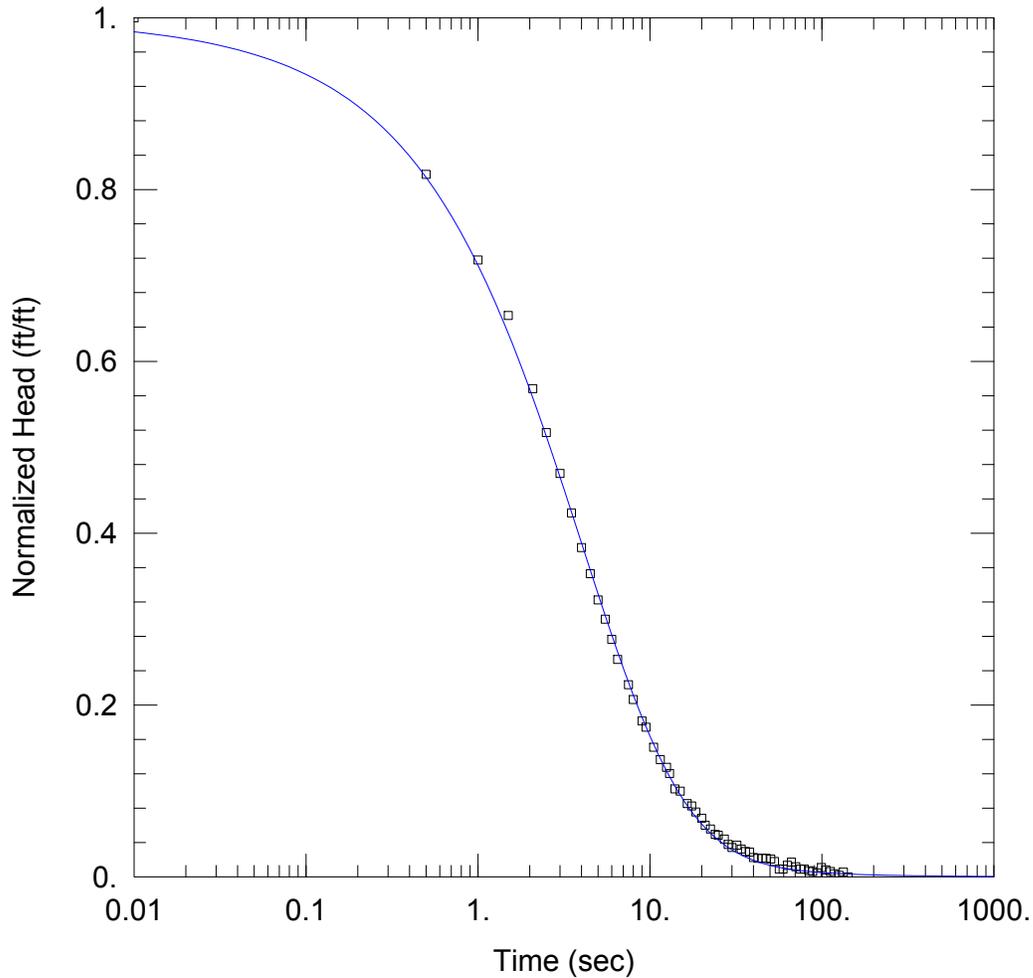
Slug Test Analysis Results for JRW MW-15003 -Test 1

Prepared By:
Arcadis

Prepared For:
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

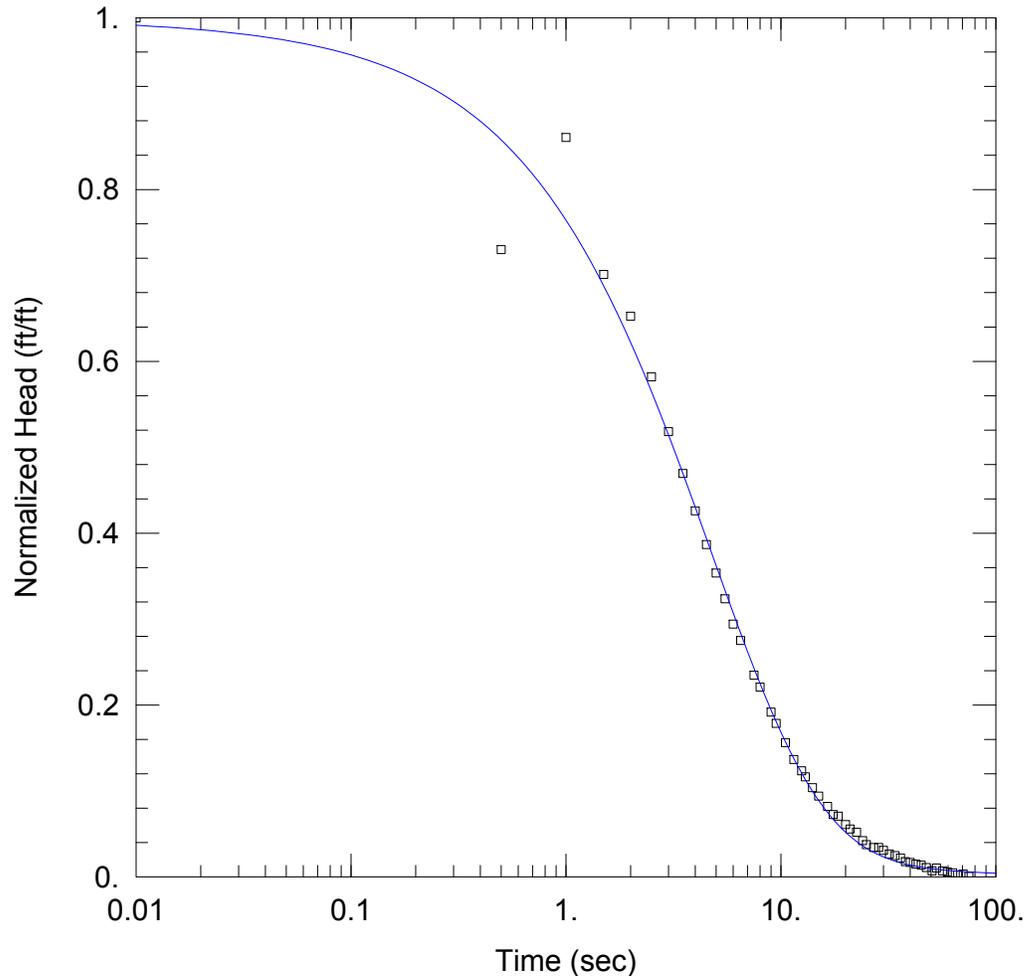
Slug Test Analysis Results for JRW MW-15003 -Test 3

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

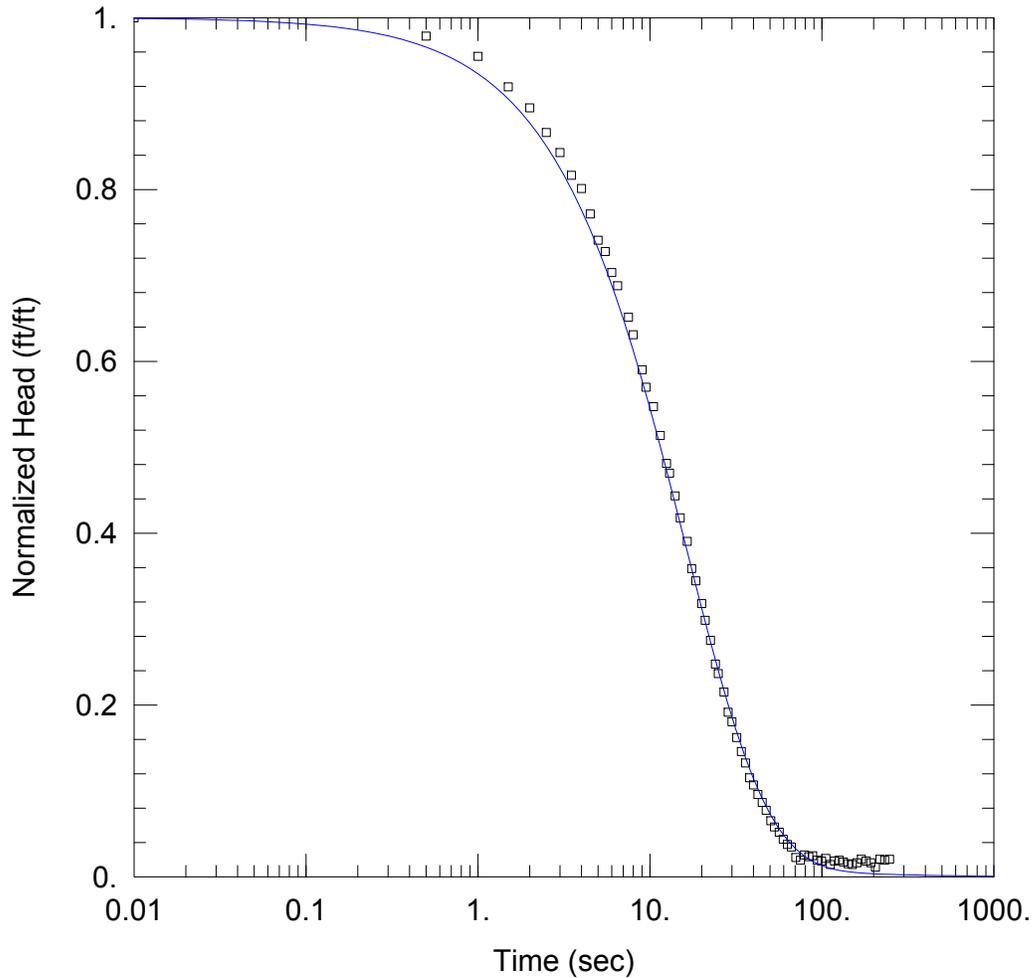
Slug Test Analysis Results for JRW MW-15005 -Test 1

Prepared By:
Arcadis

Prepared For:
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

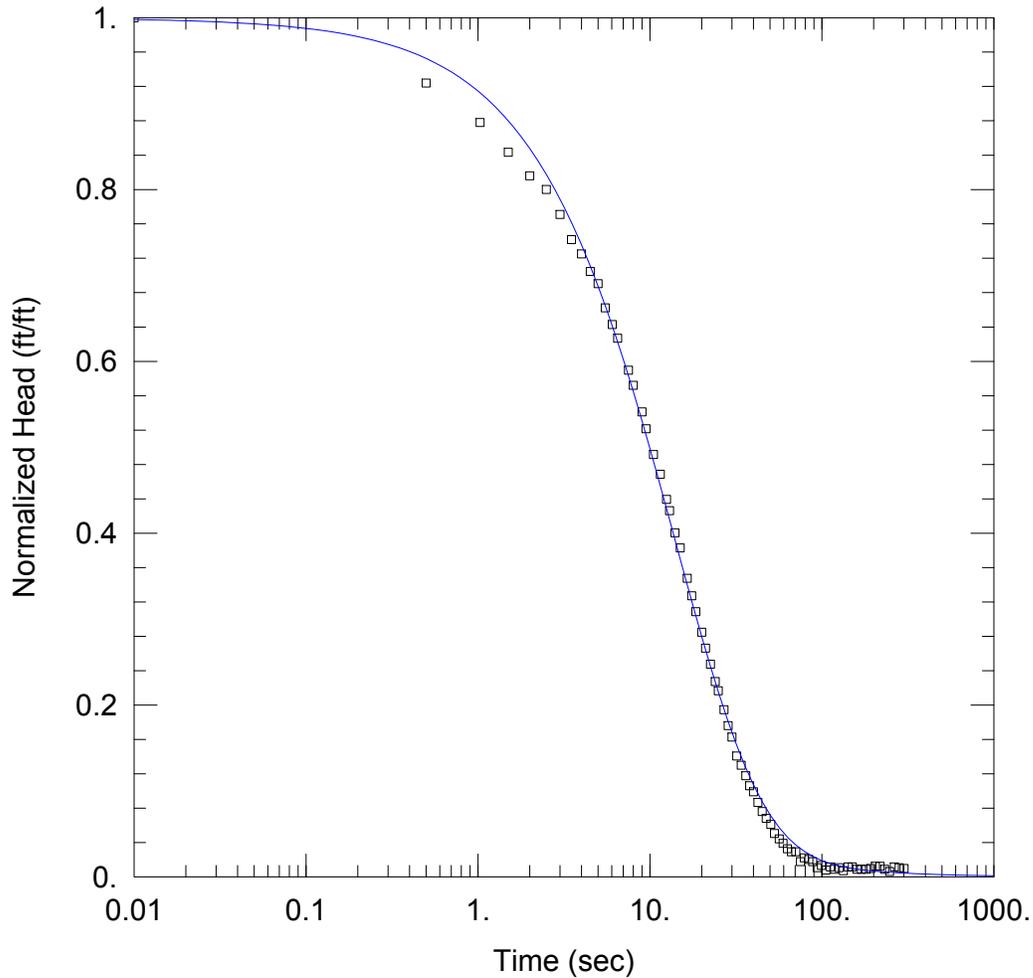
Slug Test Analysis Results for JRW MW-15005 -Test 2

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

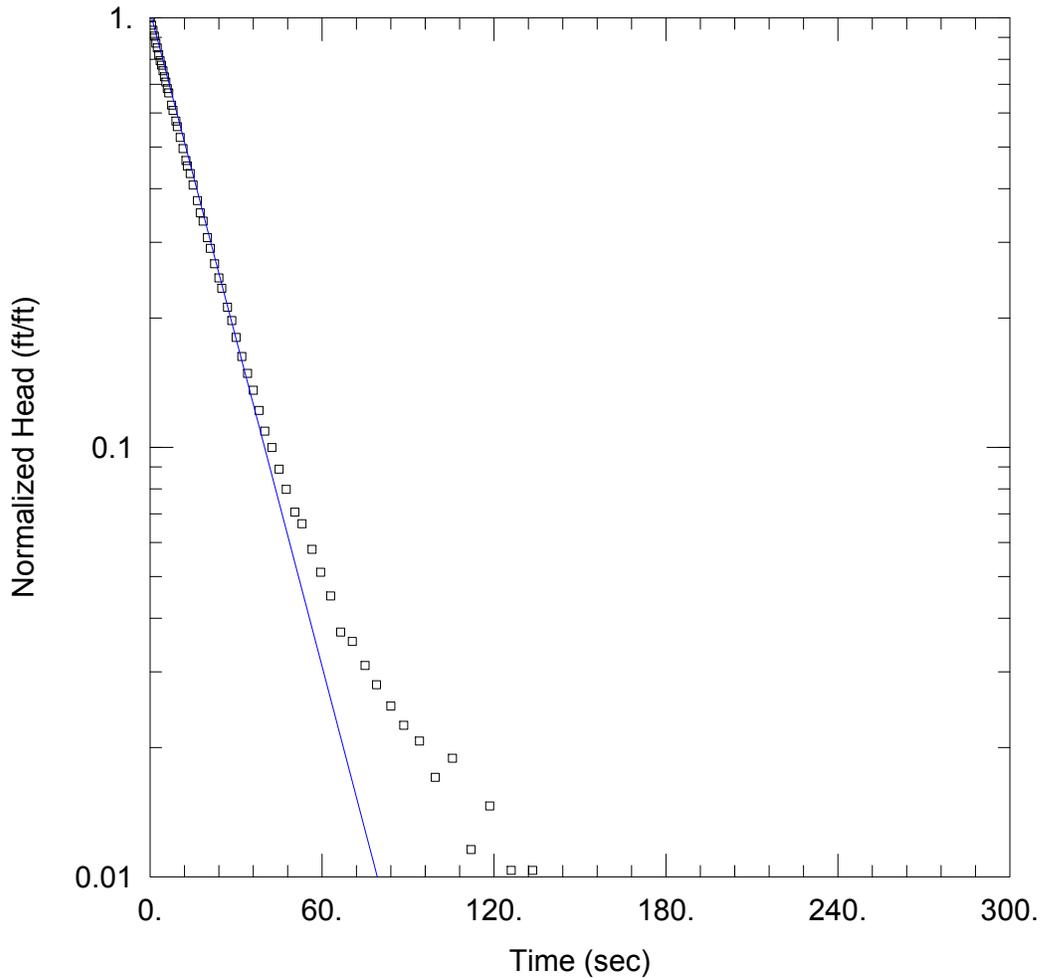
Screen Length: 10. ft

Casing Radius: 0.083 ft

Well Radius: 0.25 ft

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

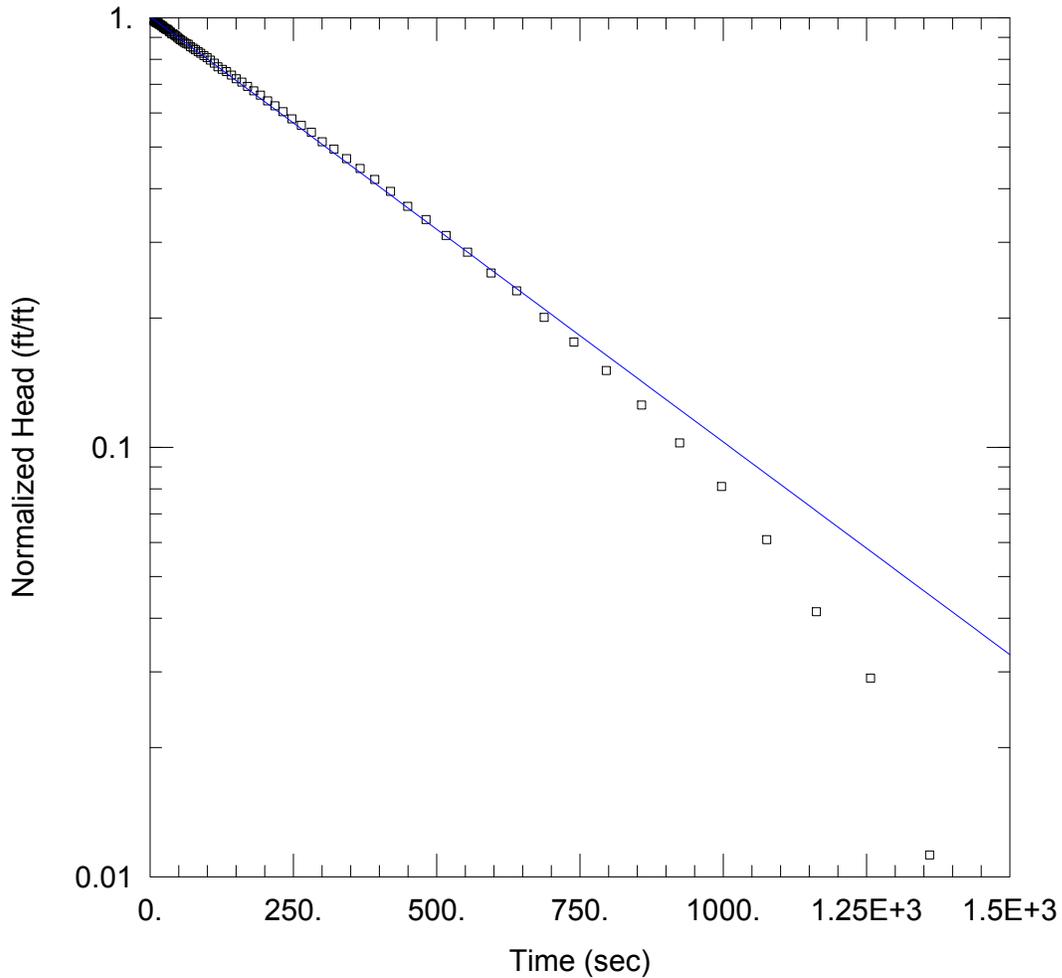
WELL DATA (JRW-MW-15010)

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



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

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



SOLUTION

Aquifer Model: Confined
 Solution Method: Hvorslev
 $K = 1.5$ ft/day $y_0 = 1.7$ 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



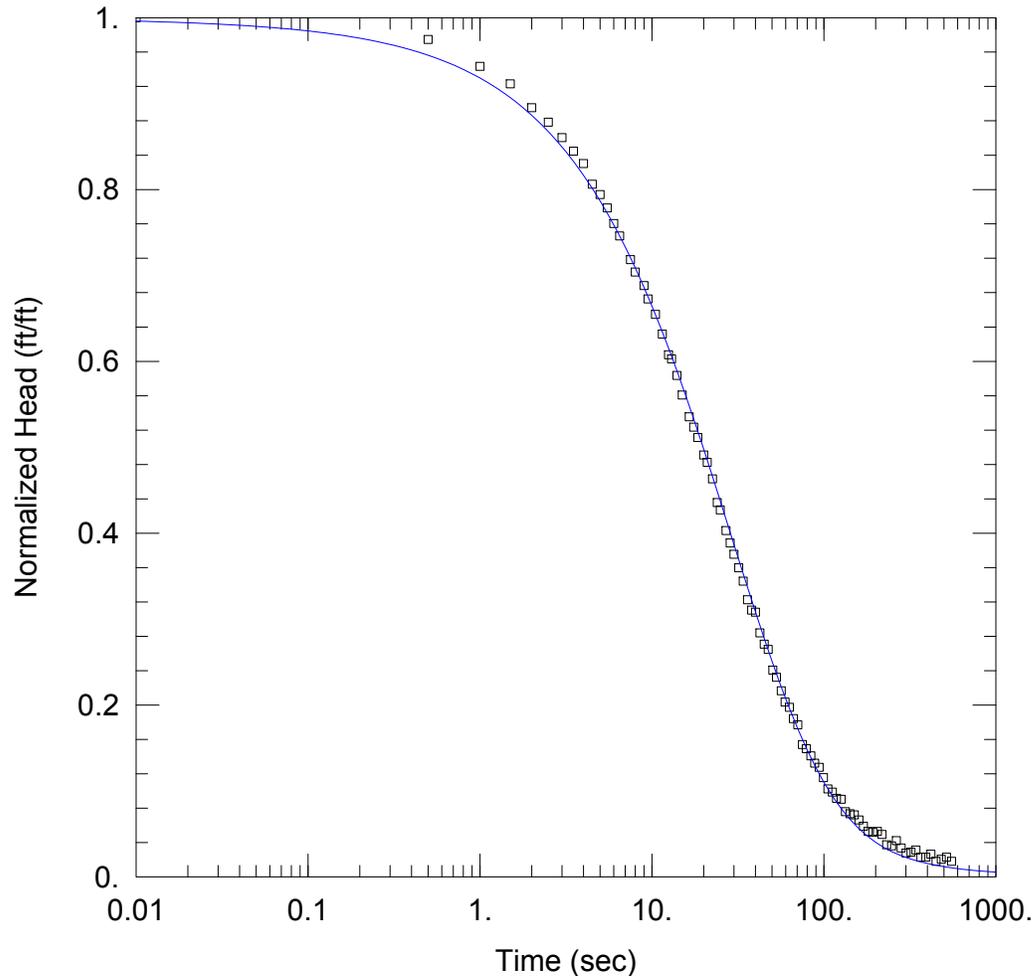
Slug Test Analysis Results for JRW MW-15012 - Test1

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
Erie, MI



SOLUTION

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

AQUIFER DATA

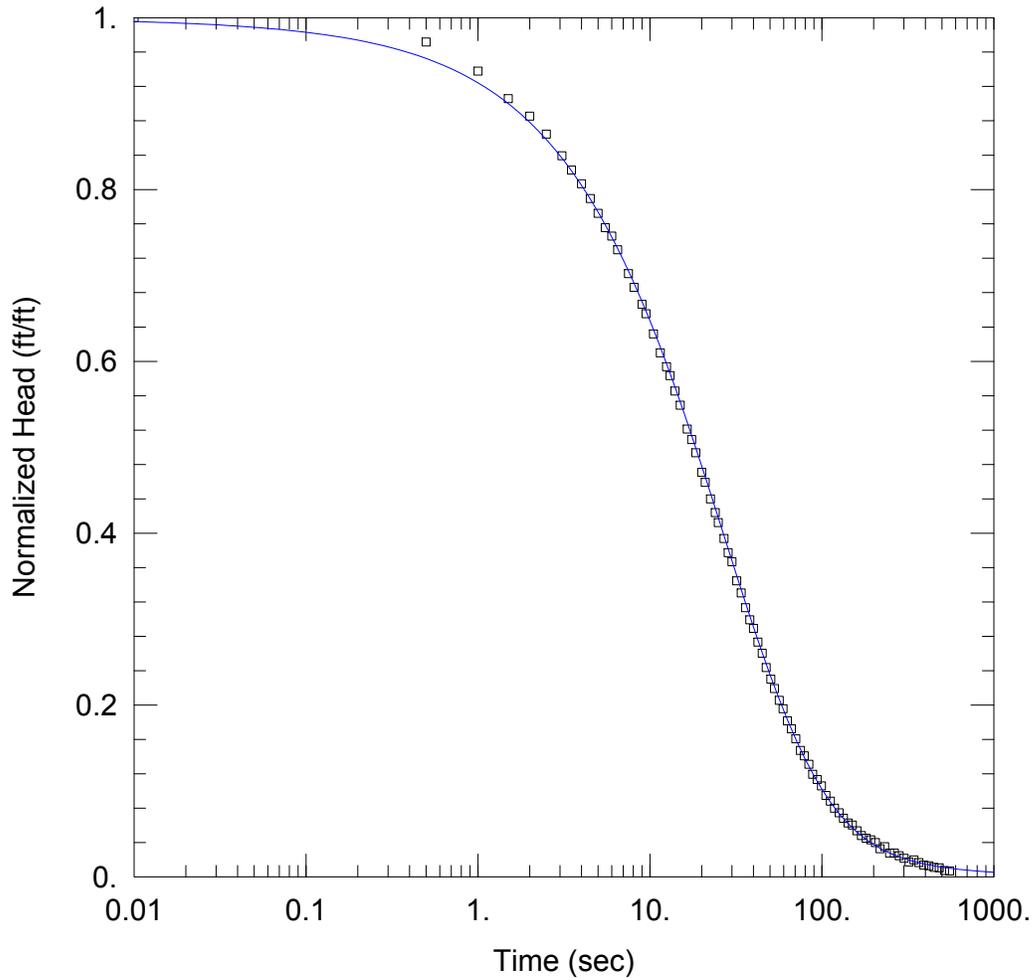
Saturated Thickness: 13.

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-Papadopoulos
 $T = 31. \text{ ft}^2/\text{day}$ $S = 0.00065$

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



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A decorative graphic consisting of three thin orange lines. One line is horizontal, extending across the width of the page. Two other lines are diagonal, starting from the bottom left and extending towards the top right, crossing the horizontal line.



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*

A handwritten signature in black ink that reads "Vincent E. Buening". The signature is written in a cursive style with a prominent initial "V".

Vincent E. Buening, CPG
Senior Project Manager

A handwritten signature in black ink that reads "David B. McKenzie". The signature is written in a cursive style with a prominent initial "D".

David B. McKenzie, PE
Senior Project Engineer

TRC Engineers Michigan | Consumers Energy

Final

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Appendix B	Photographic Log
Appendix C	Hydraulic Test Results

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 turbidity 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
Erle, 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 Gallons Removed	Final Turbidity (NTU)
Ponds 1 & 2 MW													
JRW MW-15001	---	108330.83	13374236.18	589.60	590.71	Limestone	2" PVC, 10 slot	10	78 - 88	21.34	1,450	3.92	
JRW MW-15002	---	108651.05	13374586.78	590.60	592.31	Limestone	2" PVC, 10 slot	10	81 - 91	21.89	750	2.35	
JRW MW-15003	---	108321.86	13374980.23	589.60	591.36	Limestone	2" PVC, 10 slot	10	81 - 91	19.87	412.5	3.54	
JRW MW-15004	---	107881.56	13375045.59	590.80	592.52	Limestone	2" PVC, 10 slot	10	86 - 96	23.27	70	2.80	
JRW MW-15005	---	107545.15	13374686.90	592.70	594.25	Limestone	2" PVC, 10 slot	10	86 - 96	25.28	114	5.04	
JRW MW-15006	---	107843.22	13374281.80	590.30	592.01	Limestone	2" PVC, 10 slot	10	81 - 91	25.30	650	1.69	
Pond 6 MW													
JRW MW-16001	---	111255.91	13374012.08	589.19	592.32	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	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	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	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	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	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	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	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	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	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	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		Not developed		
JRW MW-15010	93-MW-4	110458.57	13373631.59	587.10	588.09	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	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	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 1

Pictures



2016 Update [Typical] Mon. Well 2

Pictures



2015 Typical Surface Impoundment Monitoring Well 1

Pictures



NOTE: Aerial Image obtained from Google Earth. Image date copyright date 2016. For details.

Elevation Basis
Elevation = 579.56' MVD88

Coordinate Basis
State Plane Coordinate Michigan South Zone 213
ADT 608 IRS (GRAB) / NAD83 2011

Legend

- - Control Monitoring Well
- - Background Monitoring Well
- - Abandoned Monitoring Well
- - Traverse Point
- - Section Corner

GRAPHIC SCALE
1 inch = 100' ft.

Elevations are MVD88 from Benchmark (BM) Q 173 per M52 Data Sheet. (Not Shown, Approximately 1.1 mi. West of #1081). A second loop was done from CP to Traverse Point (TP) #1918 and to TP #1088. 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 to Pond 2. 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 to Pond 2. Ground elevations at base of all pipes were obtained on 11-10-15 by GPS observation.

On 11-30-16, a level loop was performed from Control Point (CP) #3081 and Monitoring Wells #16007, #16008, and #16009. A second loop was performed from CP #3081 and Monitoring Wells #16001, #16002, #16003, #16004, #16005, and #16006. Both Top of Casing and Ground Top of Casing elevations are included on both loops.

NOTE: Previous Wells #15017 thru #15012 now abandoned/removed or to be abandoned/removed.

Well ID	Monitoring Well	Location	Name	Well ID	Monitoring Well	Location	Name
5002	15024.22	13374242.80	5003	15024.22	13374242.80	5003	15024.22
5004	107545.15	13374468.50	5027	504.25	JRW MW-15005	41.792322	83.445235
5006	107851.58	13373500.59	5028	952.52	JRW MW-15004	41.792323	83.445237
5008	108151.88	13374980.33	5029	951.36	JRW MW-15003	41.792444	83.445237
5010	108521.05	13374508.78	5035	952.31	JRW MW-15002	41.792358	83.445237
5012	109022.09	13374242.29	5036	952.74	JRW MW-15001	41.792351	83.445234
Background Monitoring Wells							
Well ID	Monitoring Well	Location	Name	Well ID	Monitoring Well	Location	Name
5015	107983.21	13373506.21	5071	508.38	JRW MW-15007/16004	41.792517	83.445883
5017	107983.89	13373504.04	5075	508.71	JRW MW-15007/16005	41.792514	83.445884
5021	108261.21	13373504.04	5076	508.71	JRW MW-15007/16006	41.792514	83.445884
5023	110069.21	13373504.04	5078	508.71	JRW MW-15007/16007	41.792514	83.445884
5025	110769.45	13374463.62	5079	508.71	JRW MW-15007/16008	41.792514	83.445884
5025	108984.39	13374463.62	5083	508.11	JRW MW-15007/16009	41.792527	83.445881
Survey Control Points							
Well ID	Monitoring Well	Location	Name	Well ID	Monitoring Well	Location	Name
1	107751.58	13374463.37	5088	509.20	TP	41.792600	83.445844
2	108558.66	13374463.37	5090	509.20	TP	41.792600	83.445844
3	111723.97	13373668.48	6001	509.18	TP	41.802383	83.445836
4	108765.66	13374471.45	5772	577.09	TP	41.794624	83.445897
5	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
6	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
7	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
8	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
9	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
10	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
11	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
12	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
13	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
14	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
15	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
16	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
17	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
18	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
19	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
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21	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
22	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
23	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
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28	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
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36	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
37	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
38	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
39	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
40	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
41	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
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46	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
47	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
48	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
49	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
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51	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
52	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
53	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
54	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
55	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
56	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
57	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
58	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
59	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
60	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
61	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
62	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
63	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
64	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
65	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
66	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
67	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
68	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
69	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
70	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
71	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
72	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
73	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
74	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
75	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
76	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
77	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
78	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
79	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
80	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
81	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
82	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
83	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
84	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
85	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
86	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
87	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
88	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
89	108967.62	13372717.75	5772	577.09	TP	41.794624	83.445897
90							

Appendix A

Soil Boring and Monitoring Well Construction Logs

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

COHESIONLESS SOIL

Strength	Unconfined Compressive Strength (psf) (Primary)	Pocket Penetrometer Test (tsf) (Primary)	SPT Value (N) (Secondary)	Density	SPT Value (N)
Very Soft	0-500	0-0.25	0-2	Very Loose	<4
Soft	500-1000	0.25-0.5	3-4	Loose	4-10
Medium	1000-2000	0.5-1.0	5-8	Medium Compact	11-30
Stiff	2000-4000	1.0-2.0	9-15	Compact	31-50
Very Stiff	4000-8000	2.0-4.0	16-30	Very Compact	>50
Hard	8000-16000	4.0-8.0	31-50		
Very Hard	>16000	>8.0	>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
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ROCK RECOVERY

Rock recovery is defined as:

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

ROCK QUALITY DESIGNATION (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.

SUBSURFACE PROFILE				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 589.2	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 592.3	DEPTH (FT)
		588.2	1.0			BS-1	-		3 ft 2 in Stick-Up	
		FILL: Brown SILTY CLAY with Trace Organic Material (MH-CH)		RUN #1	100					
		FILL: Black FLY ASH with Trace Clay and Organic Material (occasional clay seams)				BS-2	-			
580			10	RUN #2	100	BS-3	-			10
		576.2	13.0			BS-4	6000*			
		Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)								
570		573.2	16.0	RUN #3	100	BS-5	3000*			20
		Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)								
		562.2	27.0			BS-6	3000*			
560			30	RUN #4	100					30
		Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)								
		552.2	37.0			BS-7**	>9000*			
550			40	RUN #5	100	BS-8	>9000*			40
		Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)				BS-9	>9000*			
		548.2	41.0			BS-10	-			
		Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (MH-CH)								
		542.2	47.0							
540		541.2	48.0	RUN #6	100					50
		Gray SAND (SP) Hard Gray SILTY CLAY with Little Gravel (MH-CH)								

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:

- * -Denotes Pocket Penetrometer Value
- ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
- 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

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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC			
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 585.8	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 588.7	DEPTH (FT)	
580		FILL: Brown SILTY CLAY with Trace Organic Material (MH-CH)	1.5	RUN #1	100	BS-1	-		2 ft 11 in in Stick-Up		
						BS-2	-				
570		FILL: Black FLY ASH with Clay Seams	10	RUN #2	100	BS-3	-				
							BS-4		2000*		
560		Medium to Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	20	RUN #3	67	BS-5**	6000*				
							BS-6		6000*		
550		Stiff to Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	30	RUN #4	100	BS-7	>9000*				
						BS-8	-				
540	Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	38.0	RUN #5	100	BS-8A	-					
		Hard to Very Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	40	RUN #6	0						
		APPARENT BOULDER	46.0	RUN #7	100						
			50								

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:

- * -Denotes Pocket Penetrometer Value
- ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
- 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



SUBSURFACE PROFILE				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 585.8	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 588.7	DEPTH (FT)
530	[Diagonal Hatching]	Hard to Very Hard Gray SILTY CLAY with Little Gravel and Trace Sand (gravel content decreases with depth) (MH-CH)	60	RUN #7	100	BS-9	>9000*	[Dotted Pattern]	65.1	60
			RUN #8	100	BS-10	>9000*				
520	[Diagonal Hatching]	519.8 66.0	70	RUN #9	67	BS-11	-	[Solid Black]	73.3	70
		517.8 ROCK FRAGMENTS 68.0								
510	[Diagonal Hatching]	511.8 74.0	80	RUN #10	100	BS-12	-	[Solid Black]	81.0	80
		509.8 CLAY With LIMESTONE FRAGMENTS 76.0								
500	[Brick Pattern]	504.8 81.0	90	RUN #11	100	BS-13	-	[Dotted Pattern]	91.0	90
		503.8 CLAY Seam (MH-CH) 82.0								
	[Brick Pattern]	LIMESTONE (reacted to HCL)	90	RUN #11	100	BS-14	-	[Dotted Pattern]	91.0	90
	[Brick Pattern]	LIMESTONE (reacted to HCL)	90	RUN #11	100	BS-16	-	[Dotted Pattern]	91.0	90
490										
480										
									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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC				
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 586.2	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 589.0	DEPTH (FT)		
580		FILL: Brown SILTY CLAY with Organic Material (MH-CH) 584.2 2.0		RUN #1	100	BS-1	-		2 ft 10 in Stick-Up			
570		FILL: BOTTOM ASH and FLY ASH (clay drain tile fragment at 4 ft)	10	RUN #2	100	BS-2	-			10		
560		566.2 20.0	20	RUN #3	100	BS-3	4000*			TREMIED CEMENT GROUT	20	
		564.2 22.0				BS-4A	1000*					
		558.9 27.3		RUN #4	100							30
		550.2 36.0				BS-4B	4000*					
	543.7 42.5		RUN #5	100				40				
540					BS-4C**	>9000*		50				
			50	RUN #6	100				50			

Total Depth: 85.0 ft
 Drilling Date: 10/23/2016
 Inspector: J. Eisey
 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:

- * -Denotes Pocket Penetrometer Value
- ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
- 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

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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 586.5	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 589.4	DEPTH (FT)
580		585.0 FILL: Black SILTY CLAY with Organic Material (MH-CH) 1.5		RUN #1	100				2 ft 10 in Stick-Up	
		FILL: Black FLY ASH	10			BS-1	-			10
		574.5 Very Stiff Brown SILTY CLAY with Trace Sand and Gravel (MH-CH) 12.0		RUN #2	100	BS-2	6000*			
570		570.5 Stiff Brown SILTY CLAY with Trace Sand and Gravel (MH-CH) 16.0	20	RUN #3	100	BS-3	3000*		TREMIED CEMENT GROUT	20
560		560.5 Stiff Gray SILTY CLAY with Trace Gravel (MH-CH) 30		RUN #4	100	BS-4**	3000*			30
		554.0 Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH) 35.5				BS-5	>9000*			
550		551.0 Hard to Very Hard Gray SILTY CLAY with Trace Gravel (MH-CH) 40.0	40							40
		546.5 Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH) 41.0		RUN #5	100	BS-6	>9000*			
540		545.5 Hard to Very Hard Gray SILTY CLAY with Trace Gravel (possible cobbles/boulders below 54 ft) (MH-CH)	50	RUN #6	100					50

Total Depth: 85.0 ft
 Drilling Date: 10/23/2016
 Inspector: J. Eisey
 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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 586.5	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 589.4	DEPTH (FT)
530	[Diagonal Hatching]	Hard to Very Hard Gray SILTY CLAY with Trace Gravel (possible cobbles/boulders below 54 ft) (MH-CH)	60	RUN #6	100	BS-7	8000*	[Stippled Pattern]	63.2	60
							BS-8			
520	[Brick Pattern]	Very Stiff SILTY CLAY with Trace Gravel (possible cobbles/boulders) (MH-CH)	70	RUN #7	100	BS-9	6000*	[Solid Black]	67.0	70
							BS-10			
510	[Brick Pattern]	LIMESTONE (reacted to HCL)	80	RUN #8	100	BS-11	-	[Stippled Pattern]	75.0	70
500	[Brick Pattern]		80	RUN #9	40	BS-13	-	[Stippled Pattern]	75.0	70
490	[Brick Pattern]		85.0			BS-15	-	[Stippled Pattern]	85.0	80
480									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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 589.3	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 592.1	DEPTH (FT)
									2 ft 10 in Stick-Up	
		FILL: Brown SILTY CLAY with Trace Gravel and Organic Material (MH-CH)	4.0	RUN #1	80	BS-1	-			
580		FILL: Black FLY ASH with Trace Clay and Organic Material	10	RUN #2	100	BS-2	-			10
						BS-3	-			
						BS-4	6000*			
570		Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	18.0	RUN #3	100	BS-5	2000*			20
		Stiff to Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	28.0	RUN #4	100	BS-6	3000*			30
560		Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	36.5			BS-7**	>9000*			
		Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	38.0			BS-8	>9000*			40
550		Hard to Very Hard Gray SILTY CLAY with Trace Sand and Gravel (gravel content increases with depth) (MH-CH)		RUN #5	100					
				RUN #6	100					
540			50							50

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

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.

SUBSURFACE PROFILE				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 588.3	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 591.0	DEPTH (FT)
580		586.8 FILL: Brown SILTY CLAY with Trace Sand and Organic Material (MH-CH) 1.5		RUN #1	100	BS-1	-	TREMIED CEMENT GROUT	2 ft 9 in Stick-Up	
		FILL: Black FLY ASH with Trace Clay and Organic Material	10	RUN #2	100	BS-2	-			
		573.3 15.0				BS-3	5000*			
570		Stiff to Very Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)	20	RUN #3	100	BS-4	4000*			
		561.3 27.0				BS-5**	-			
		Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	30	RUN #4	100	BS-6	3000*			
560		547.3 41.0								
		Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	40	RUN #5	100					
		543.3 45.0								
		Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	47.0							
550		541.3 47.0								
		Gray Alternating Layers of SILT and SAND (ML-SM)	50	RUN #6	100	BS-8	-			
540						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:

- * -Denotes Pocket Penetrometer Value
- ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
- 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

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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 579.5	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 582.3	DEPTH (FT)
		579.0	0.5						2 ft 10 in Stick-Up	
		TOPSOIL								
		Stiff Brown SILTY CLAY with Trace Organic Material (MH-CH)		RUN #1	100	BS-1	-			
		574.5	5.0			BS-2	-			
		572.5	7.0							
		Brown SILTY SAND (SM)								
570			10	RUN #2	100					10
		Medium to Stiff Brown and Gray SILTY CLAY with Trace Gravel (MH-CH)								
		563.5	16.0			BS-3	3000*			
560			20	RUN #3	100					20
		Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)				BS-4	3000*			
		553.5	26.0							
550			30	RUN #4	100					30
		Stiff to Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)				BS-5**	>9000*			
		546.5	33.0							
		Hard Gray SILTY CLAY with Trace Gravel (MH-CH)				BS-6	-			
		543.5	36.0							
		543.0	36.5							
		Gray SAND (SP)								
540			40	RUN #5	100					40
		Hard Gray SILTY CLAY with Trace Gravel (2 inch sand seam at 39.5') (MH-CH)								
		535.0	44.5			BS-7	-			
		534.5	45.0							
		Gray SAND (SP)								
530			50	RUN #6	100					50
		Hard Gray SILTY CLAY with Trace Gravel (sand and silt seams present) (MH-CH)				BS-8	-			
						BS-9	-			

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:

- * -Denotes Pocket Penetrometer Value
- ** -Indicates Clay rich sample packaged for hydraulic permeability testing.
- No groundwater observations made during or upon completion of drilling due to water added during drilling.
- 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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 579.5	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 582.3	DEPTH (FT)
		Hard Gray SILTY CLAY with Trace (sand and silt seams present) (MH-CH)	54.5	RUN #6	100	BS-10	>9000*			
520		Very Hard Gray SILTY CLAY with Little Sand and Trace Gravel (color lightens with depth) (cobble/boulder at 63')	60	RUN #7	100	BS-11	-		TREMIED CEMENT GROUT	60
510		LIMESTONE (reacted to HCL)	70	RUN #8	50	BS-12	-		BENTONITE PELLETS	
						BS-13	-			
						BS-14	-			
500			78.3						FILTER SAND	70
490										
480										
470										
									78.0	
									78.3	END OF BORING

Monitoring Well JRW MW-16008

Project Name: J.R. Whiting Observation Wells

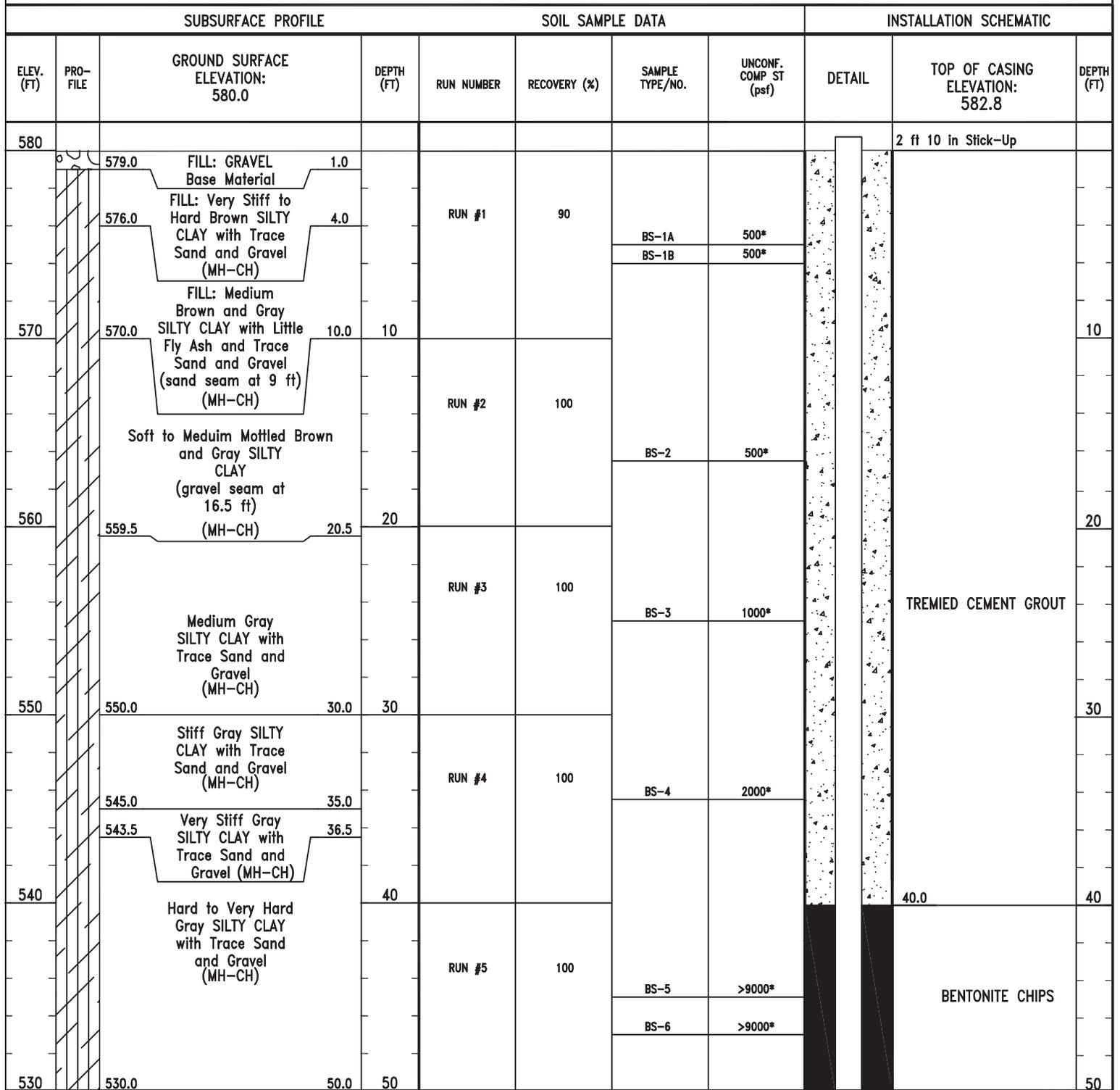
Project Location: J.R. Whiting Generating Facility, Erie, MI



FK Engineering Associates

Project No: 16-085

Checked By: Z. Carr, P.E.



Total Depth: 75.0 ft
 Drilling Date: 10/27/2016
 Inspector: J. Eisey
 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

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				SOIL SAMPLE DATA				INSTALLATION SCHEMATIC		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 579.9	DEPTH (FT)	RUN NUMBER	RECOVERY (%)	SAMPLE TYPE/NO.	UNCONF. COMP ST (psf)	DETAIL	TOP OF CASING ELEVATION: 582.6	DEPTH (FT)
		FILL: Brown SILTY CLAY with Gravel and Organic Material (MH-CH)		RUN #1	100	BS-1	6000*		2 ft 8 in Stick-Up	
		573.9	6.0			BS-2	-			
		FILL: Brown SILTY CLAY and FLY ASH mix				BS-3	-			
570		571.4	8.5			BS-4	2000*			
		Soft to Medium Brown SILTY CLAY (MH-CH)		RUN #2	100					
		564.9	15.0							
		563.9 Medium to Stiff Brown SILTY CLAY (MH-CH)	16.0			BS-5	2000*			
560		Medium to Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	20	RUN #3	100					
		553.9	26.0			BS-6	5000*			
550		Very Stiff Gray SILTY CLAY with Trace Gravel (MH-CH)	30	RUN #4	100					
		548.9								
		545.9	34.0							
540		Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	40			BS-7	>9000*			
		538.9	41.0							
		538.4 Gray SILTY SAND (SM)	41.5	RUN #5	100	BS-8	>9000*			
		536.4 Hard Gray SILTY CLAY with Trace Gravel (MH-CH)	43.5			BS-9	-			
		535.9	44.0			BS-10	-			
		533.9 Gray SAND (SP)	46.0							
		Hard Gray SILTY CLAY with Trace Gravel (silty sand seam at 45 ft) (MH-CH)		RUN #6	100					
			50							

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:

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

Coordinates: Northing-107653.55 Easting-13372573.73

FIGURE NO. 11

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	[Diagonal Hatching]	FILL: Brown SILTY CLAY with Trace Organic Material	1	BS-1	-	-	-	-	
588				BS-2	-	-	-	-	
		587.8	1.4						
587	[Cross-hatching]	FILL: Gray FLY ASH	2	BS-3	-	-	-	-	
586									
585									
		584.2	5.0	5	BS-4	-	-	-	
584		END OF BORING							
			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-16001.

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

GPS Coordinates:

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

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	1.0	1				
584				2				
583		FILL: Gray BOTTOM/ FLY ASH with Ocasional Clay Seams	3	3				
582			4	4				
581			5.0	5				
580		END OF BORING						

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

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-16002.

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

GPS Coordinates:

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

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	1.0	1	BS-1	-	-	-
585			1.8	2	BS-2	-	-	-
584			FILL: Gray FLY ASH and BOTTOM ASH (bottom ash increases with depth)	2	BS-3	-	-	-
583				3				
582				4	BS-4	-	-	-
581		END OF BORING	5.0	5	BS-5	-	-	-
			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:

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

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

SOIL SAMPLE DATA

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 586.5	DEPTH (ft)	SAMPLE NO.	HOUSEL TESTS (Blows/6 Inches)	MOIST. CONTENT (%)	DRY DENSITY (PCF)	UNCONF. COMP ST (PSF)
586		FILL: Dark Brown to Black SILTY CLAY with Trace Organic Material	1	BS-1	-	-	-	-
585	585.3		1.3	BS-2	-	-	-	-
584		FILL: Gray FLY ASH	2					
583	583.5		3.0	BS-3	-	-	-	-
582		FILL: Gray FLY ASH and BOTTOM ASH (bottom ash increases with depth)	4	BS-4	-	-	-	-
581	581.5		5.0	BS-5	-	-	-	-
		END OF BORING	5					
			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-16004.

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

GPS Coordinates:

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

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

SOIL SAMPLE DATA

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 589.3	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 Gravel and Organic Material	1	BS-1	-	-	-	-
588			2	BS-2	-	-	-	-
587			3	BS-3	-	-	-	-
586			4	BS-4	-	-	-	-
585			5	BS-5	-	-	-	-
584.3		END OF BORING	5.0					

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:

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)
588	[Diagonal Hatching]	FILL: Brown SILTY CLAY with Trace Organic Material	1.0	BS-1	-	-	-	-
587				BS-2	-	-	-	-
586	[Cross-hatching]	FILL: Gray/Black FLY ASH (clay seams from 2ft to 3ft)	3.0	BS-3	-	-	-	-
585								
584								
583		END OF BORING	5.0	BS-4	-	-	-	-

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:

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

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	1.2					
578								
		FILL: Dark Brown SAND with Trace Clay and Organic Material	2	BS-3	-	-	-	-
577					BS-4	-	-	-
		576.5	3.0	3				
576		Dark Brown SILTY CLAY	4	BS-5	-	-	-	-
575								
		574.8	4.7					
		Brown SAND with Trace Silt	5.0	5	BS-6	-	-	-
		574.5	5.0	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-16007.
 2) Used chisel to penetrate asphalt encountered at 1ft.

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

GPS Coordinates:

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

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. COMP ST (PSF)
580								
		FILL: GRAVEL BASE MATERIAL						
		579.5	0.5					
		ASPHALT						
		579.3	0.7					
579		FILL: GRAVEL BASE MATERIAL	1					
		578.5	1.5					
578			2					
		FILL: Brown SILTY CLAY with Trace Sand and Gravel						
577			3					
576		576.0	4.0	4				
		FILL: Brown and Gray SILTY CLAY with Little Black Fly Ash and Trace Sand and Gravel						
		575.2	4.8					
575		Brown SAND	5.0	5				
		575.0	5.0					
		END OF BORING						
574			6					

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

Water Level Observation:
 Groundwater observed at 4.8 ft during drilling and 4.2 ft 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-16008.
 2) Used chisel to penetrate asphalt encountered at 0.5ft.

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

GPS Coordinates:

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

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. COMP ST (PSF)
579		FILL: Gray SAND with Little Gravel and Trace Fly Ash	1	BS-1	-	-	-	-
578			2	BS-2	-	-	-	-
577		FILL: Brown SILTY CLAY	3	BS-3	-	-	-	-
576			4	BS-4	-	-	-	-
575			5	BS-5	-	-	-	-
574		END OF BORING	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:

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

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:



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:

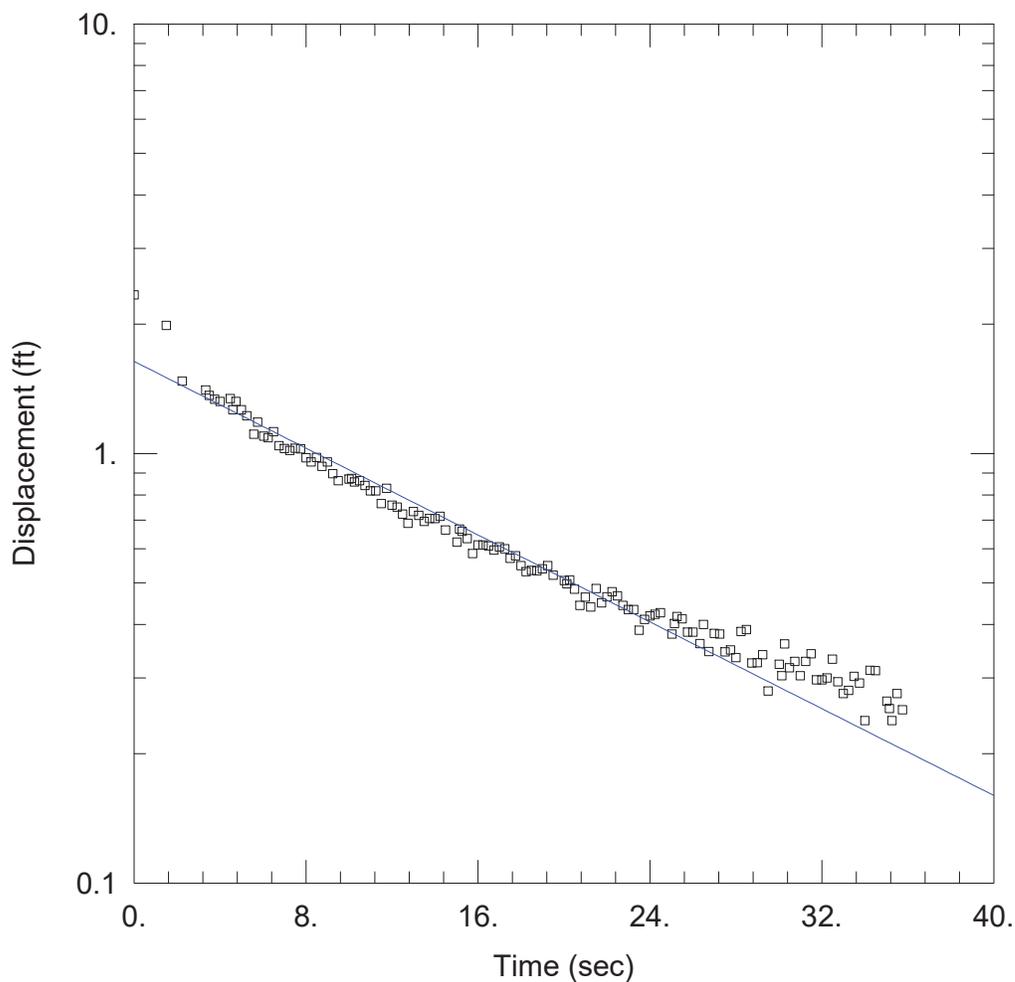


JRW MW-16009 66-76 feet bgs

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)

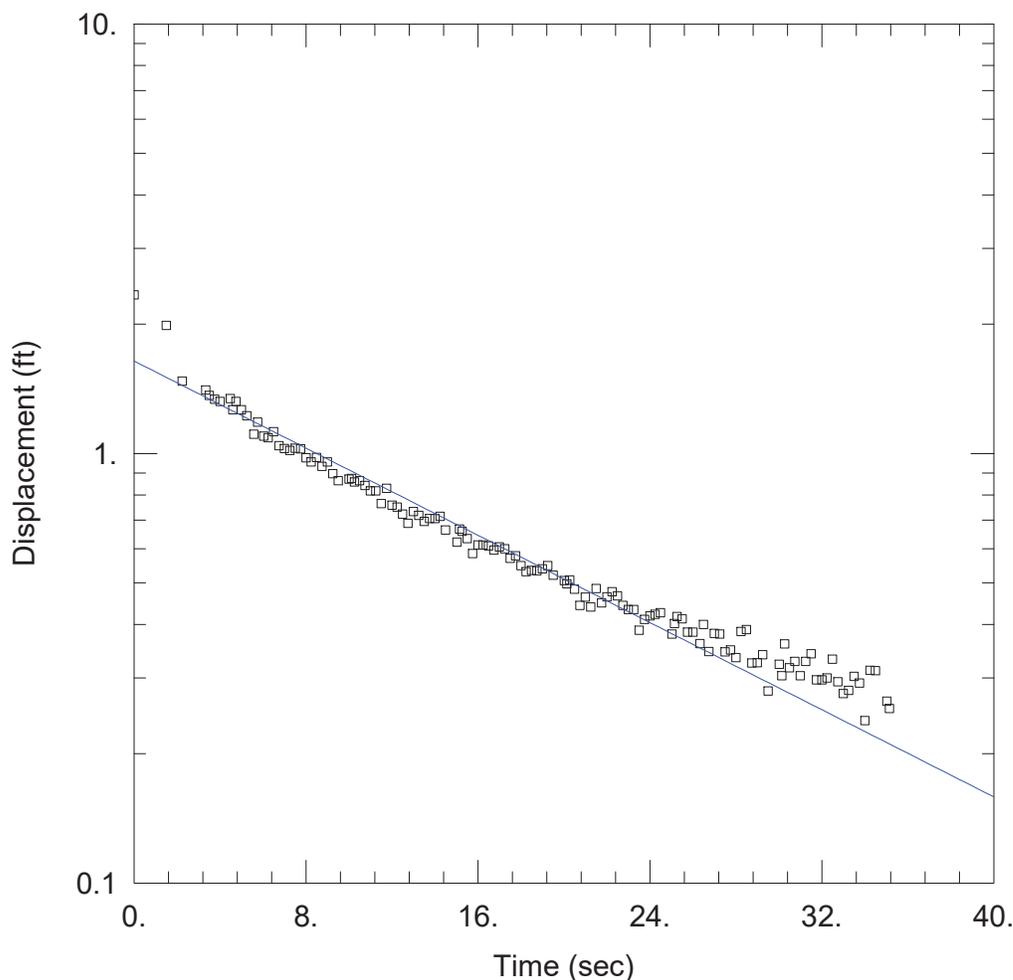
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.161 ft/day

Solution Method: Bower-Rice
 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)

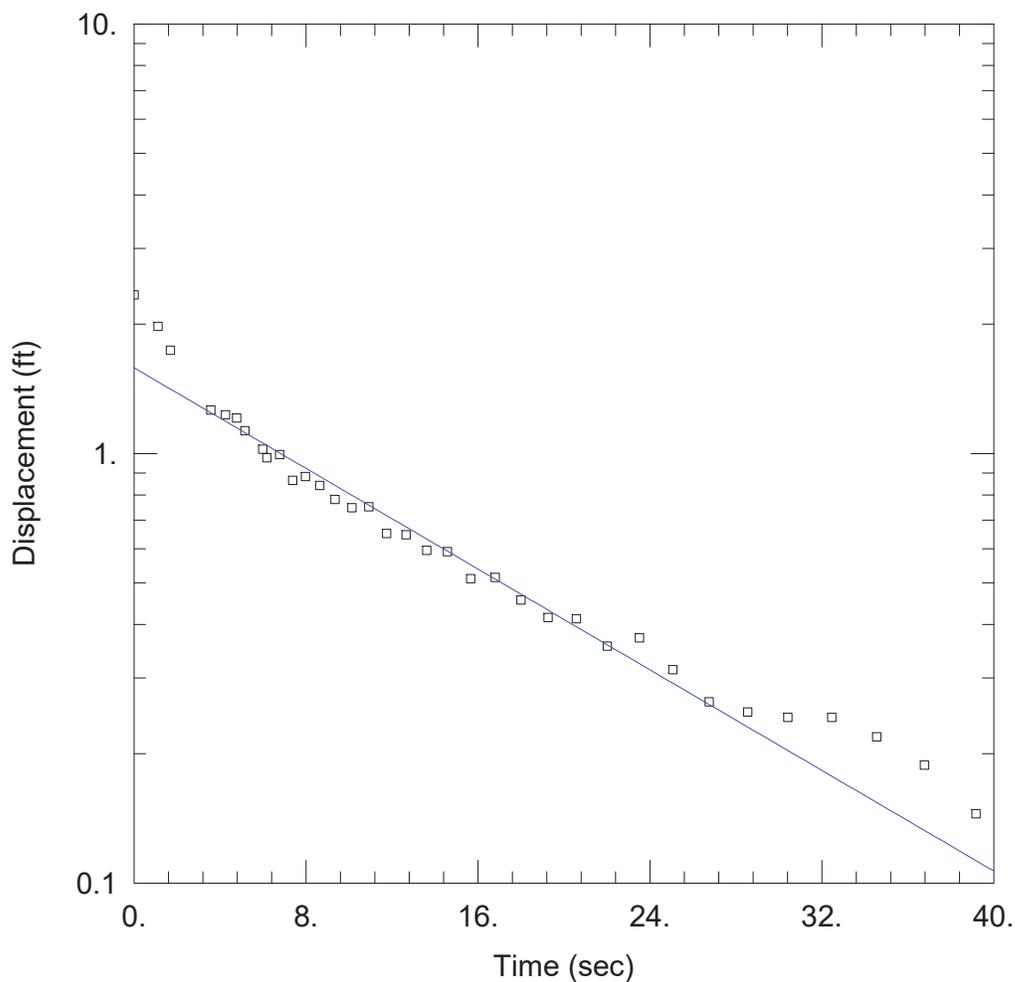
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.672 ft/day

Solution Method: Hvorslev
 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)

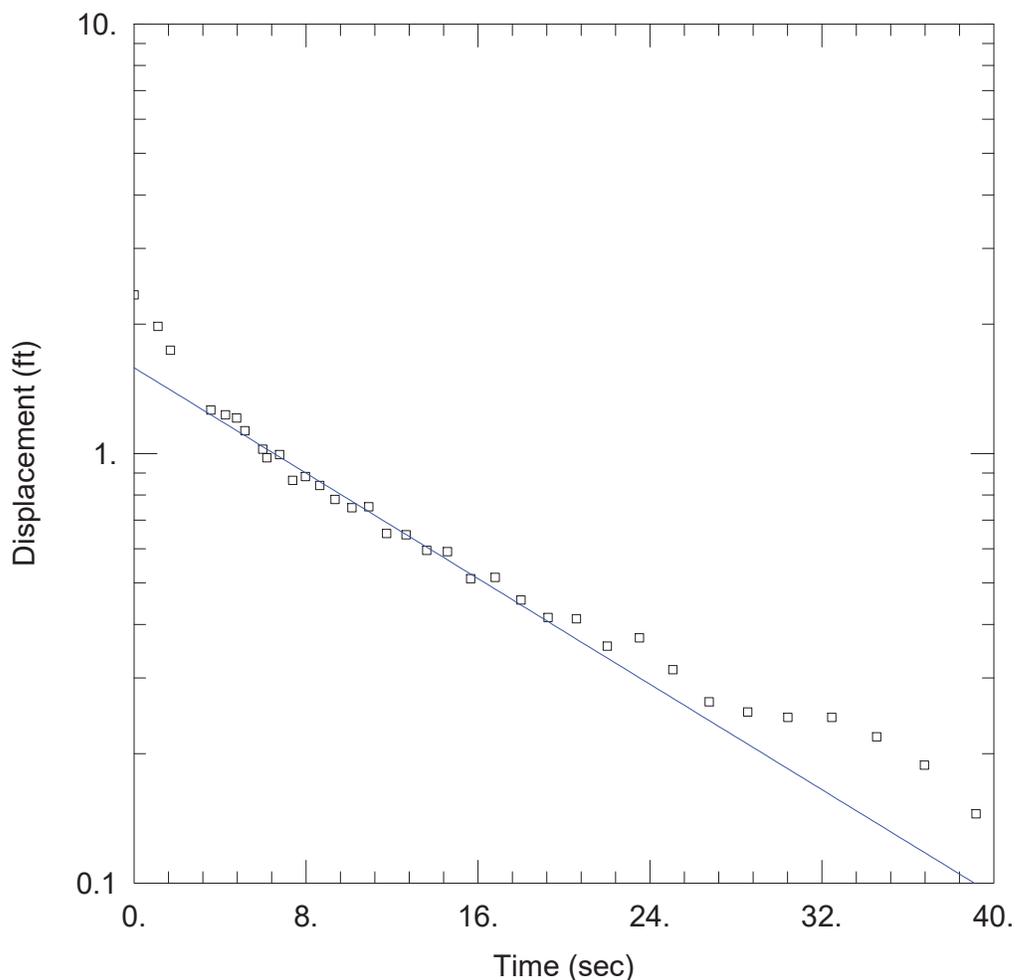
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.666 ft/day

Solution Method: Bouwer-Rice
 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)

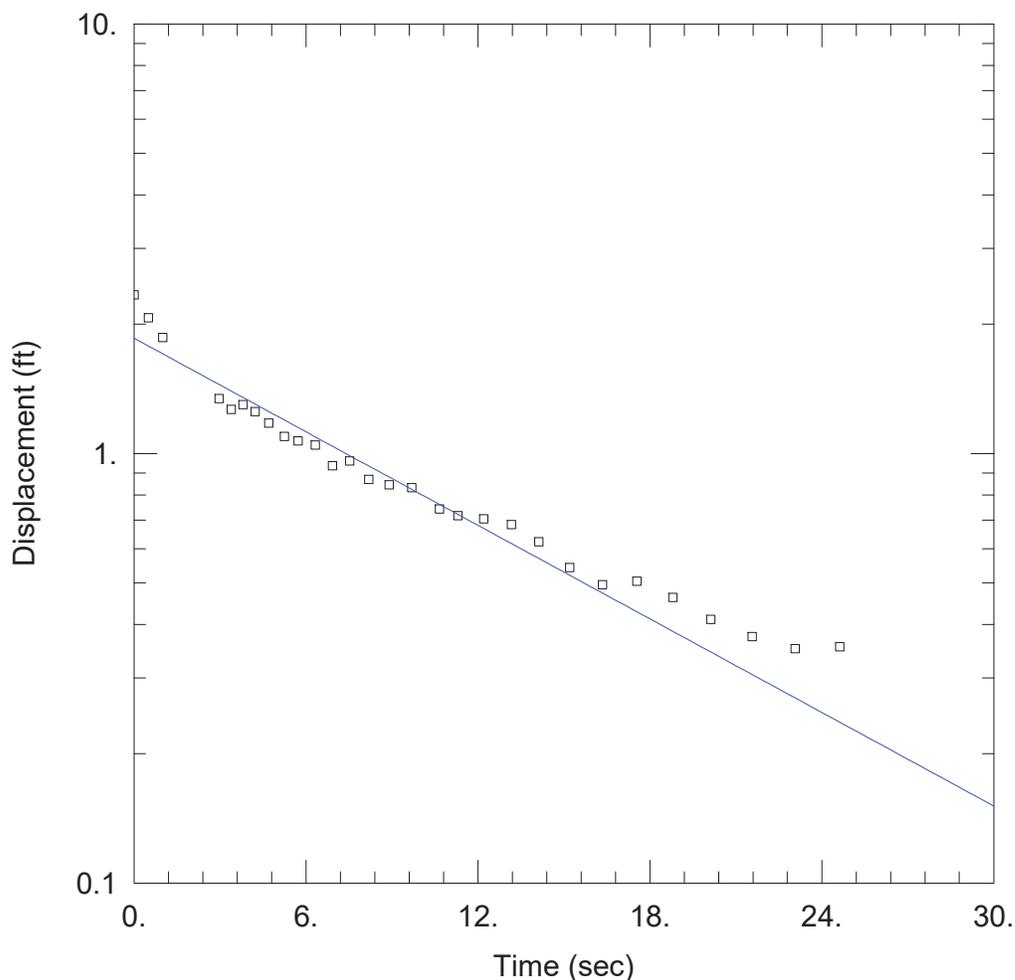
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.652 ft/day

Solution Method: Hvorslev
 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)

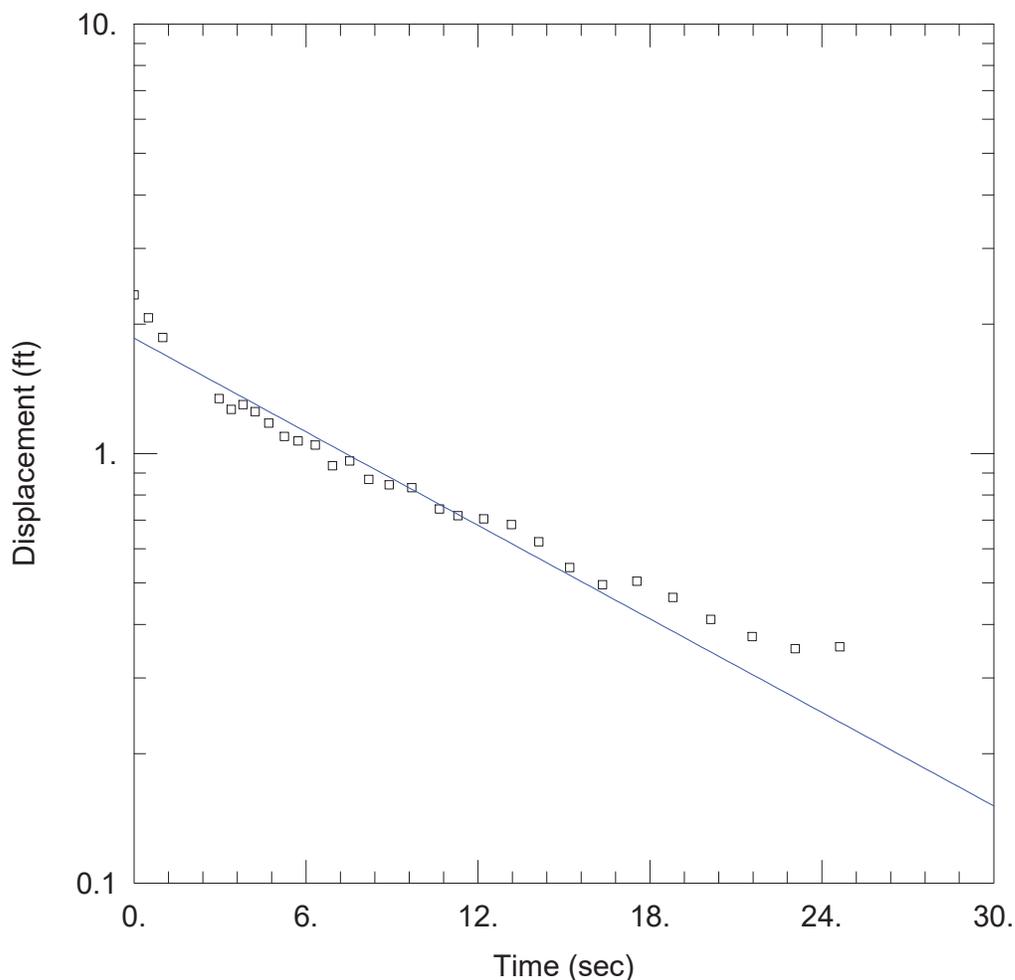
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.545 ft/day

Solution Method: Bouwer-Rice
 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)

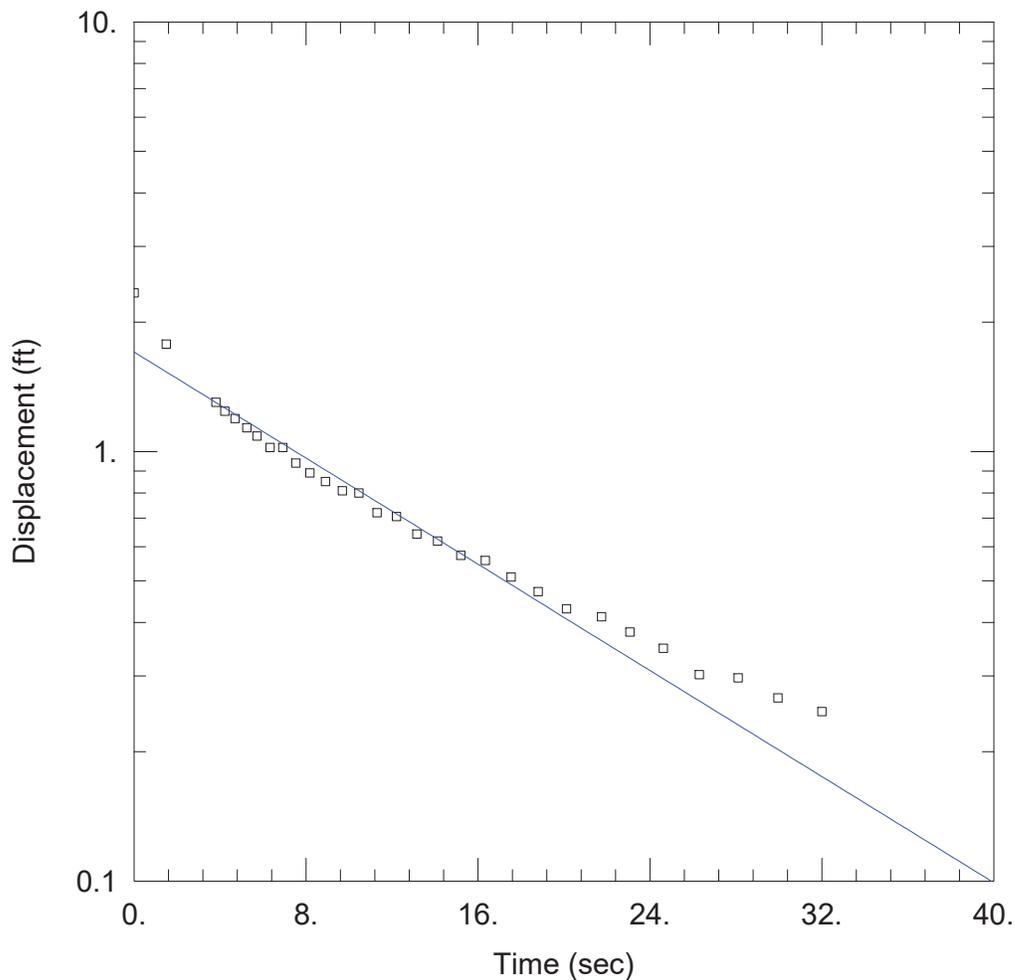
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 6.686 ft/day

Solution Method: Hvorslev
 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)

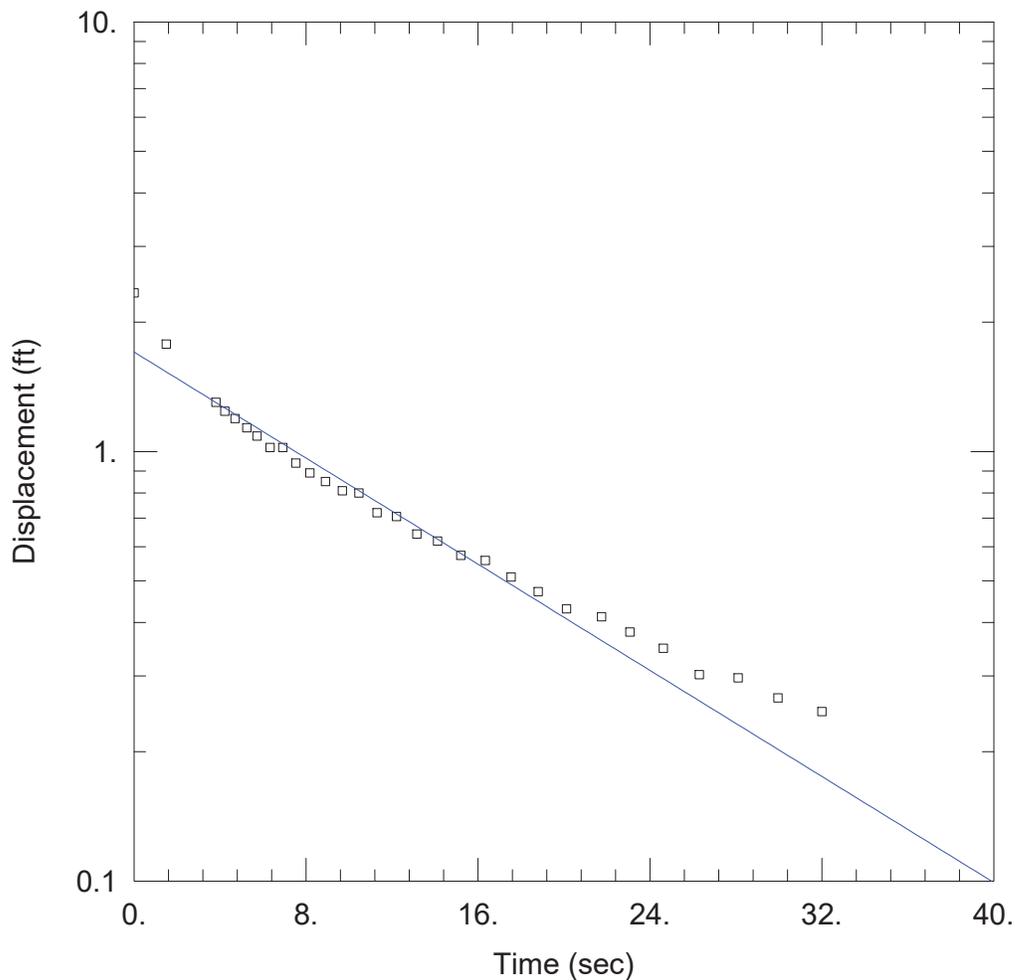
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.865 ft/day

Solution Method: Bouwer-Rice
 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)

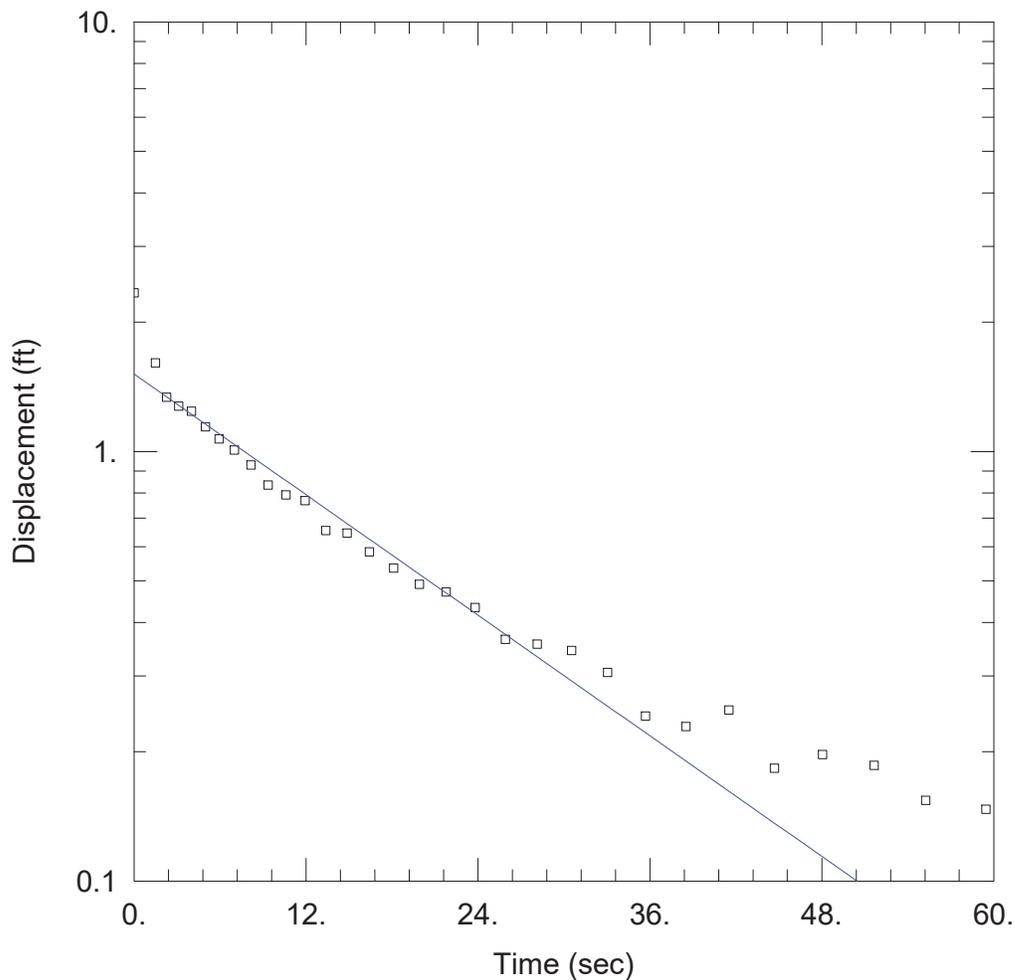
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 66.3 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.686 ft/day

Solution Method: Hvorslev
 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)

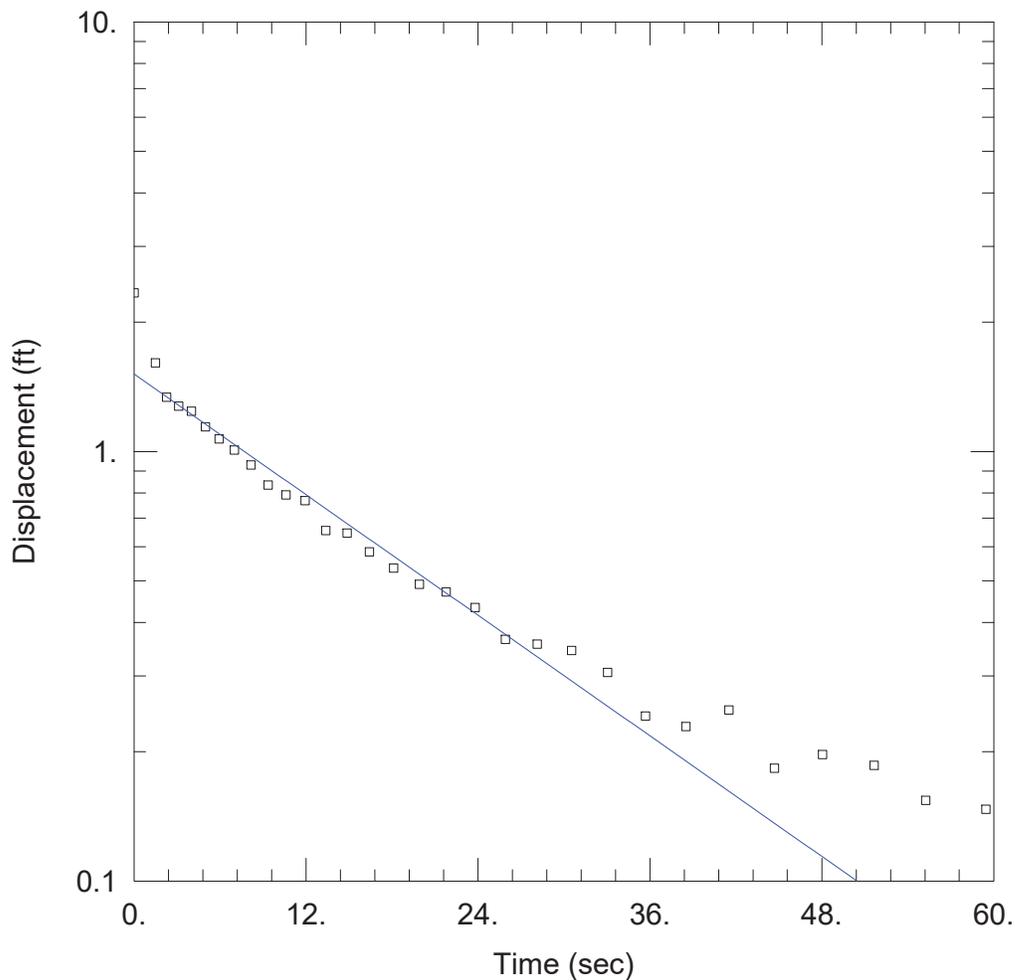
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.016 ft/day

Solution Method: Bouwer-Rice
 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)

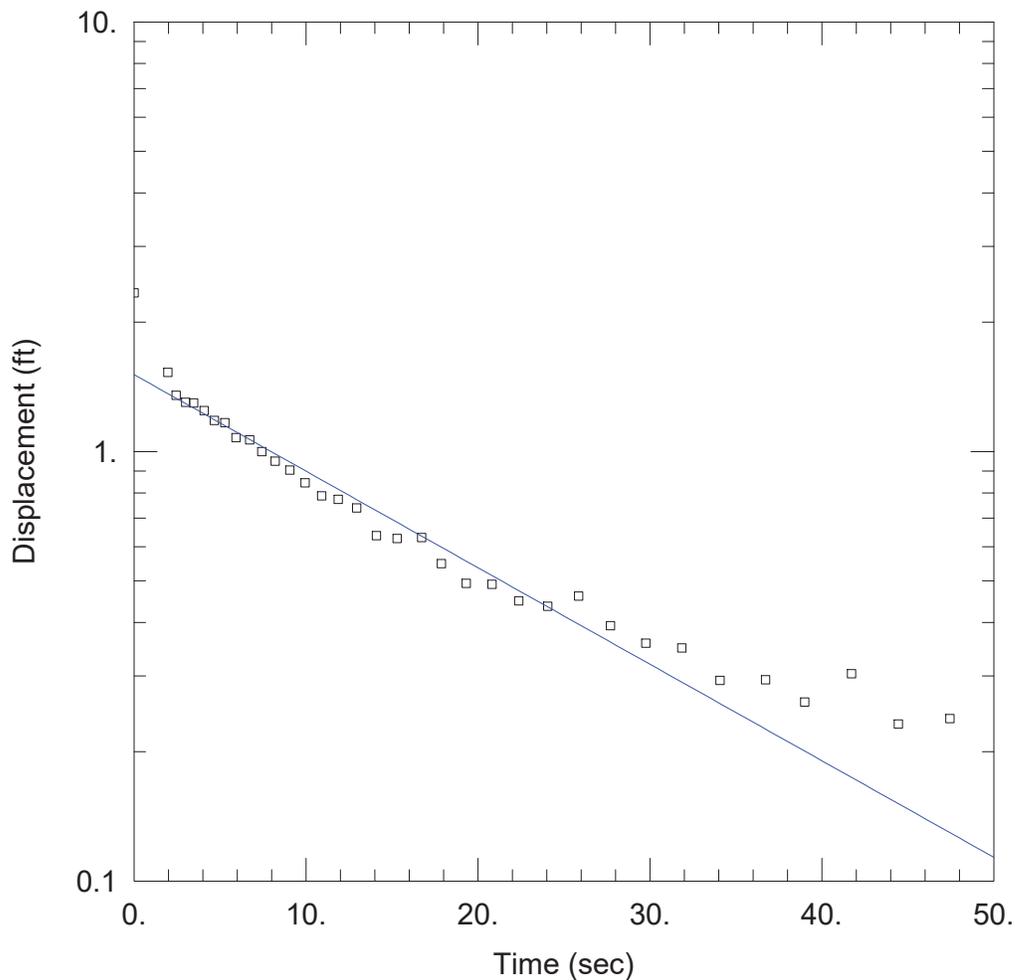
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.31 ft/day

Solution Method: Hvorslev
 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)

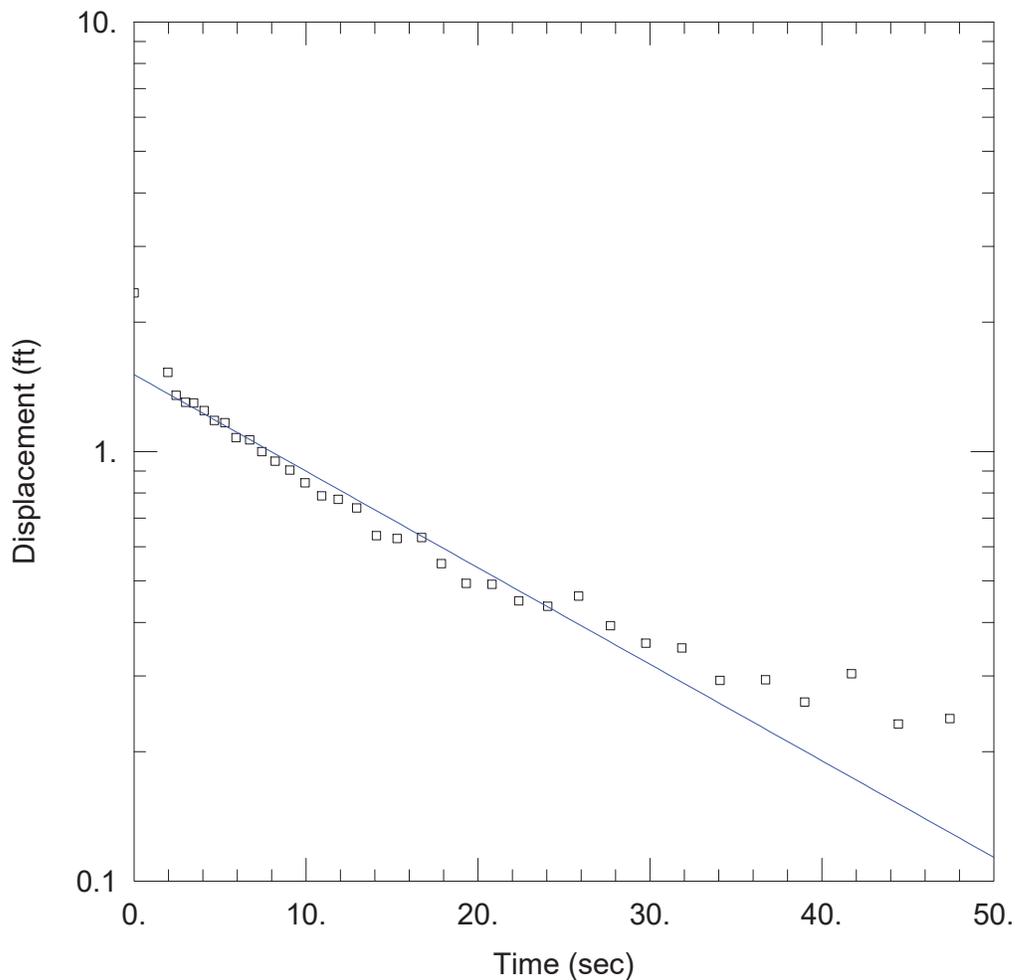
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 2.897 ft/day

Solution Method: Bouwer-Rice
 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)

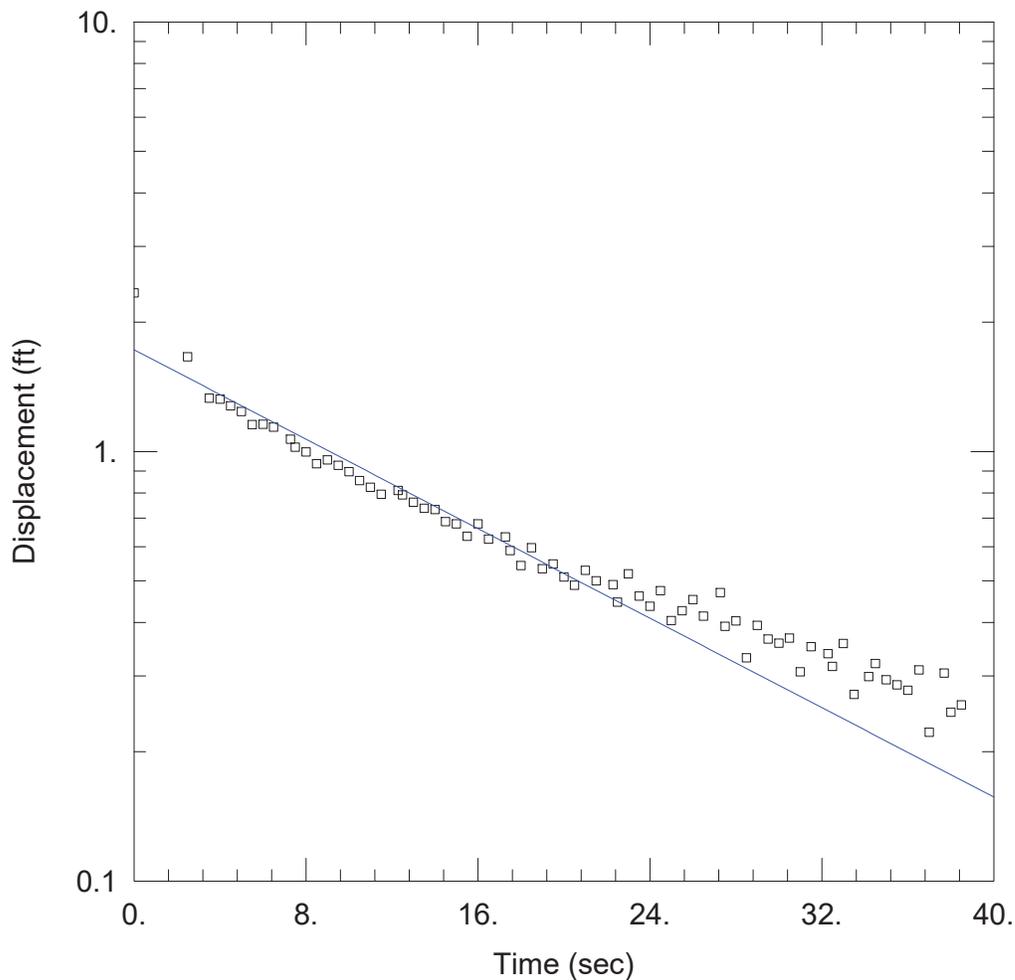
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.14 ft/day

Solution Method: Hvorslev
 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)

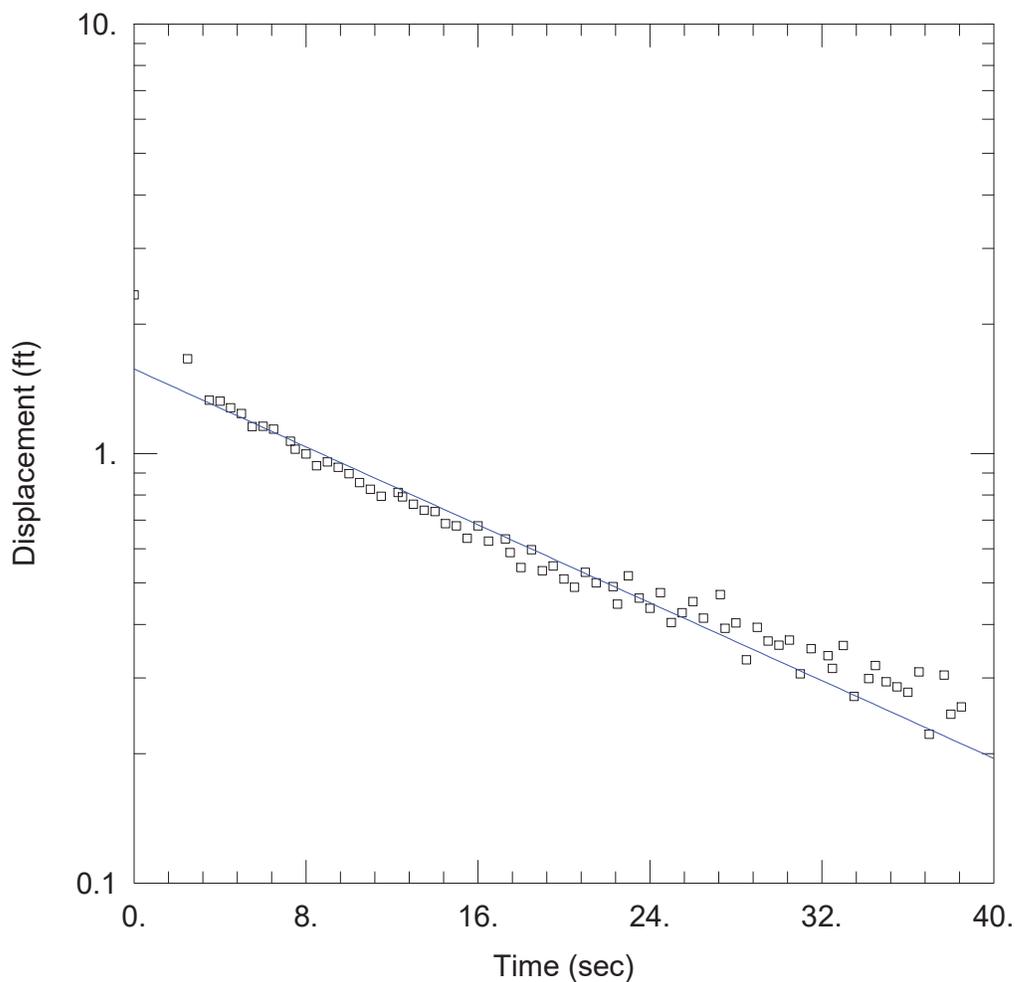
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.355 ft/day

Solution Method: Bouwer-Rice
 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)

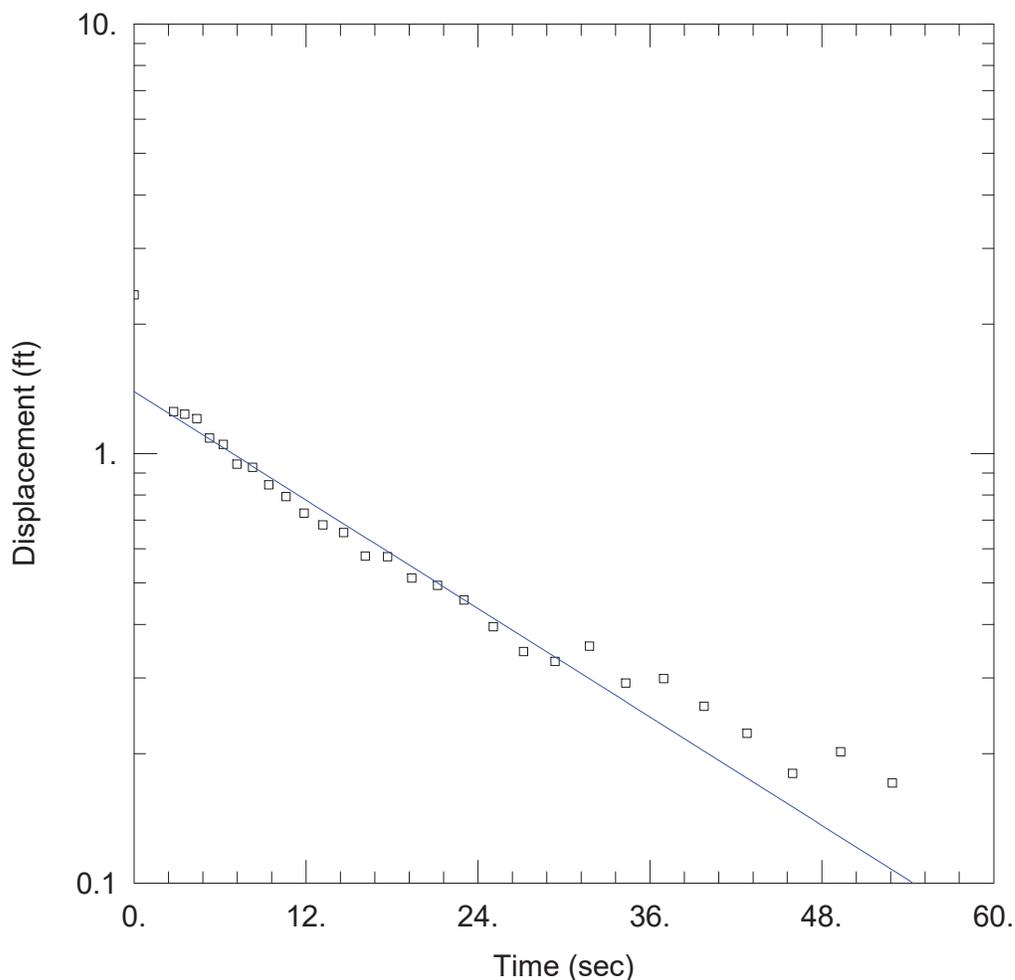
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.174 ft/day

Solution Method: Hvorslev
 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)

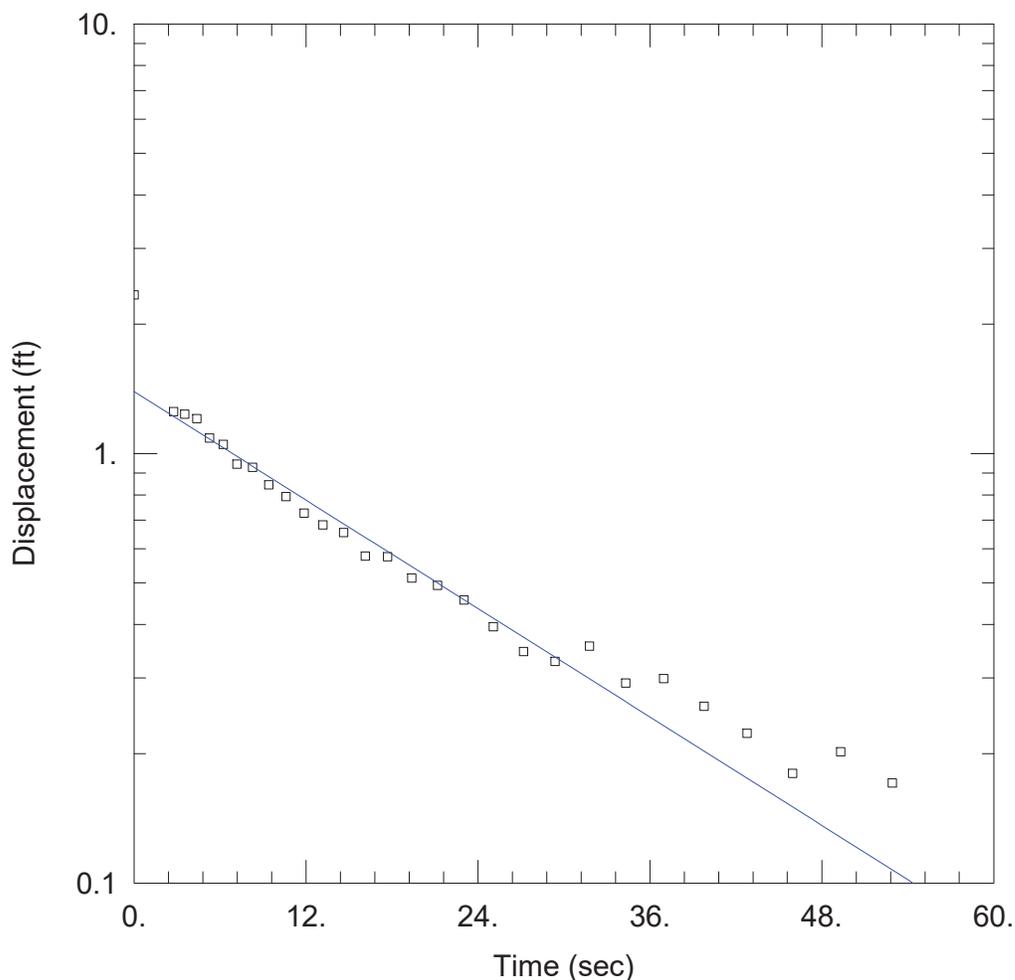
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 2.713 ft/day

Solution Method: Bouwer-Rice
 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)

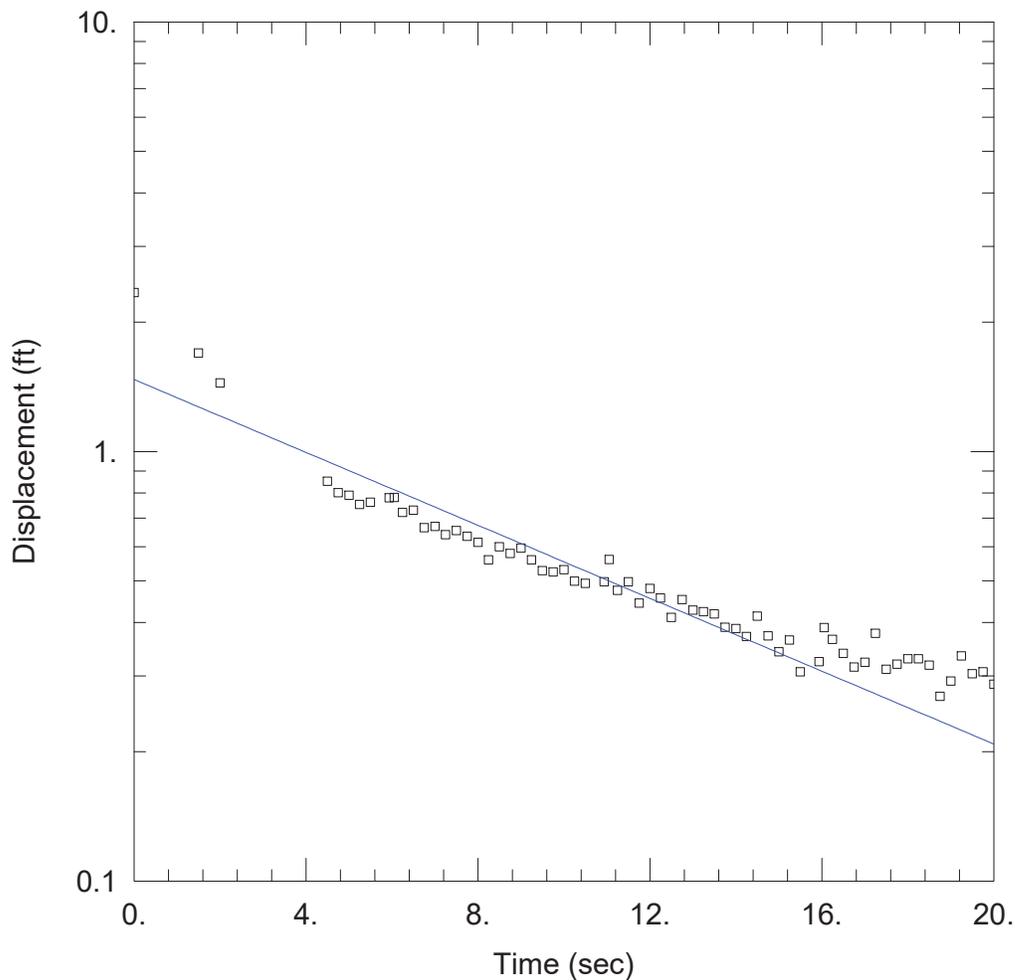
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 79.5 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.877 ft/day

Solution Method: Hvorslev
 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)

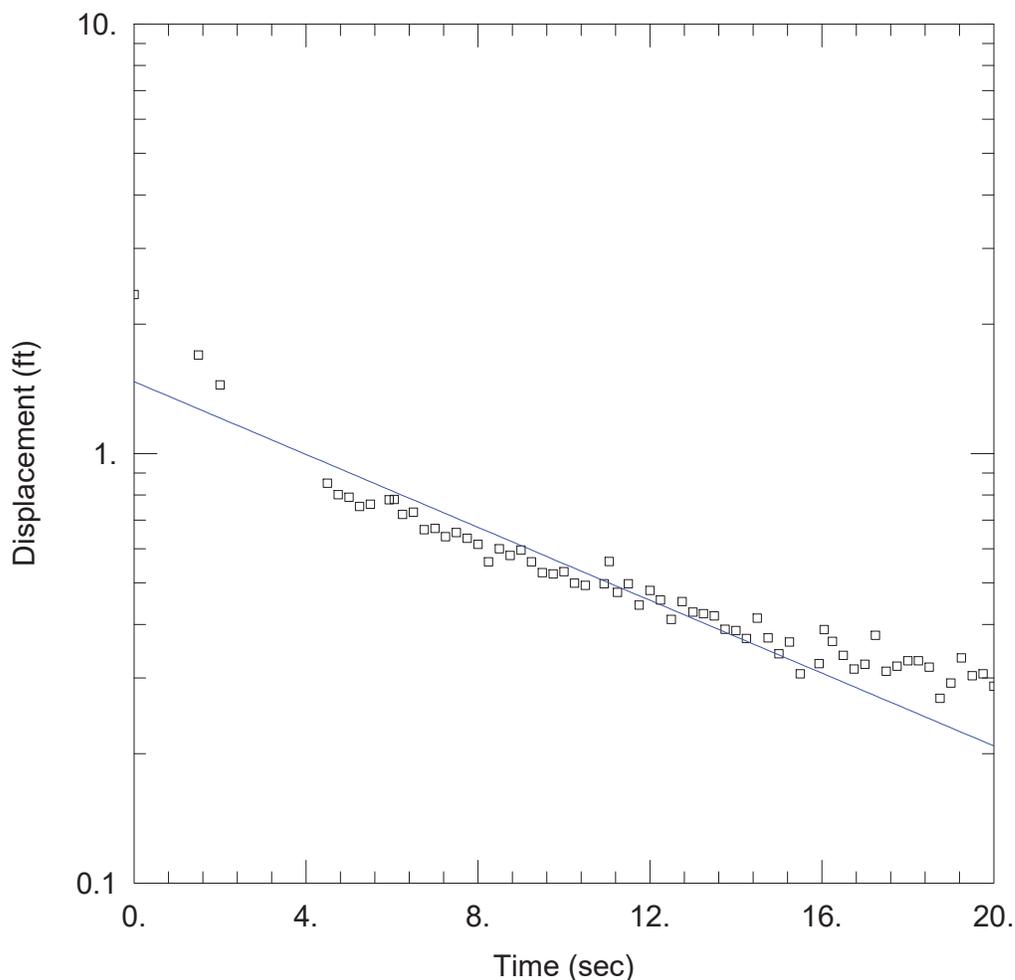
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.31 ft/day

Solution Method: Bouwer-Rice
 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)

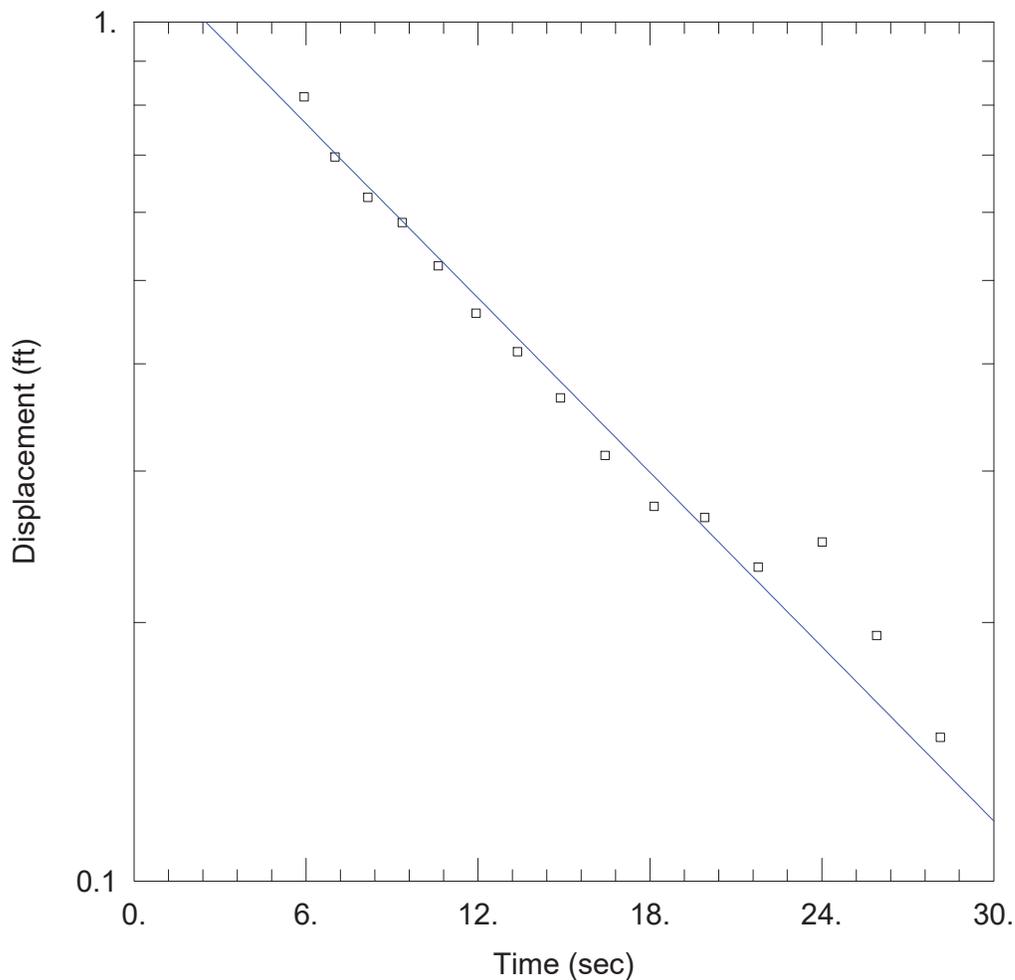
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.811 ft/day

Solution Method: Hvorslev
 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)

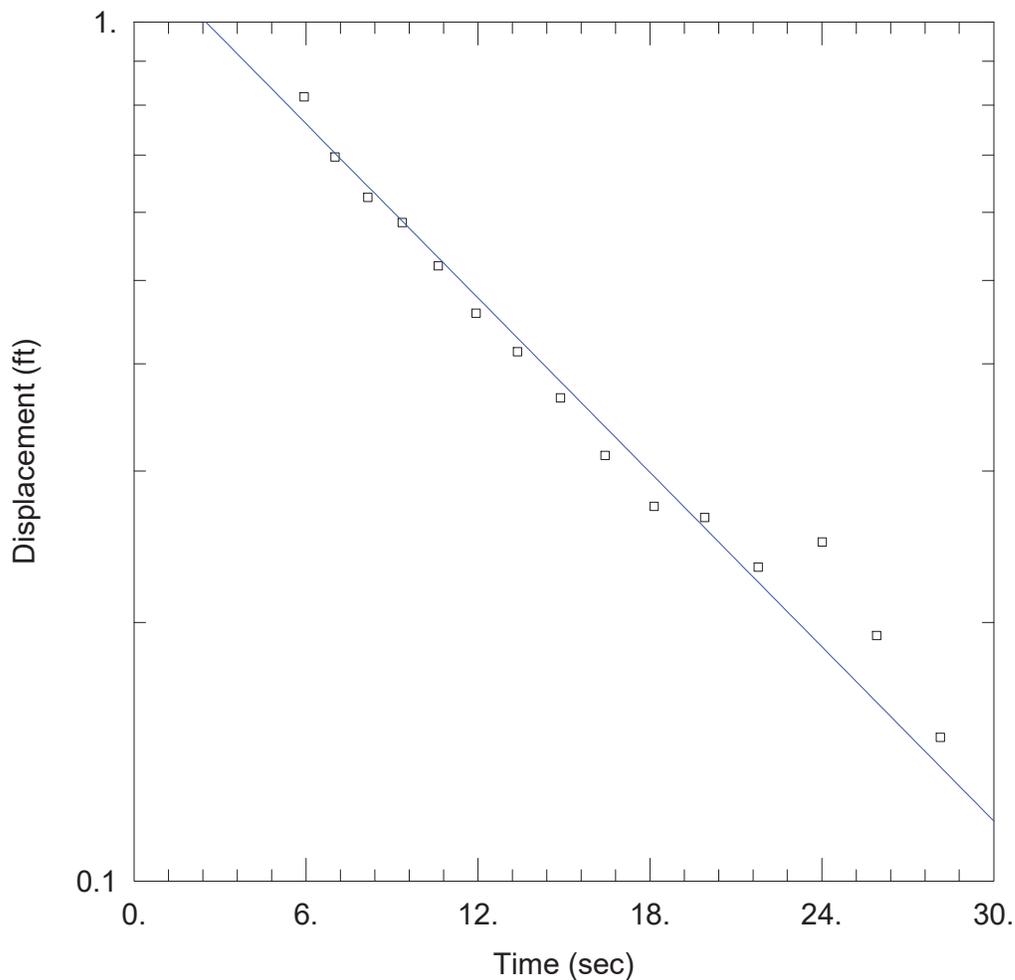
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.235 ft/day

Solution Method: Bouwer-Rice
 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)

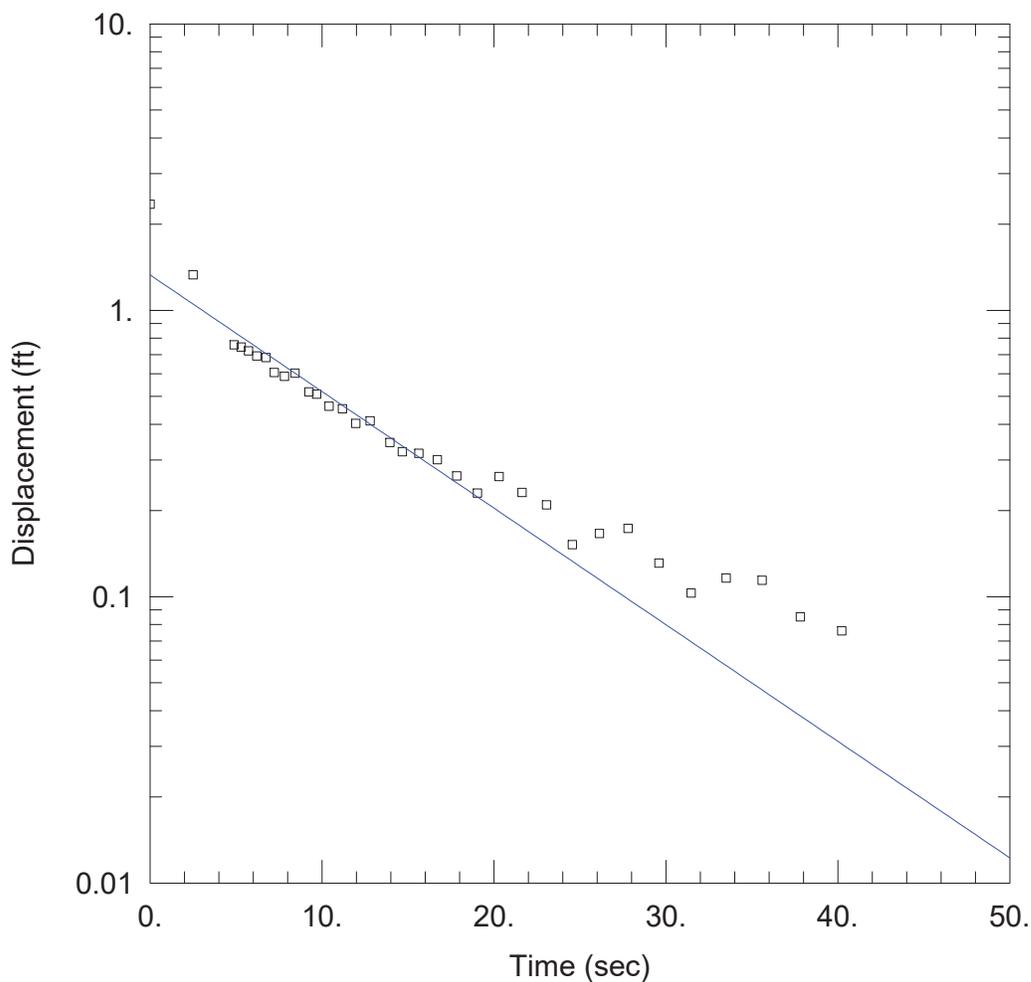
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 6.232 ft/day

Solution Method: Hvorslev
 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)

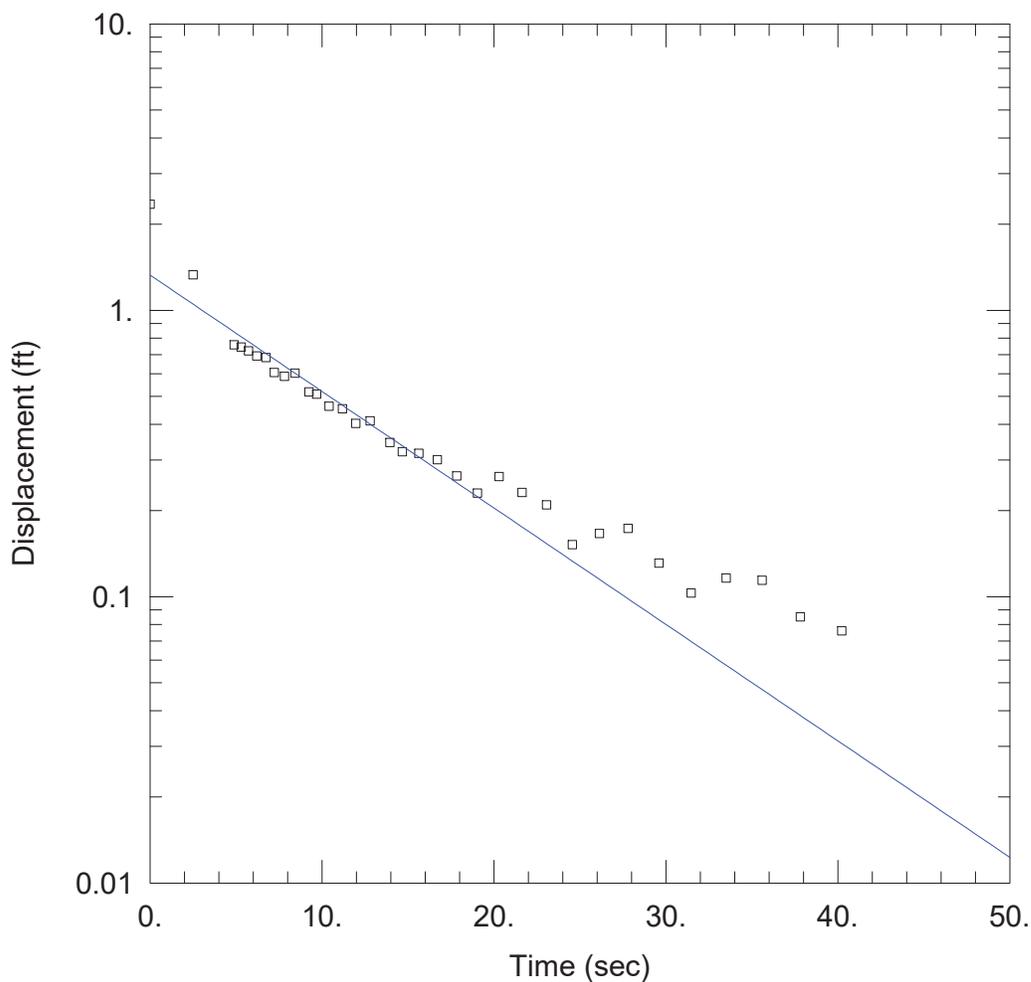
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.097 ft/day

Solution Method: Bouwer-Rice
 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)

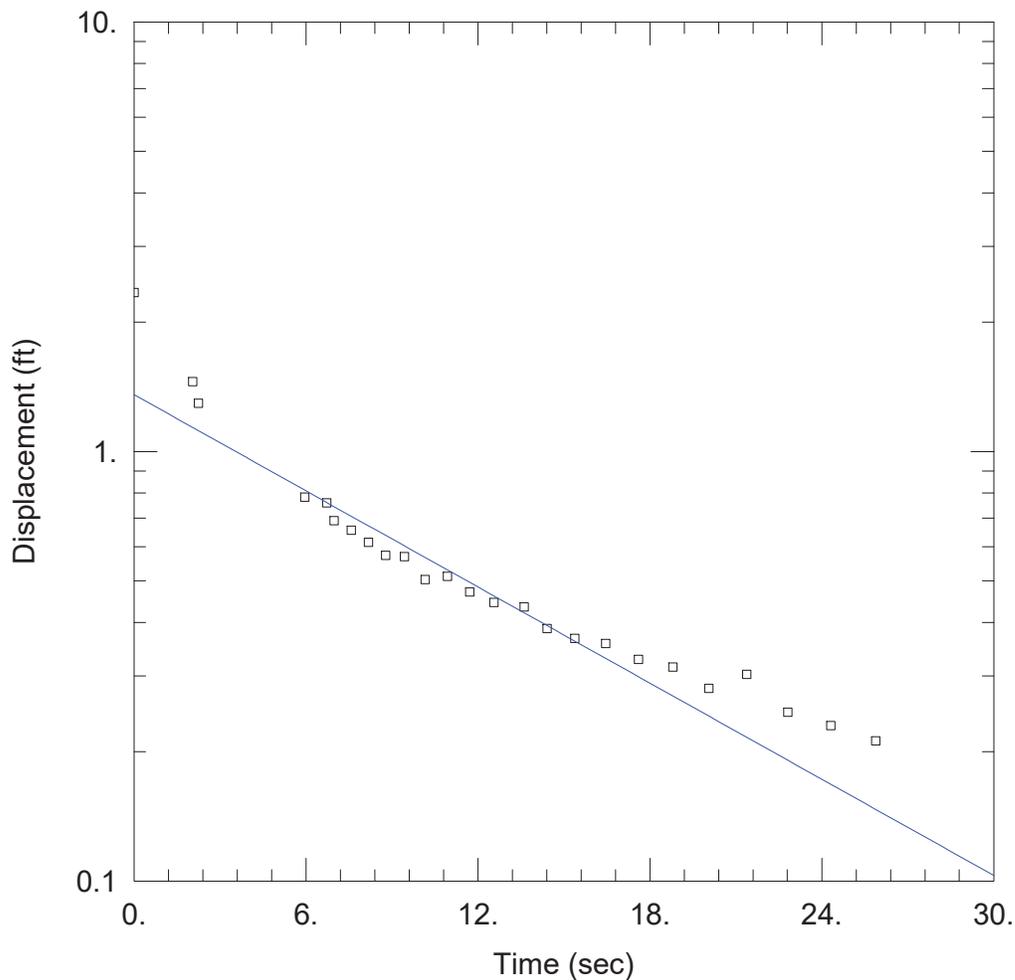
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.493 ft/day

Solution Method: Hvorslev
 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)

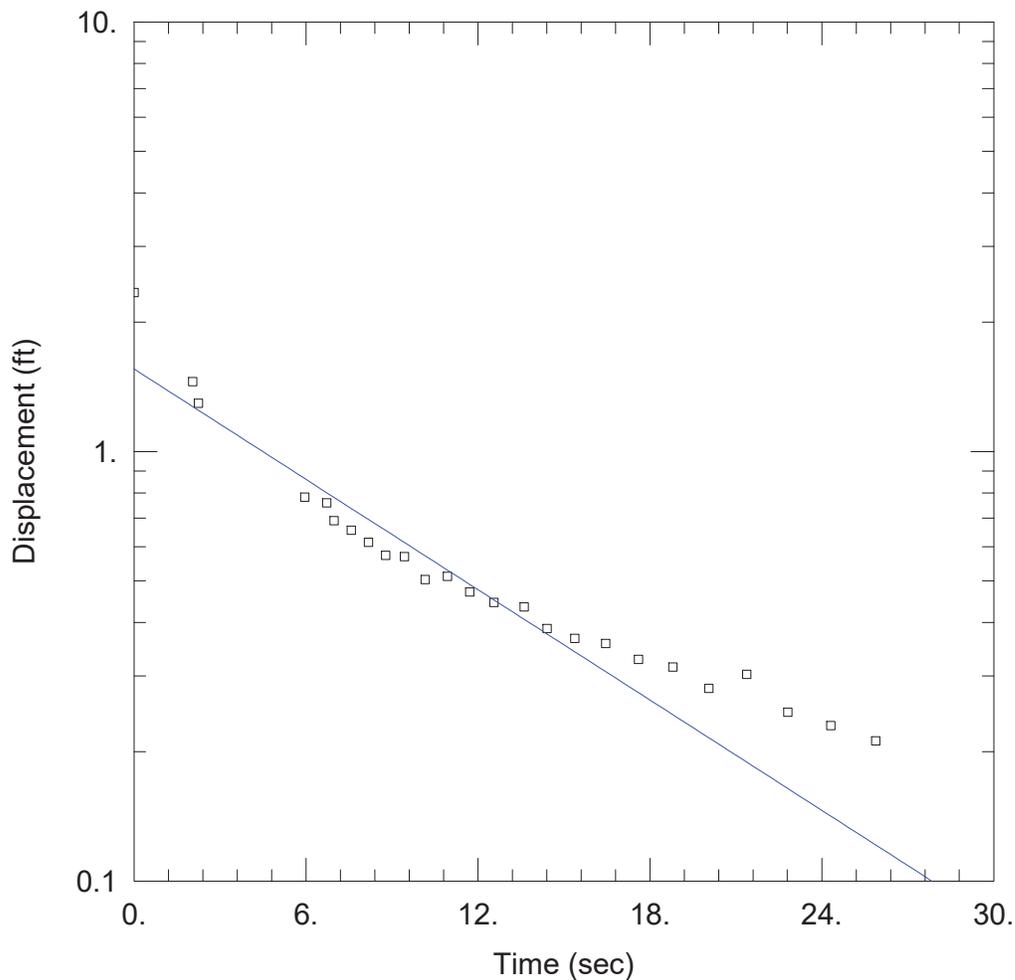
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.671 ft/day

Solution Method: Bouwer-Rice
 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)

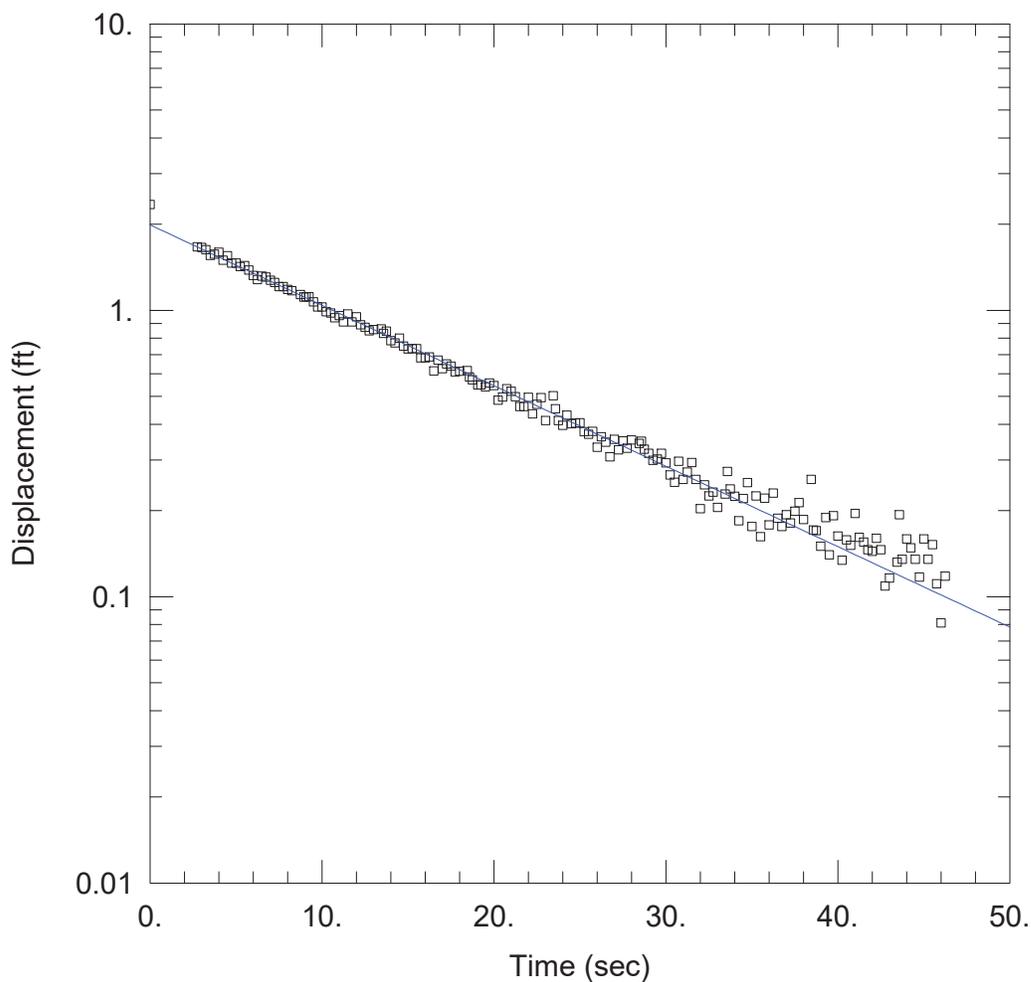
Initial Displacement: 2.345 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 71.1 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.888 ft/day

Solution Method: Hvorslev
 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 (K_z/K_r): 1.

WELL DATA (JR MW-16004)

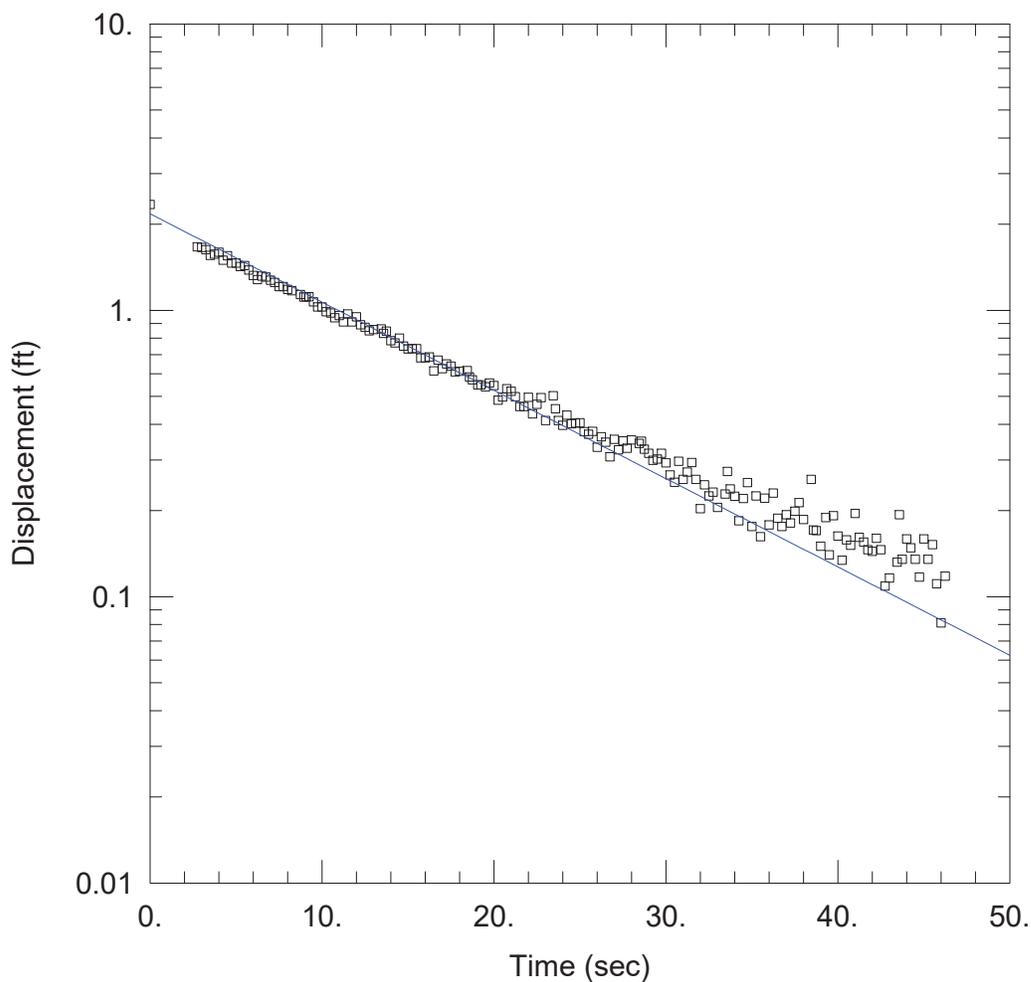
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.669 ft/day

Solution Method: Bouwer-Rice
 y_0 = 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 (K_z/K_r): 1.

WELL DATA (JR MW-16004)

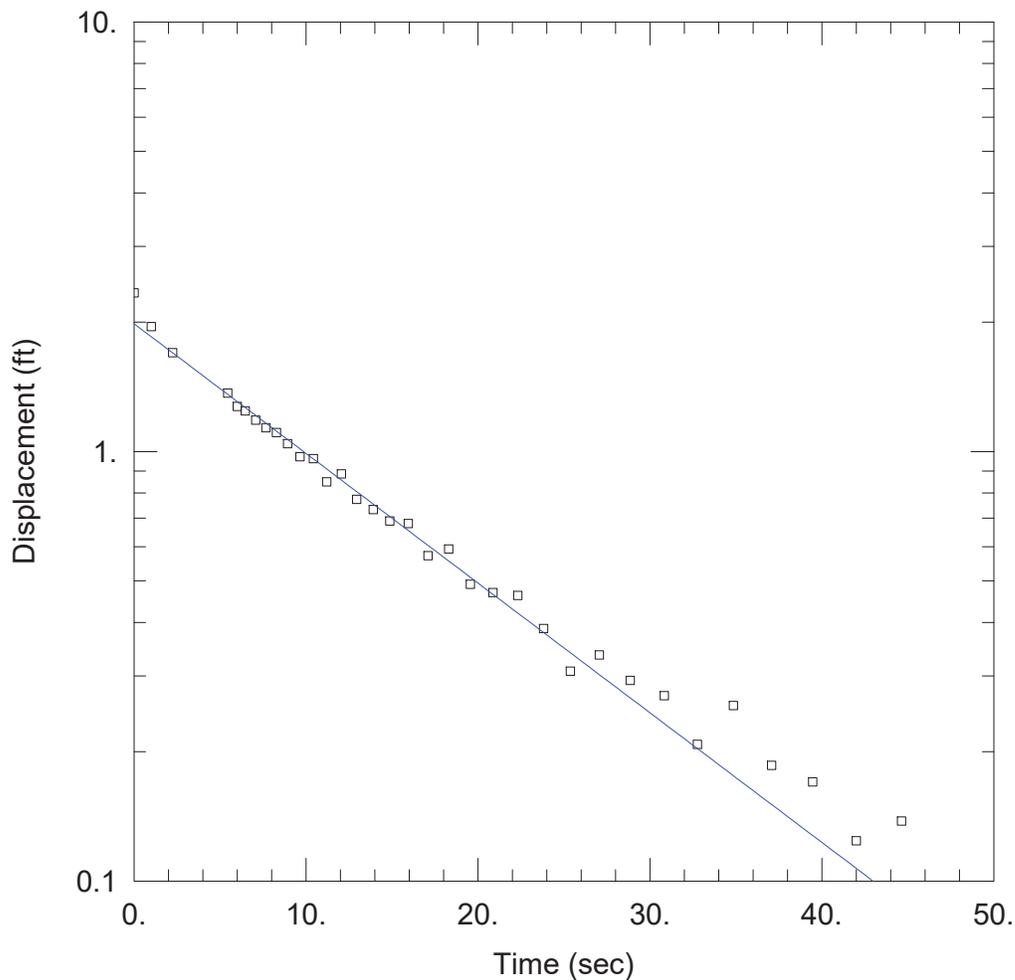
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.68 ft/day

Solution Method: Hvorslev
 y_0 = 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)

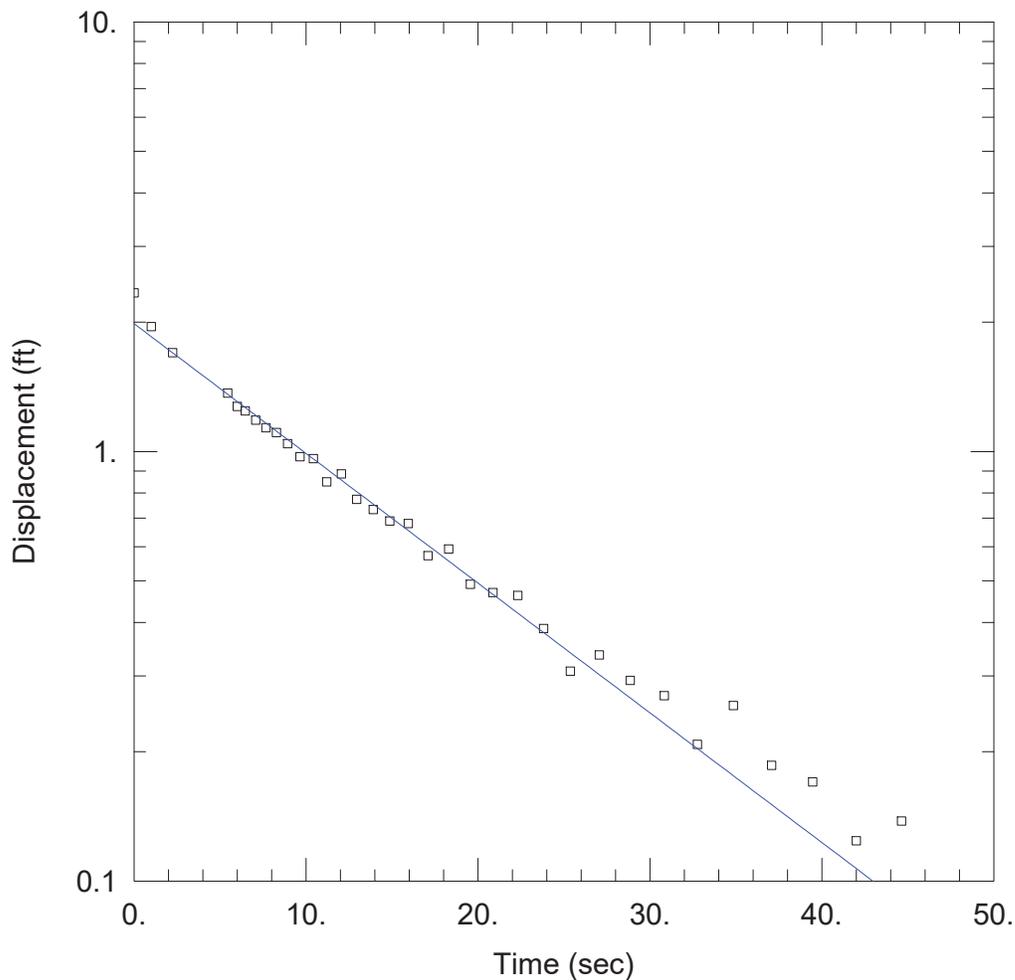
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.942 ft/day

Solution Method: Bouwer-Rice
 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)

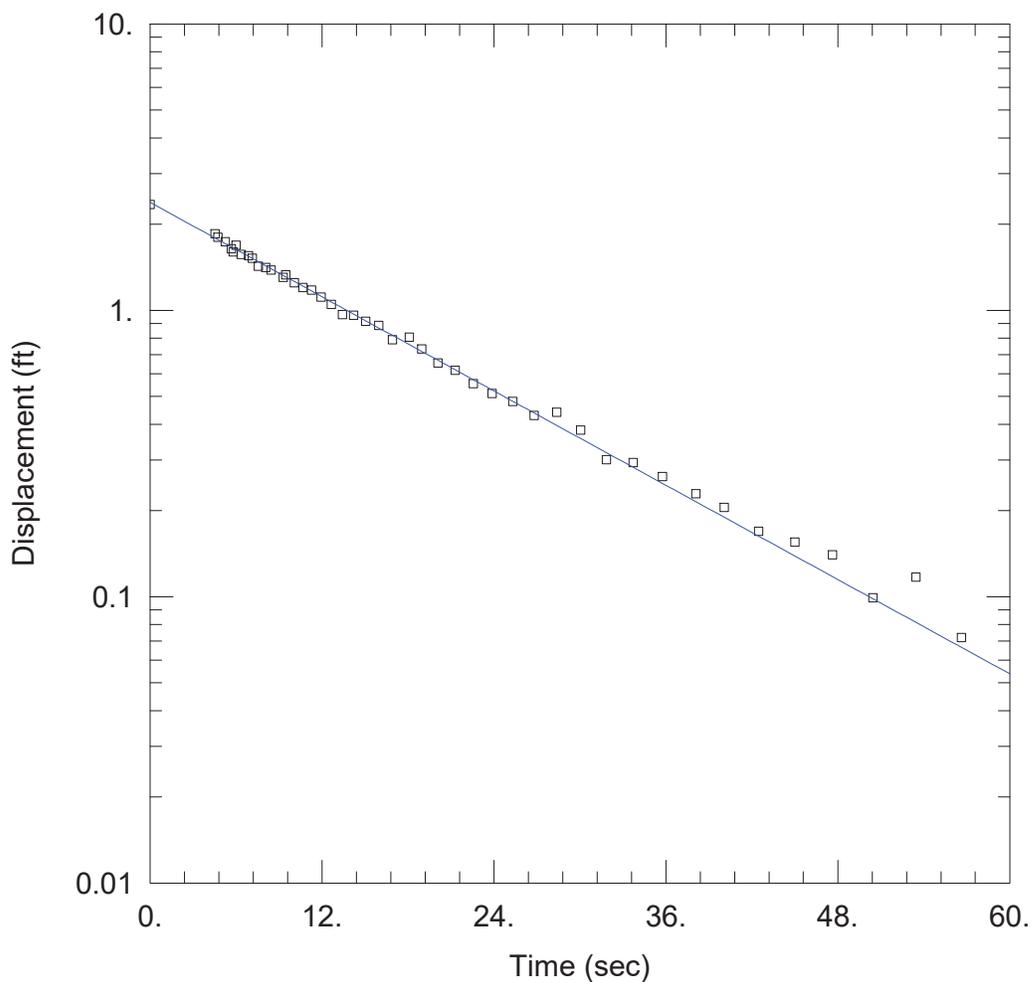
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.563 ft/day

Solution Method: Hvorslev
 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)

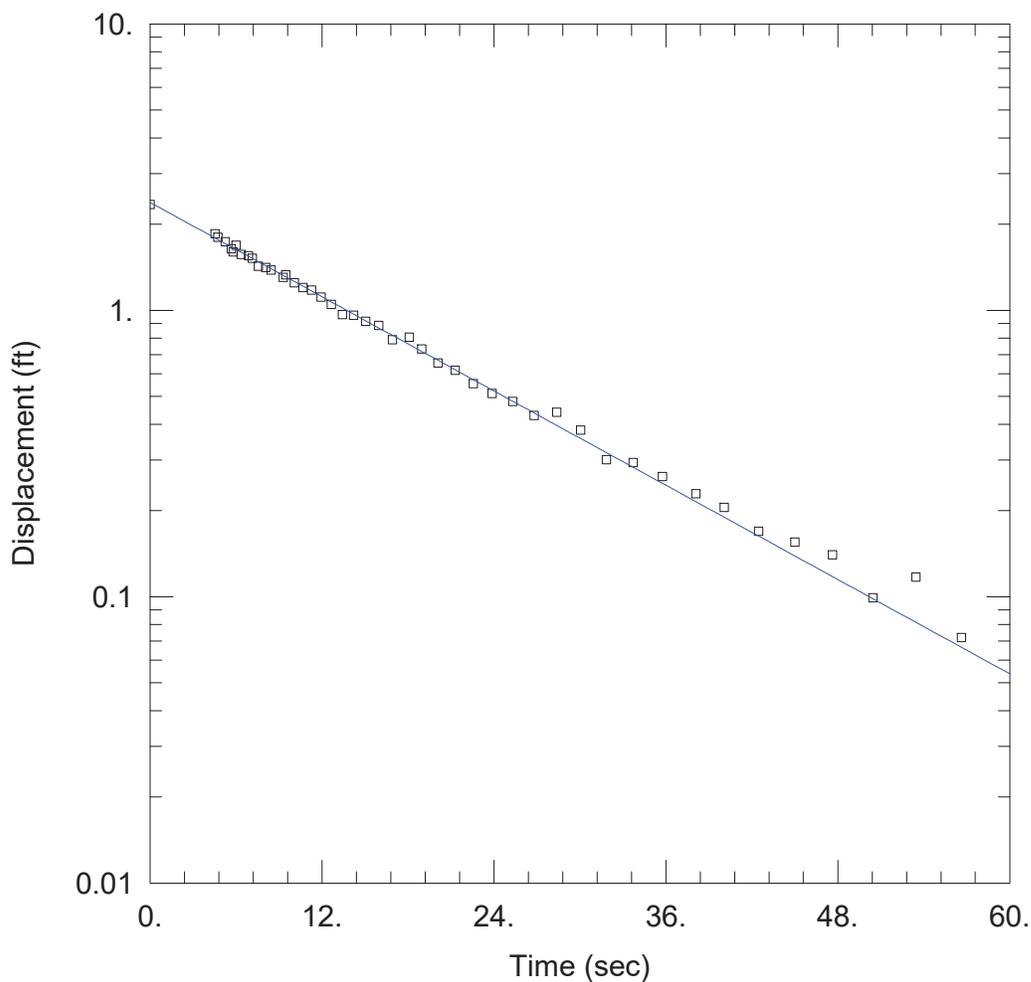
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.583 ft/day

Solution Method: Bouwer-Rice
 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)

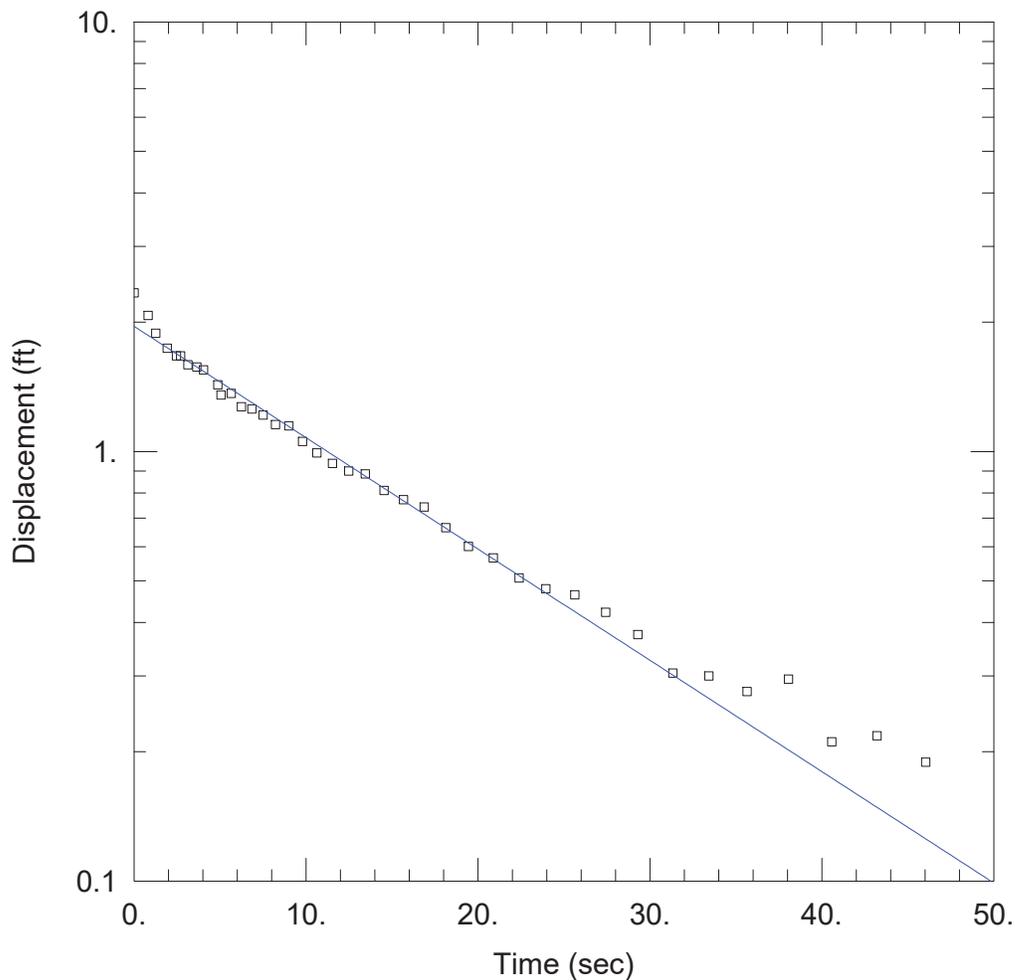
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.055 ft/day

Solution Method: Hvorslev
 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)

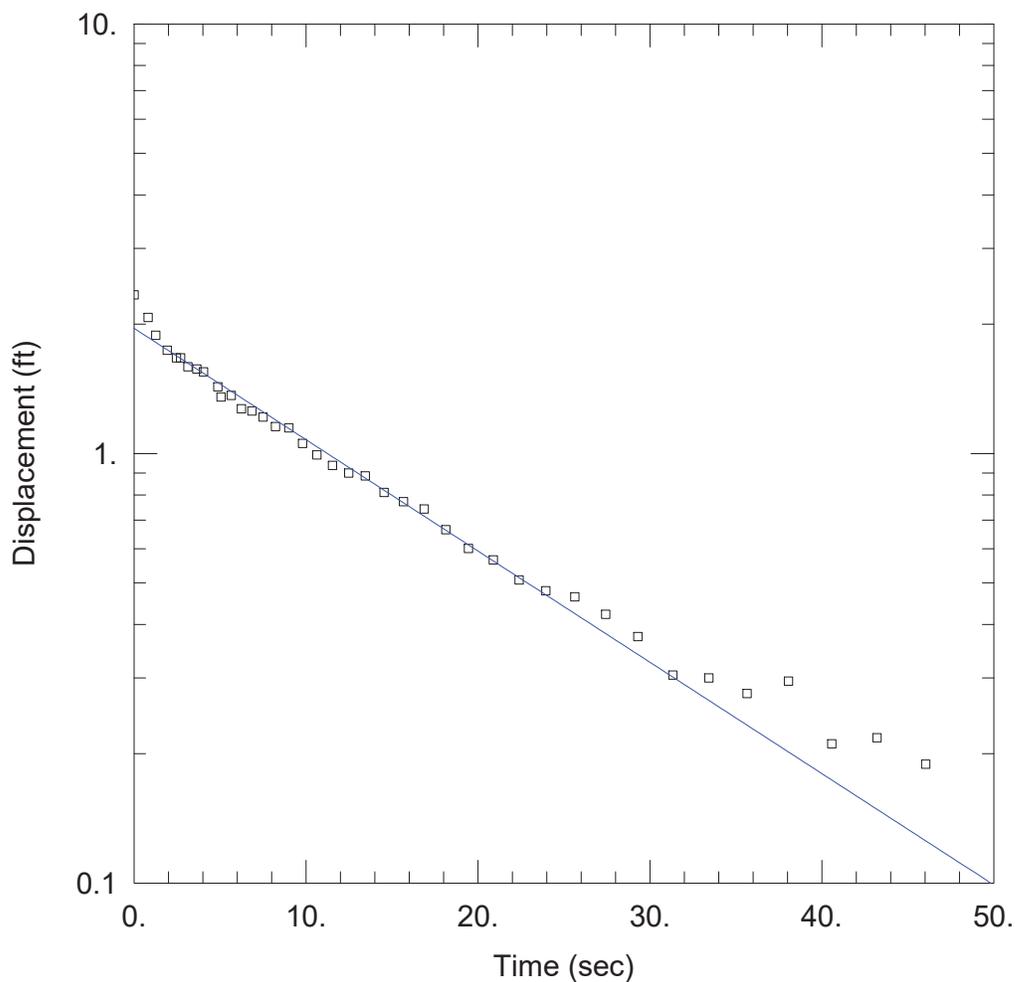
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.384 ft/day

Solution Method: Bouwer-Rice
 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)

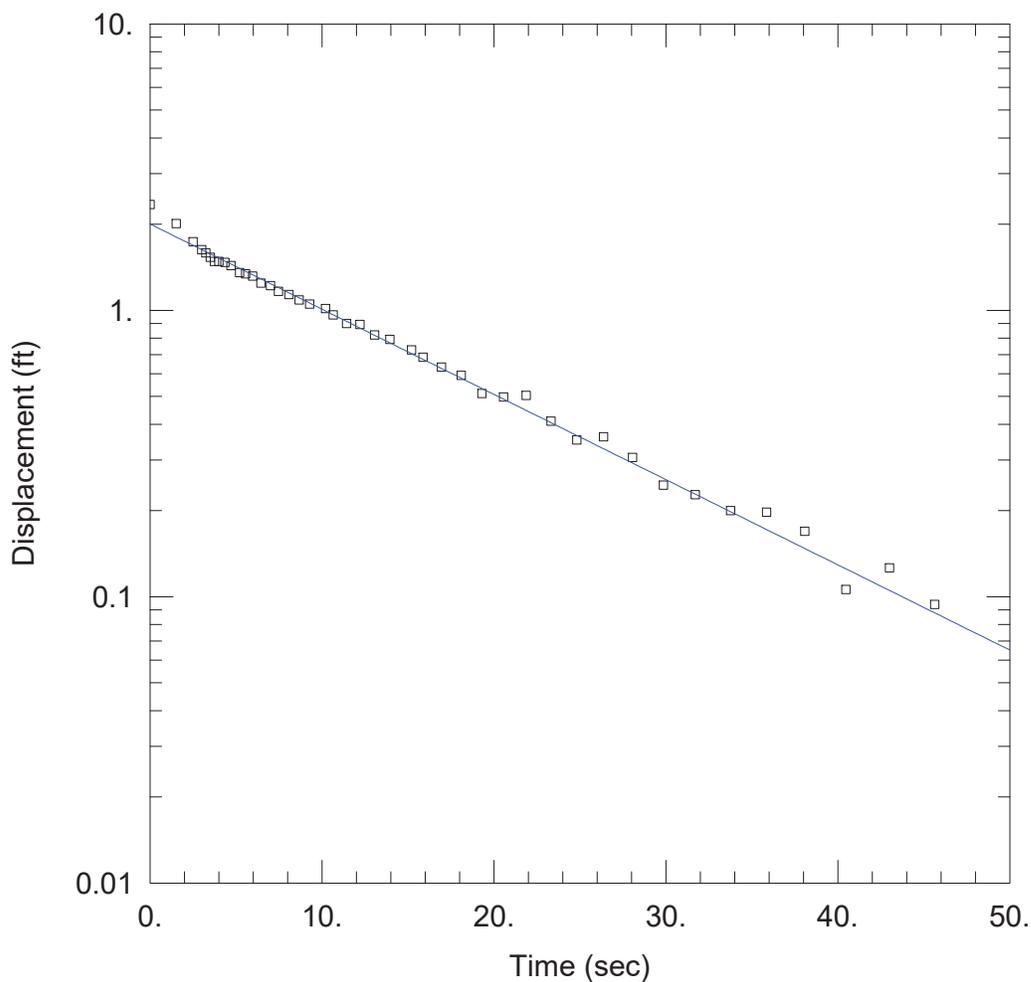
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.774 ft/day

Solution Method: Hvorslev
 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)

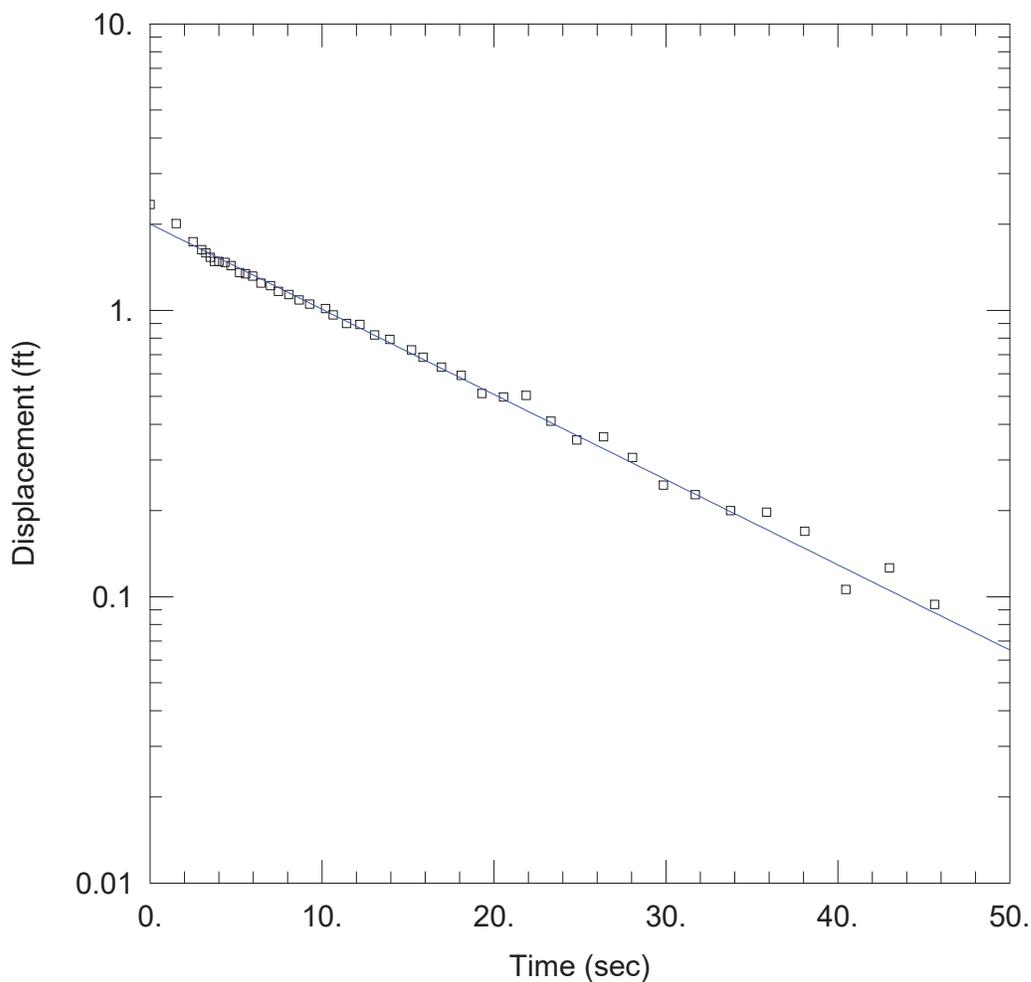
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.886 ft/day

Solution Method: Bouwer-Rice
 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)

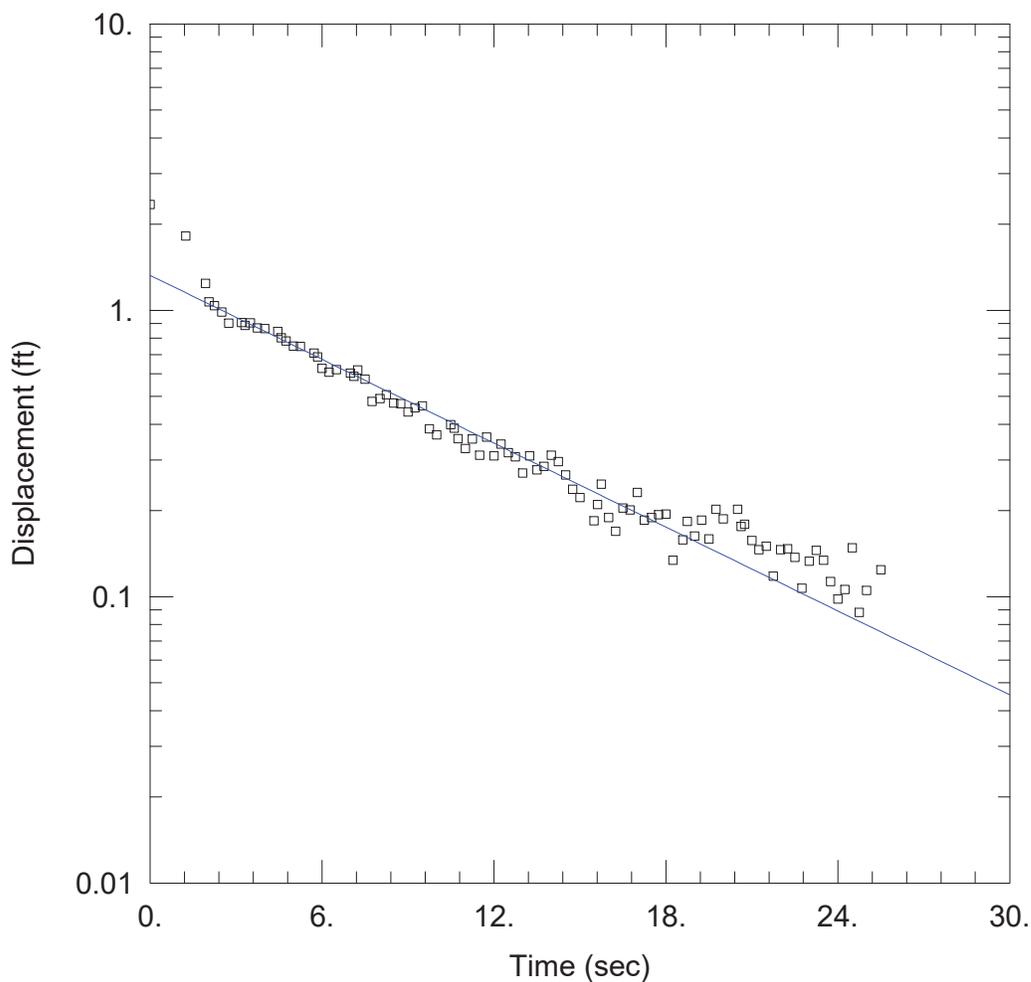
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 16. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 5.482 ft/day

Solution Method: Hvorslev
 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)

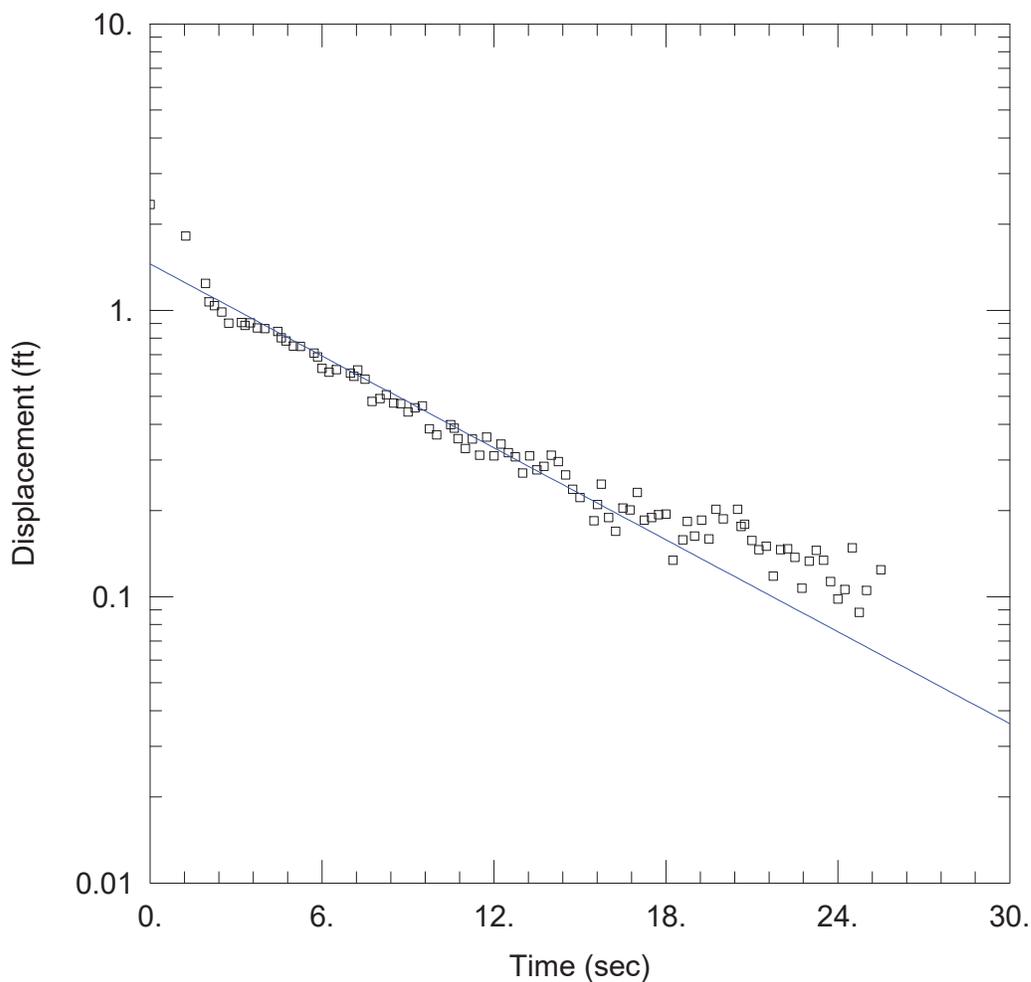
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 6.296 ft/day

Solution Method: Bouwer-Rice
 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)

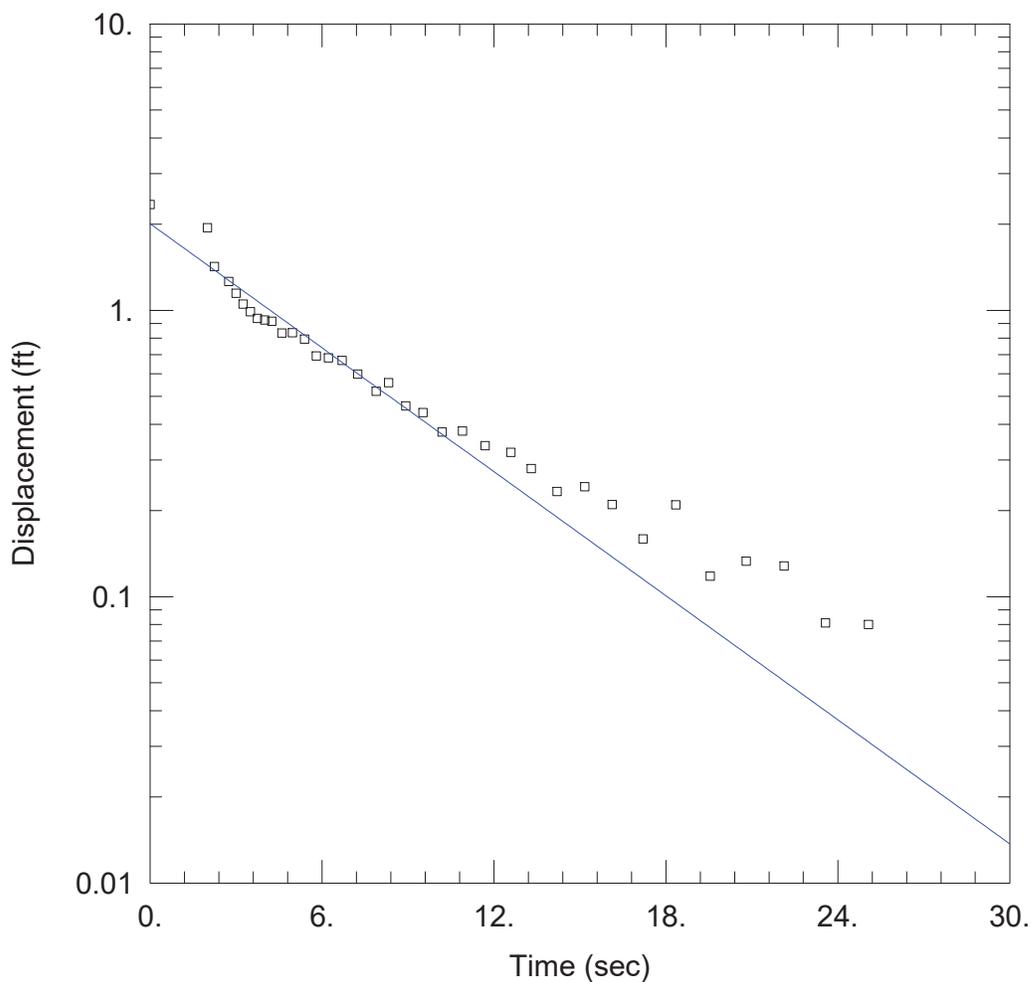
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 9.859 ft/day

Solution Method: Hvorslev
 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)

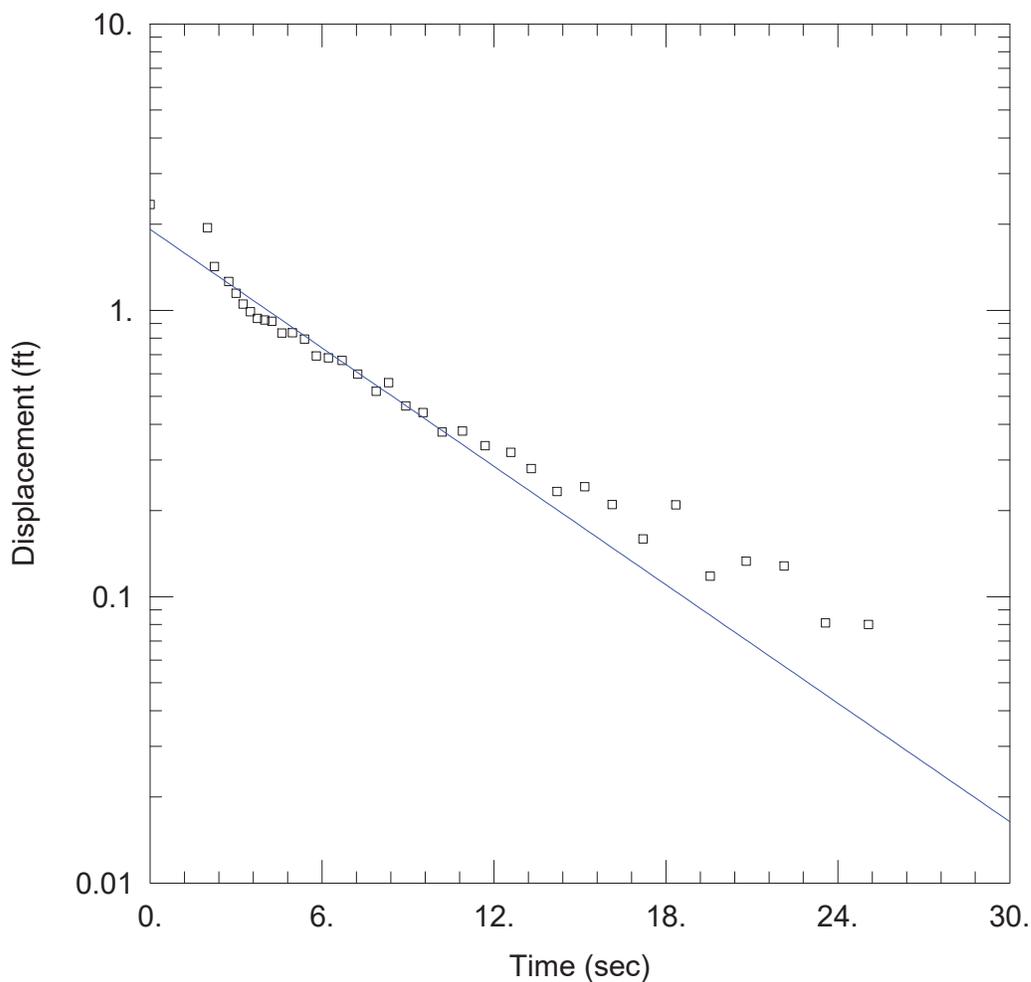
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 9.309 ft/day

Solution Method: Bouwer-Rice
 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)

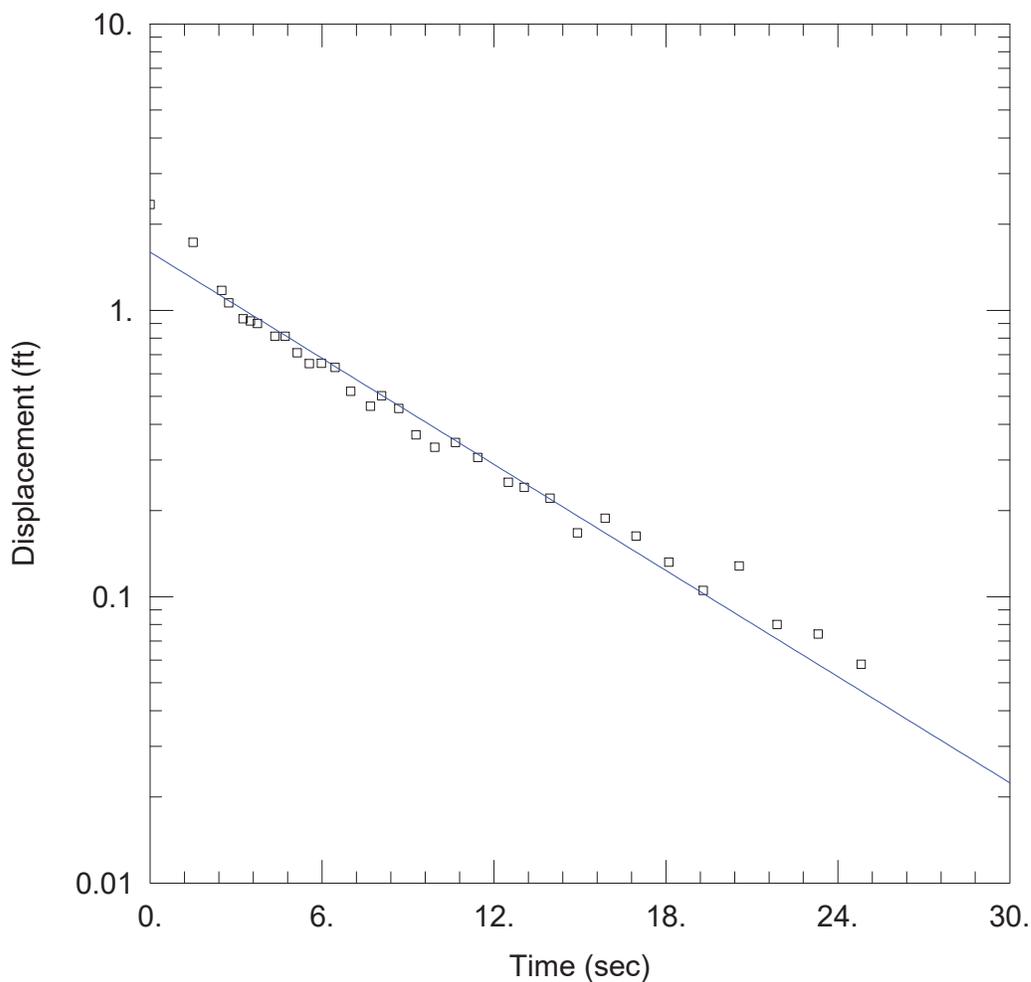
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 12.7 ft/day

Solution Method: Hvorslev
 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)

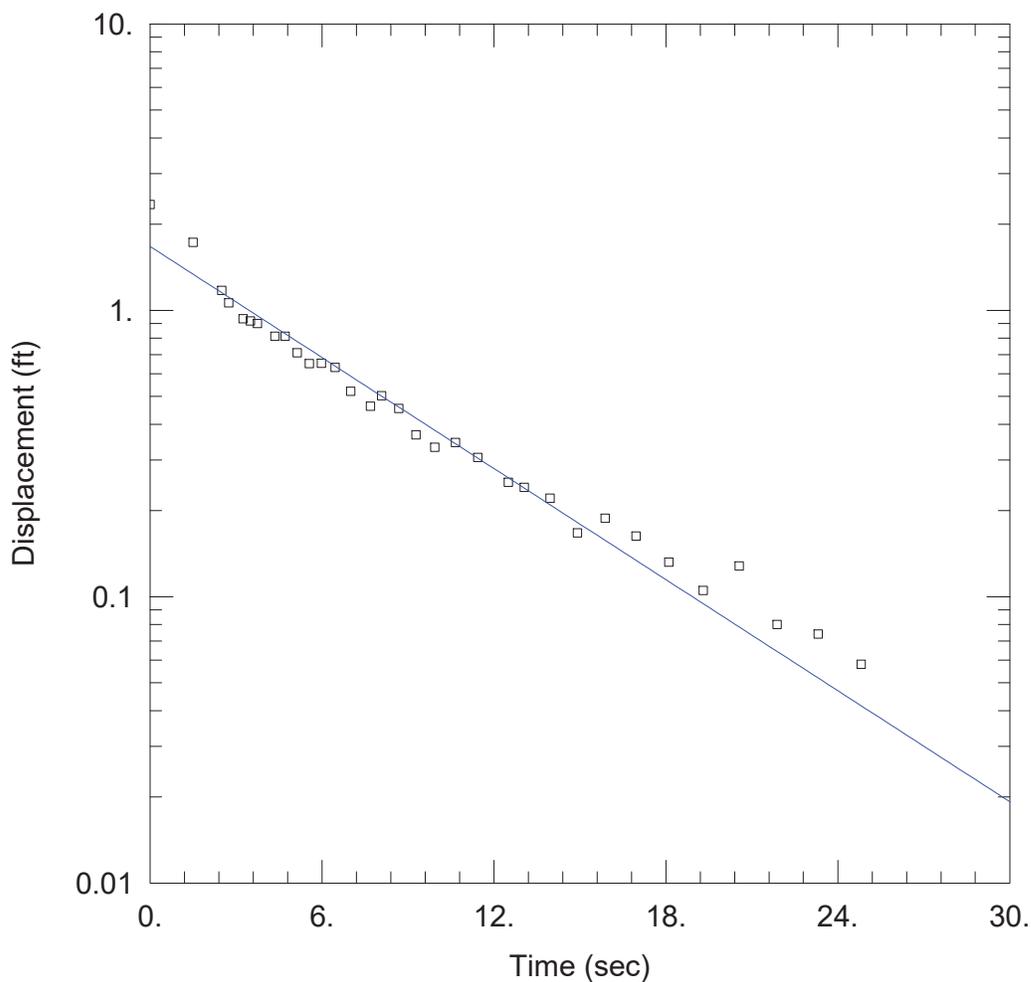
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.965 ft/day

Solution Method: Bouwer-Rice
 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)

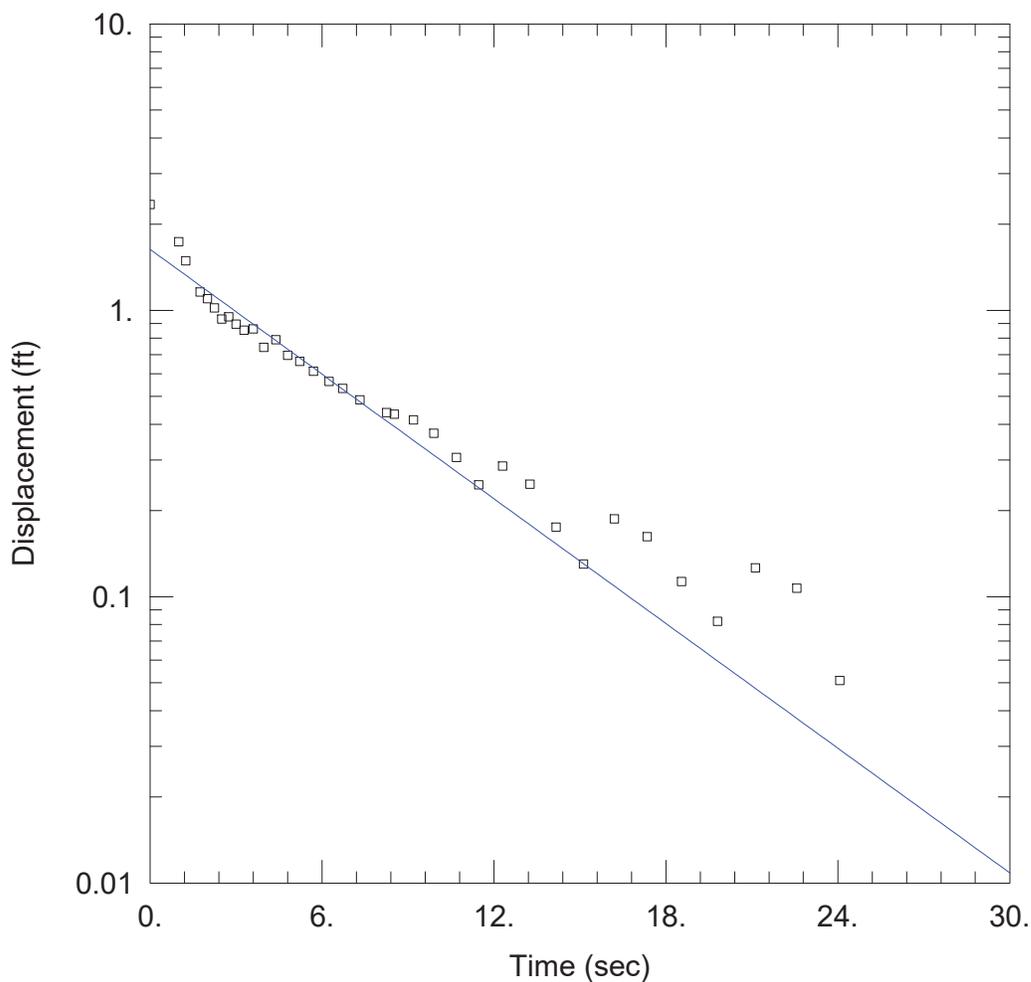
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 11.91 ft/day

Solution Method: Hvorslev
 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)

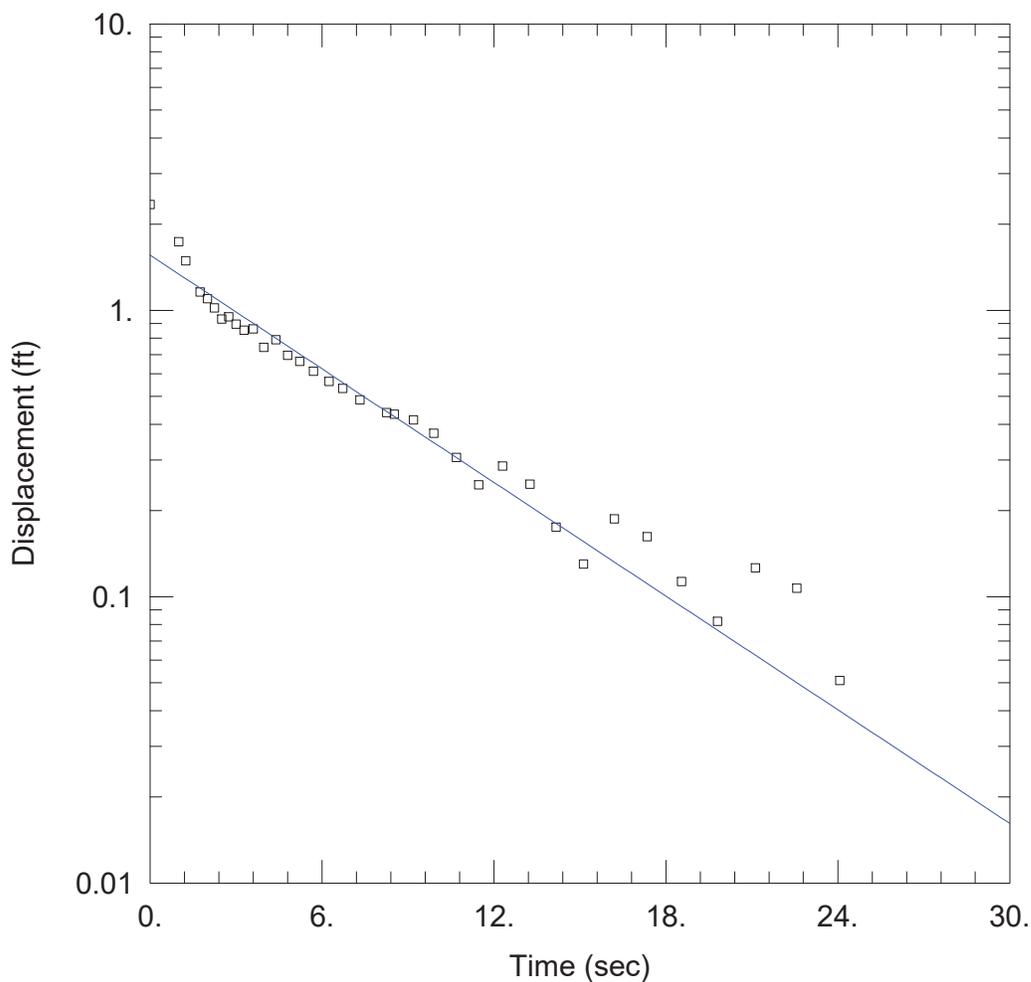
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 9.359 ft/day

Solution Method: Bouwer-Rice
 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)

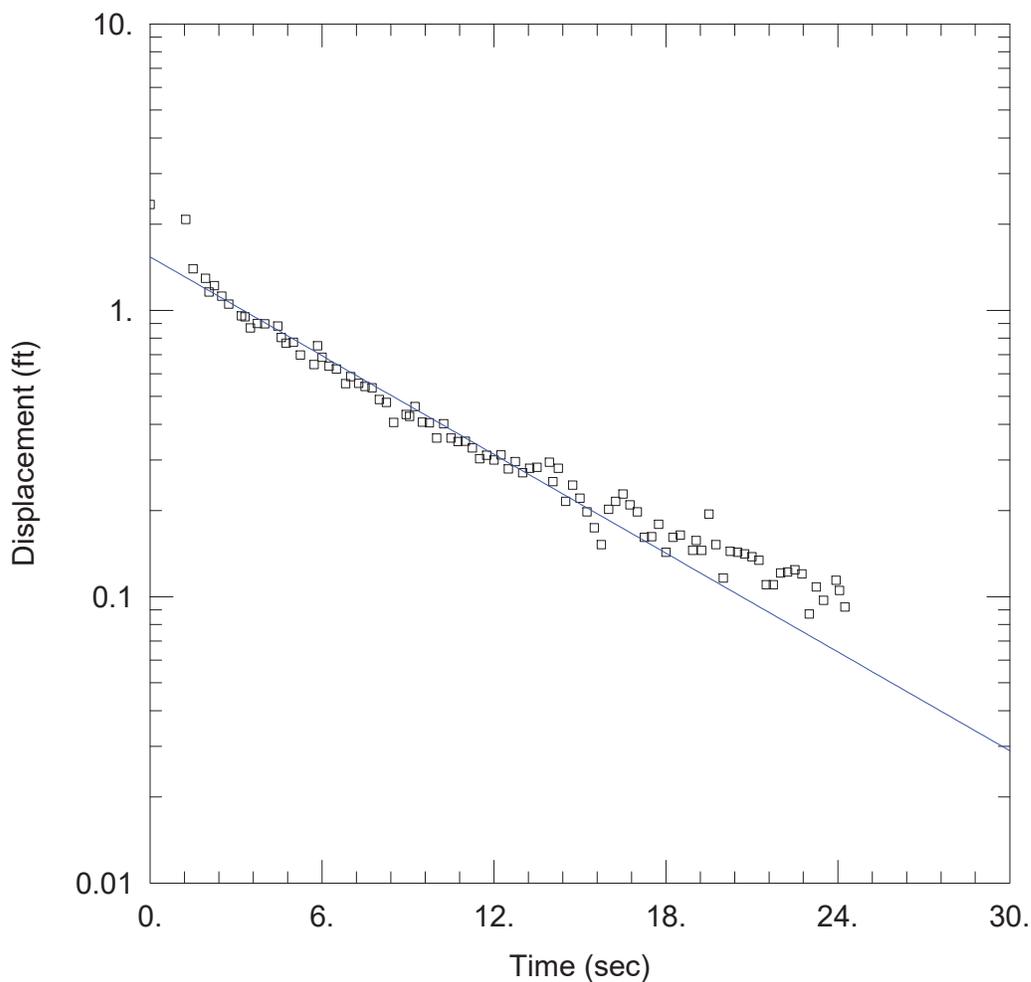
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 15. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73.2 ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 12.19 ft/day

Solution Method: Hvorslev
 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)

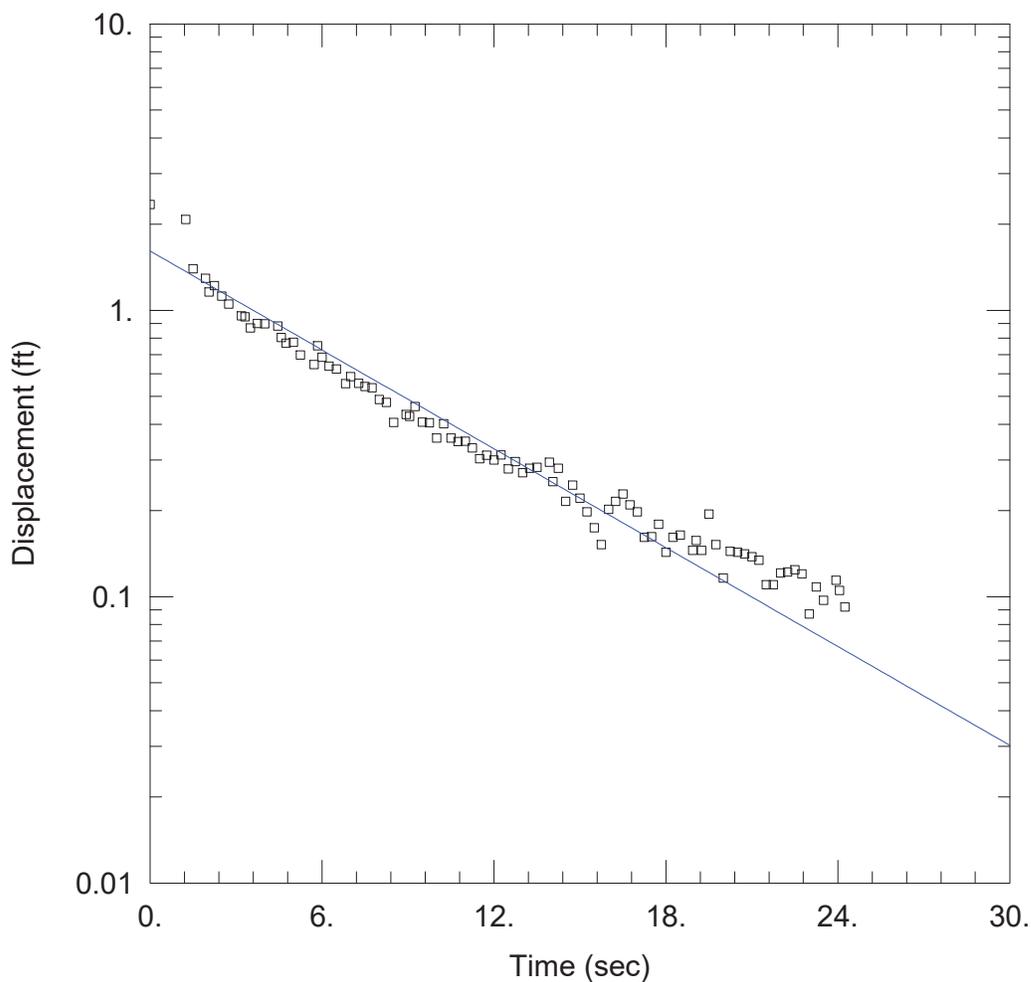
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.198 ft/day

Solution Method: Bouwer-Rice
 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)

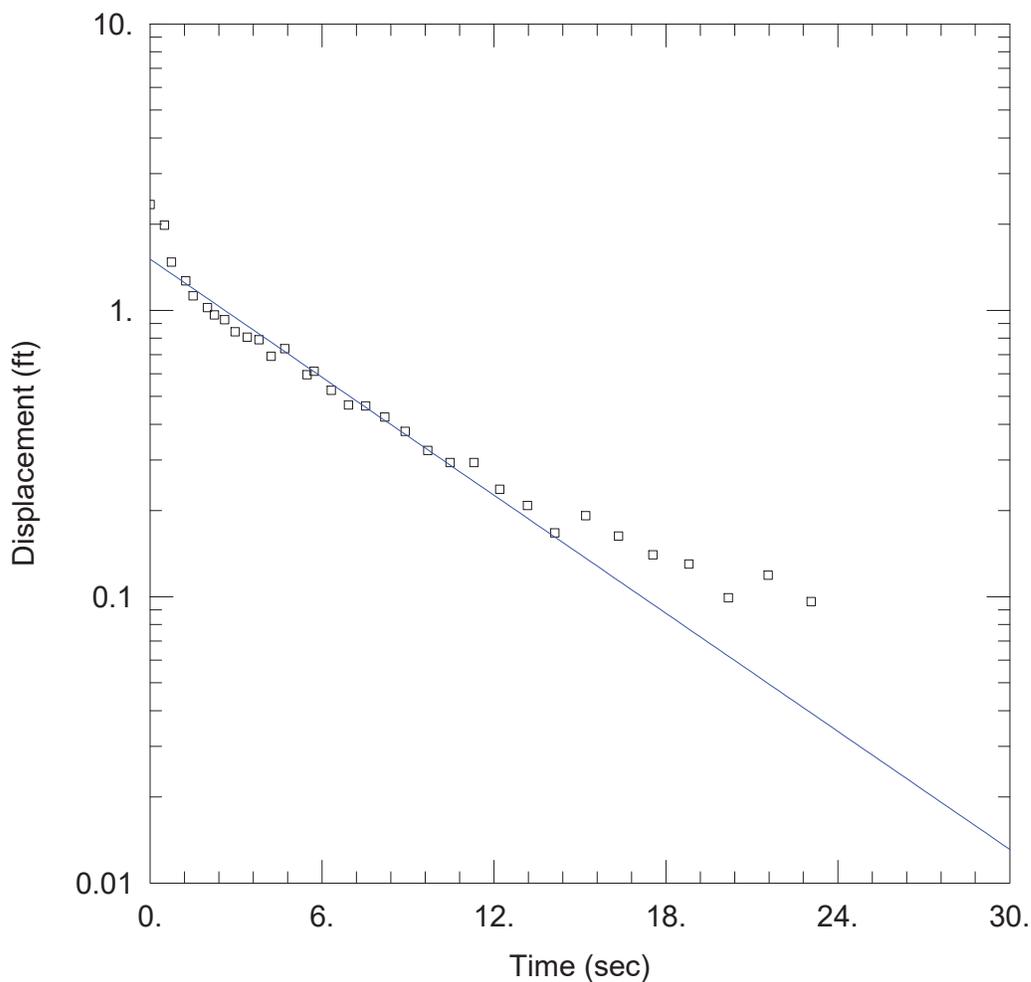
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 10.6 ft/day

Solution Method: Hvorslev
 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)

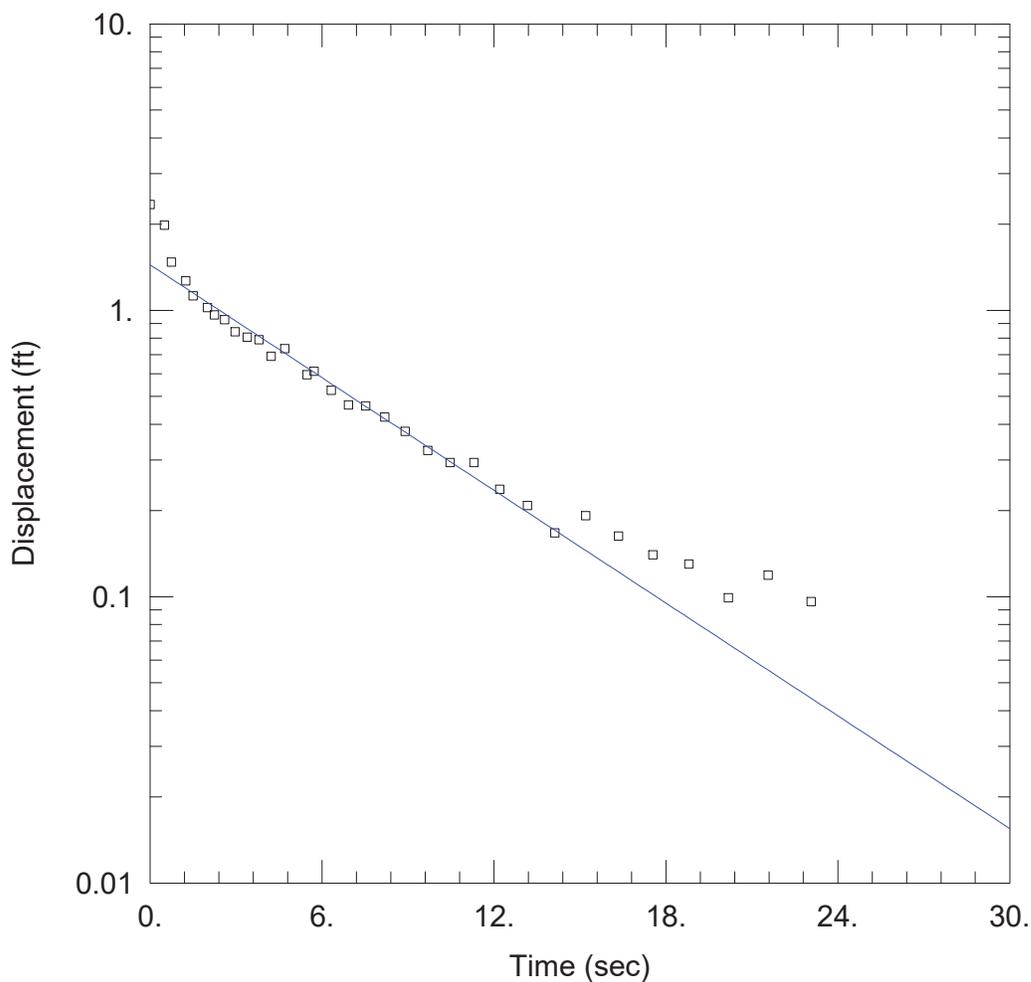
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 8.603 ft/day

Solution Method: Bouwer-Rice
 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)

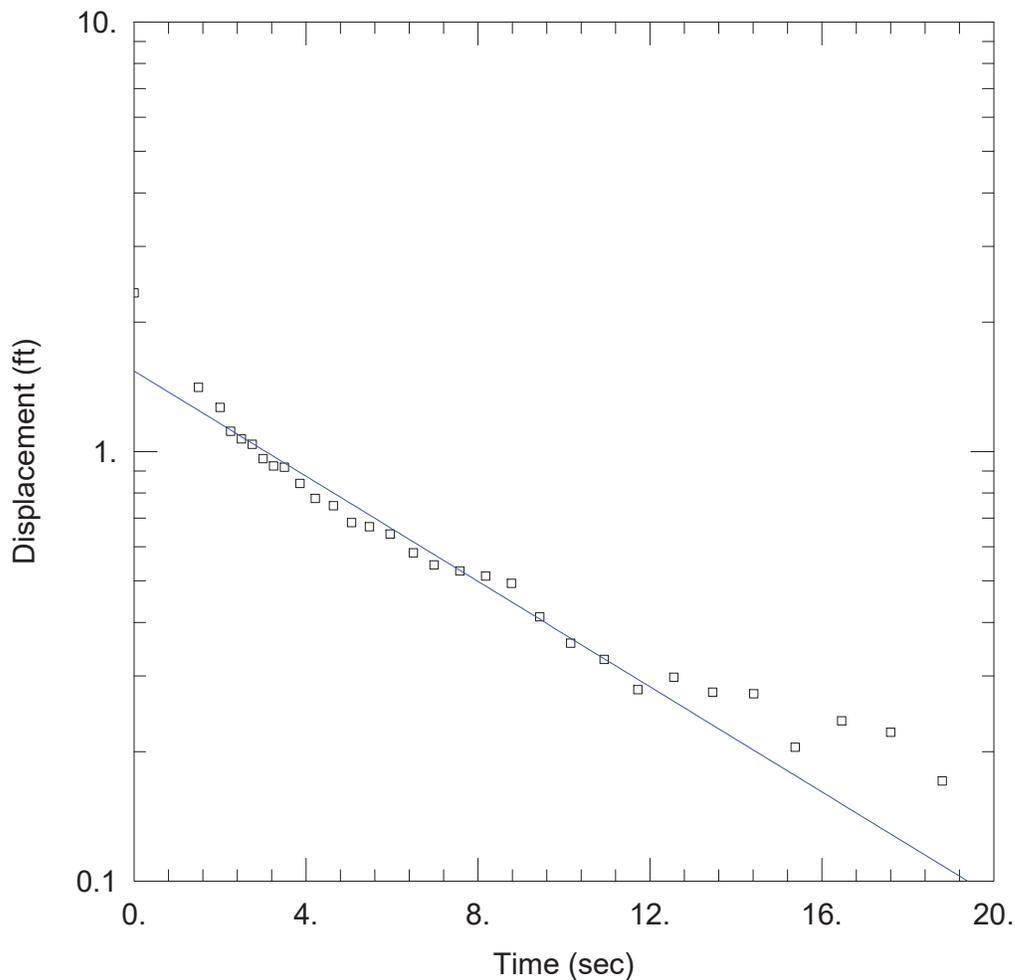
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 12.09 ft/day

Solution Method: Hvorslev
 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)

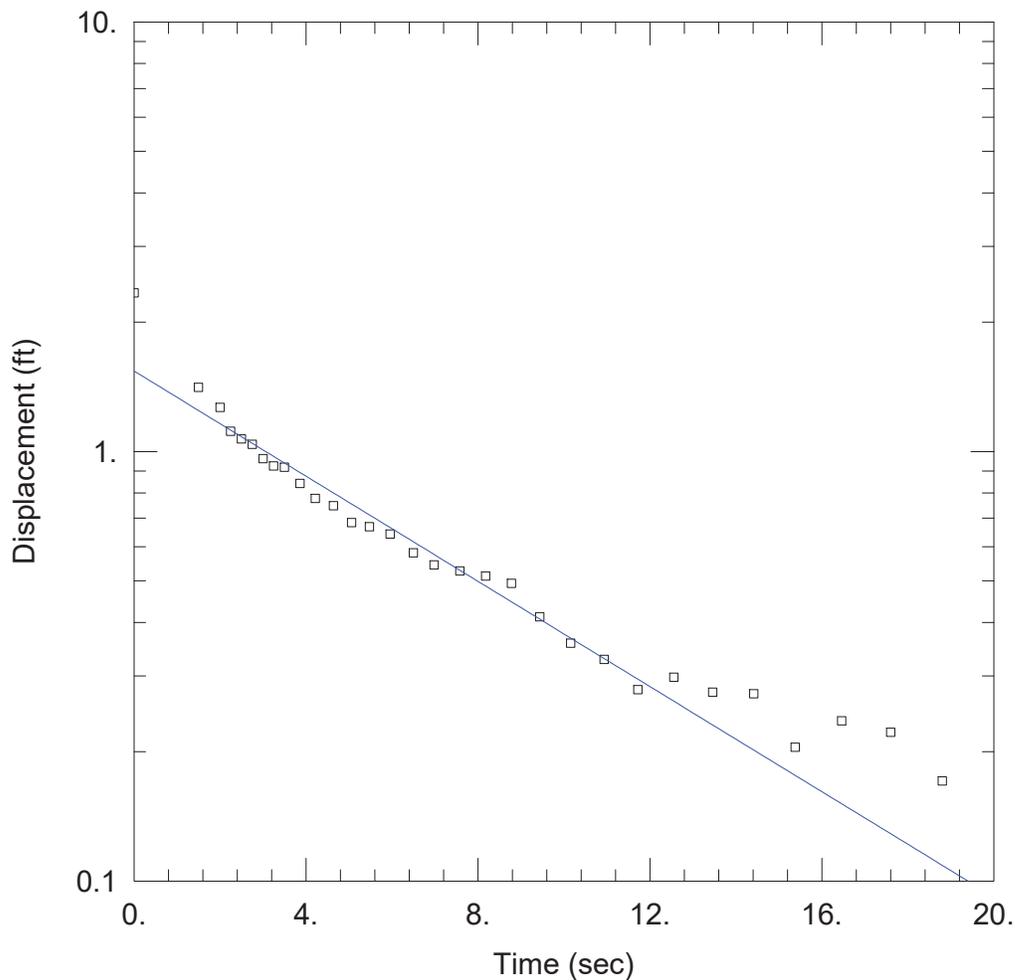
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.663 ft/day

Solution Method: Bouwer-Rice
 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)

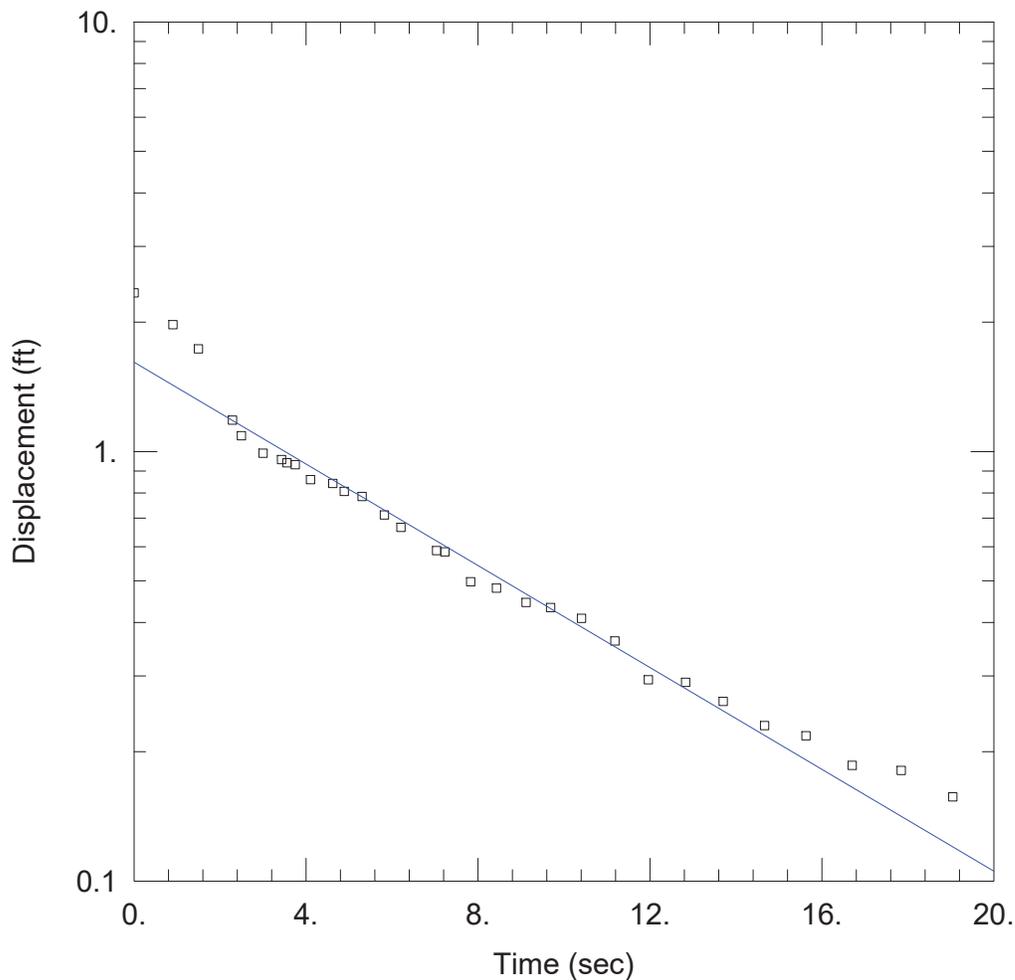
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 11.27 ft/day

Solution Method: Hvorslev
 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)

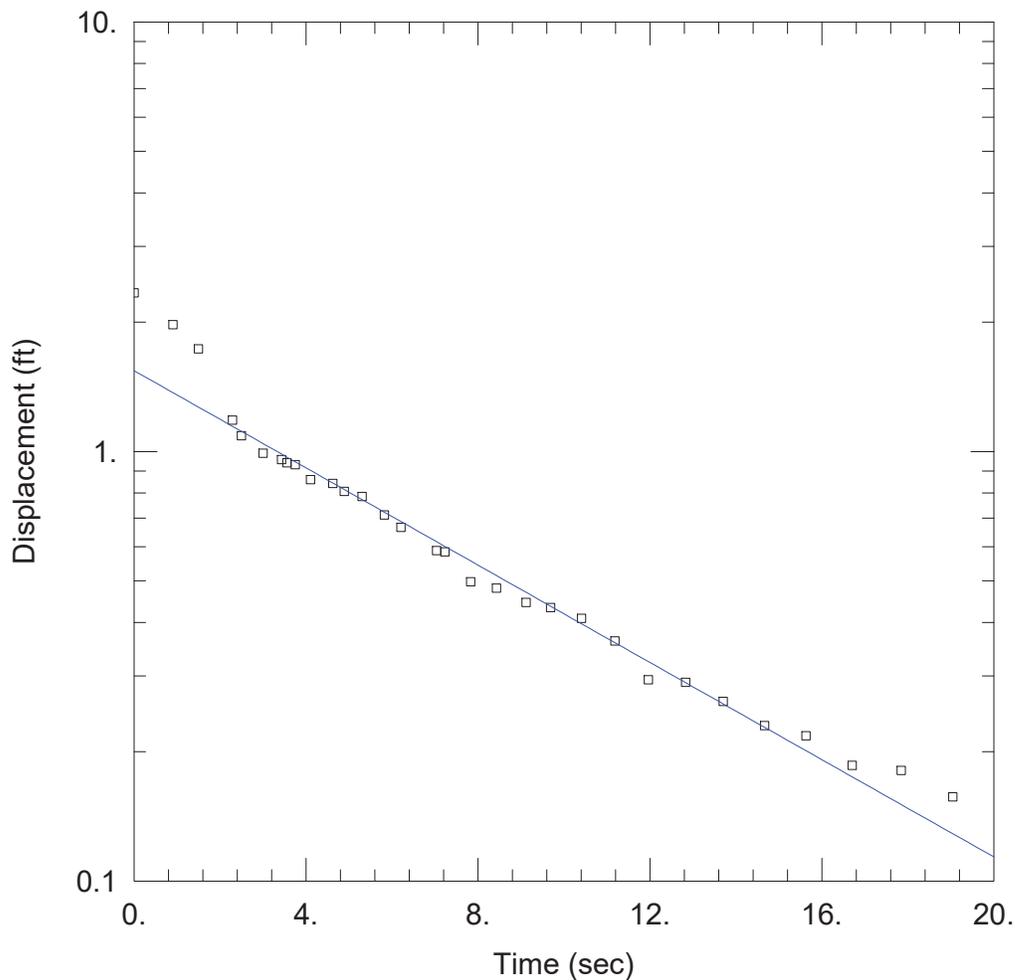
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 7.415 ft/day

Solution Method: Bouwer-Rice
 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)

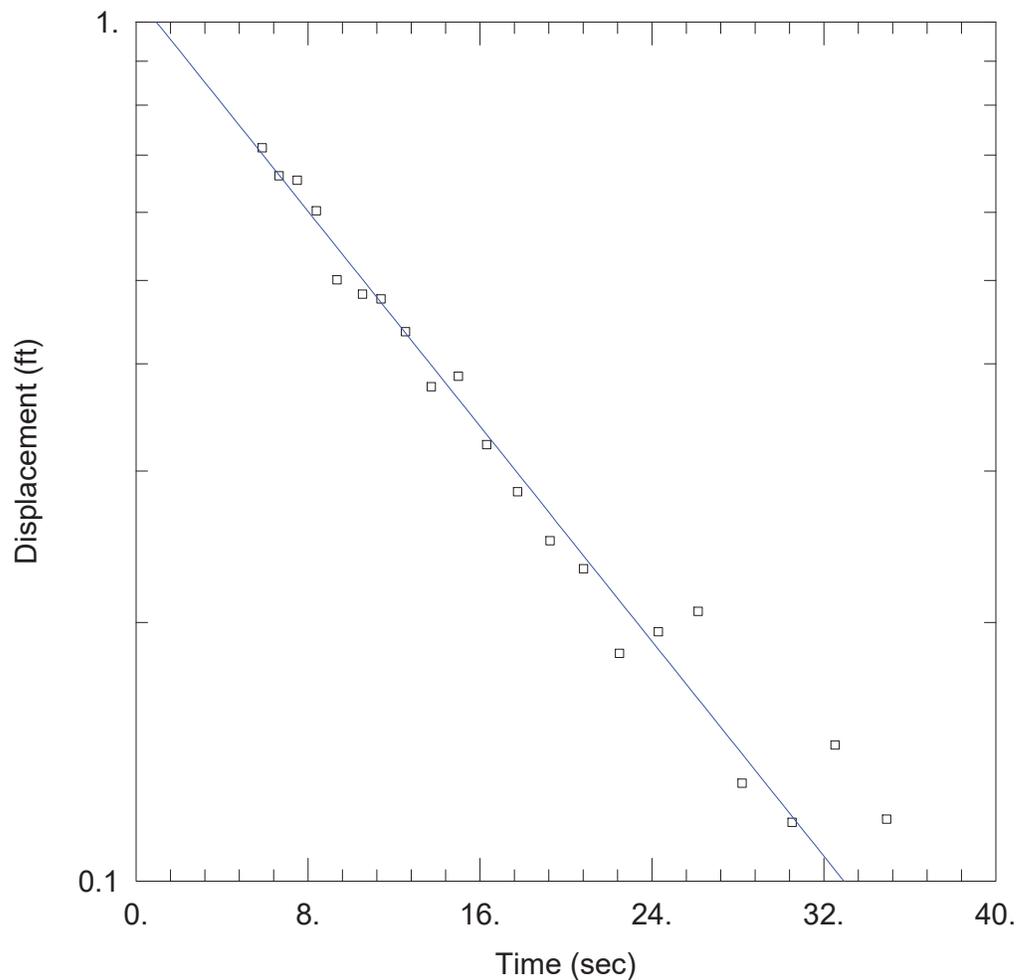
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 75. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 10.42 ft/day

Solution Method: Hvorslev
 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)

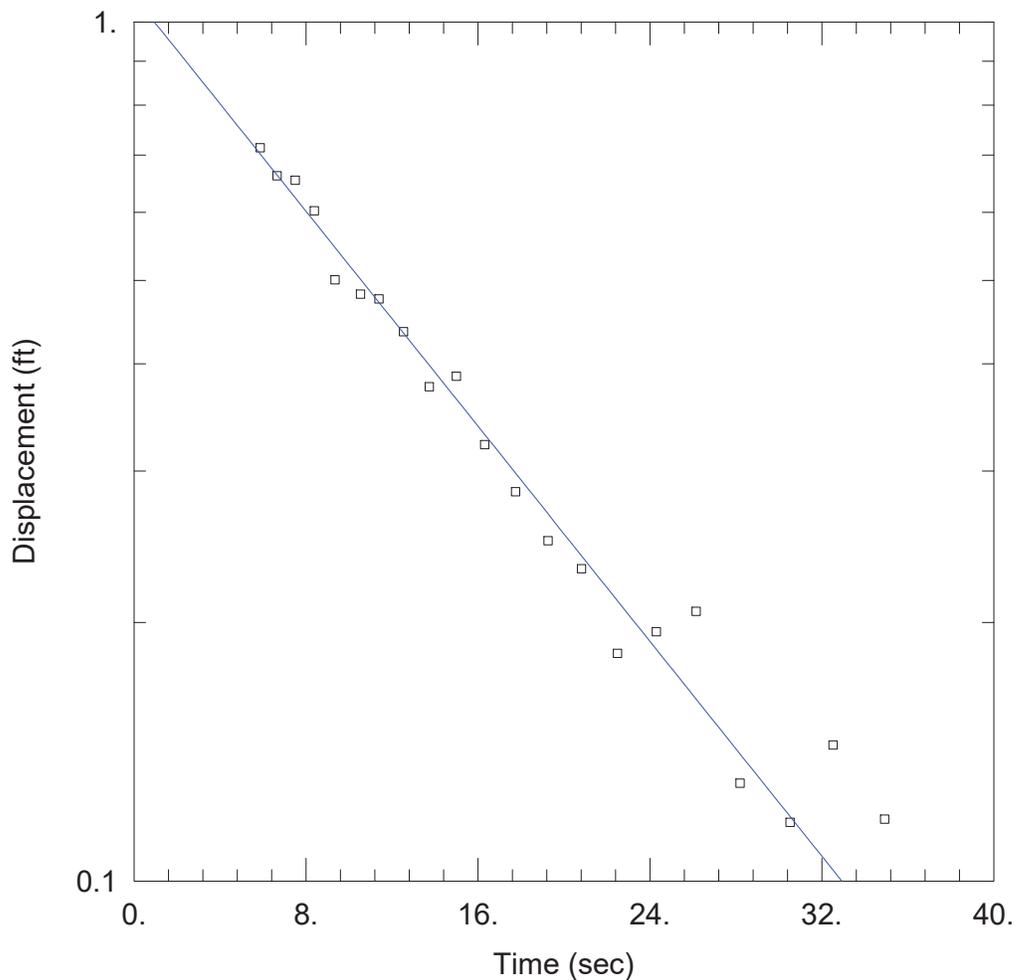
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.816 ft/day

Solution Method: Bouwer-Rice
 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)

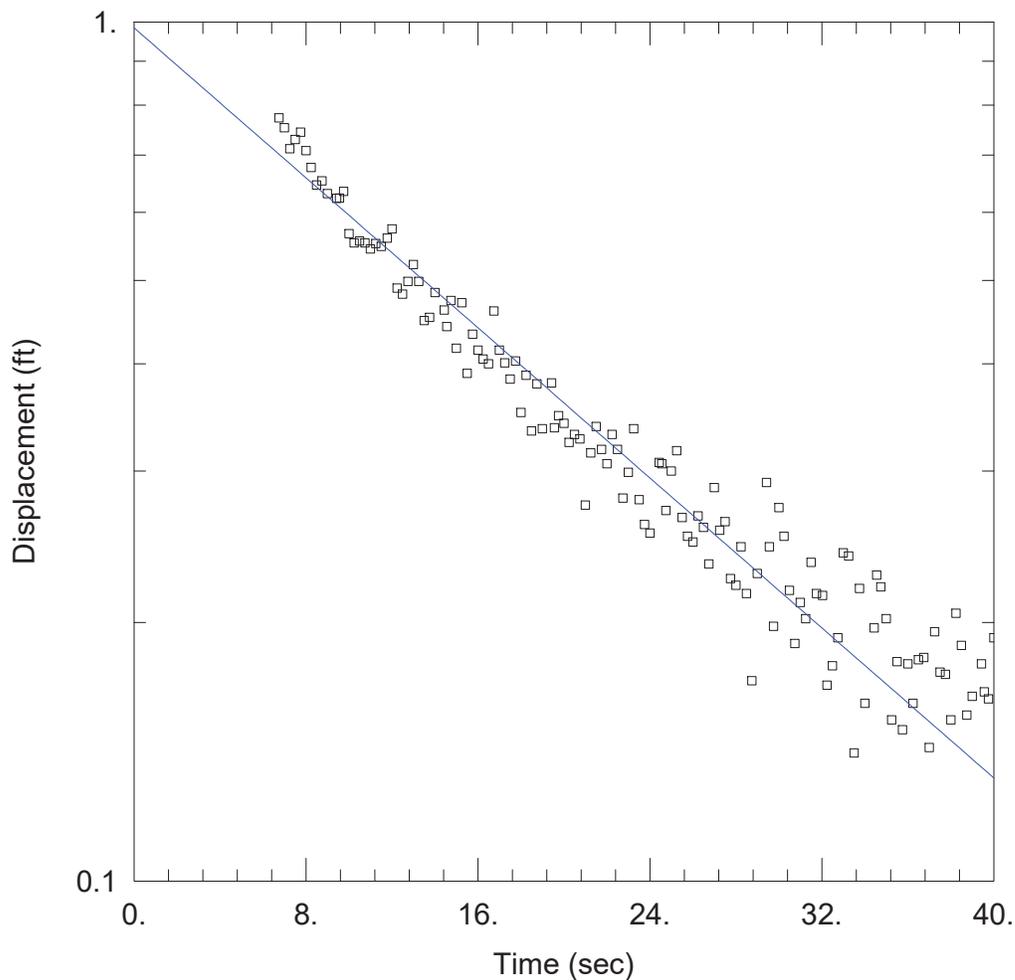
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 4.849 ft/day

Solution Method: Hvorslev
 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 (K_z/K_r): 1.

WELL DATA (JR MW-16007)

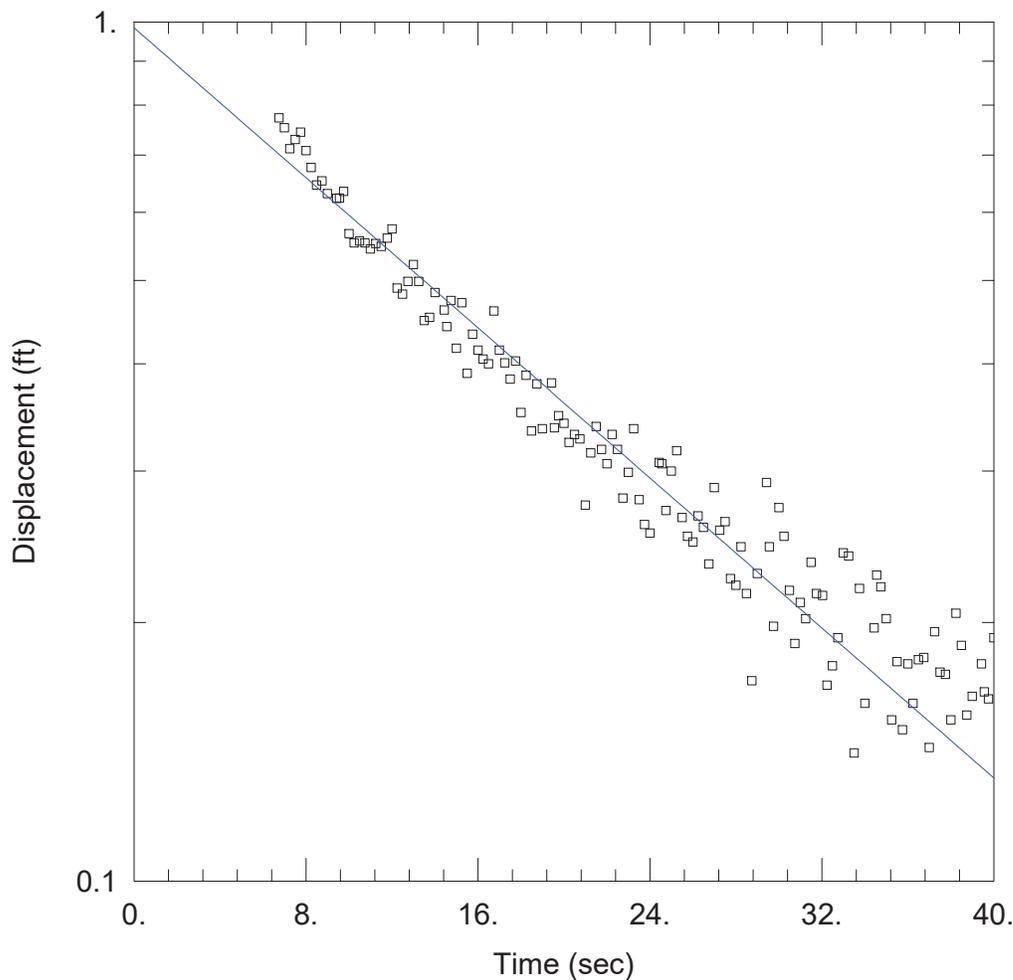
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 2.664 ft/day

Solution Method: Bower-Rice
 y_0 = 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 (K_z/K_r): 1.

WELL DATA (JR MW-16007)

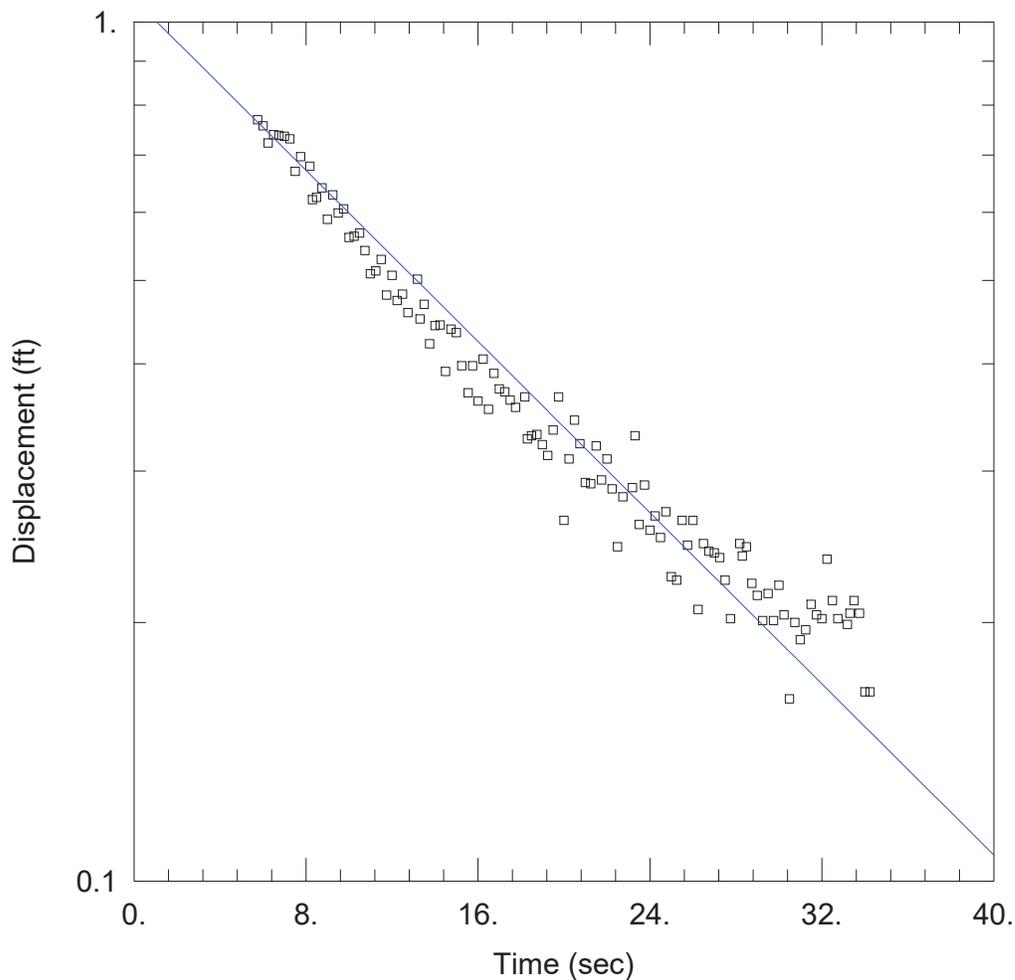
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.385 ft/day

Solution Method: Hvorslev
 y_0 = 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)

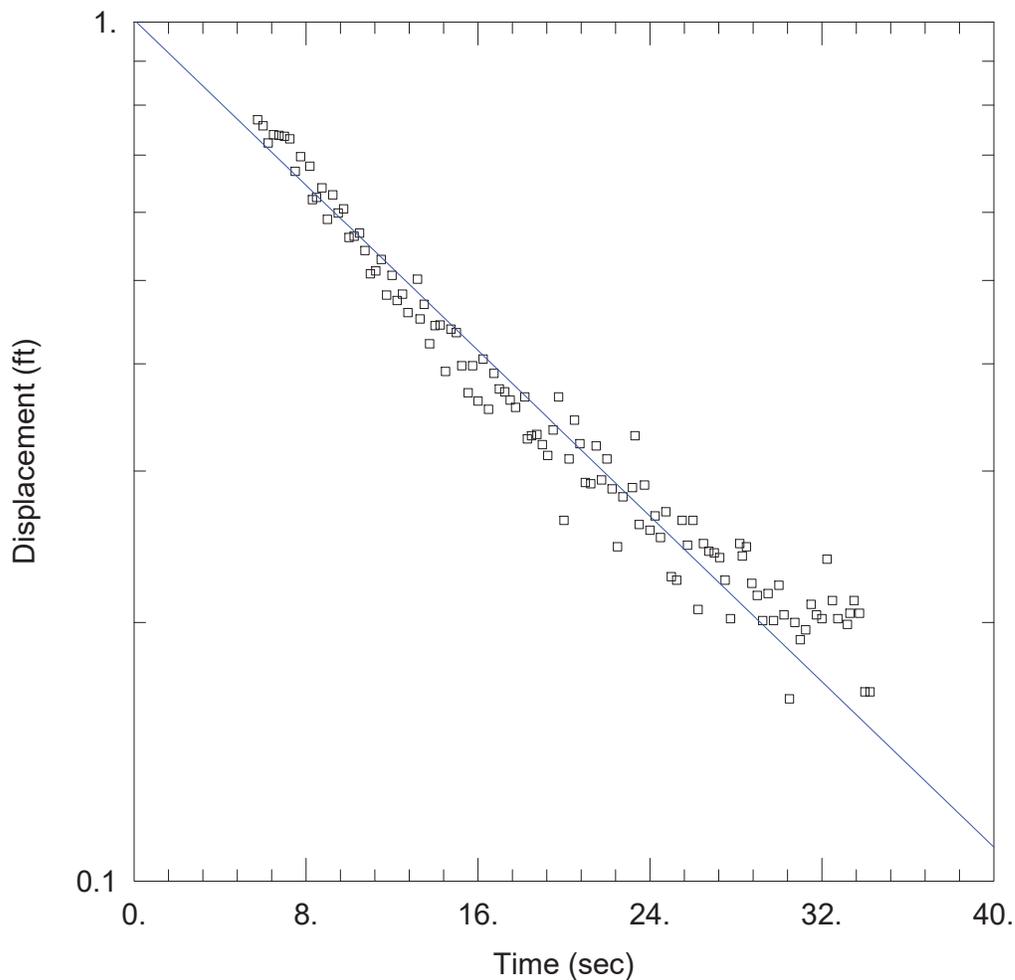
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.04 ft/day

Solution Method: Bowyer-Rice
 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)

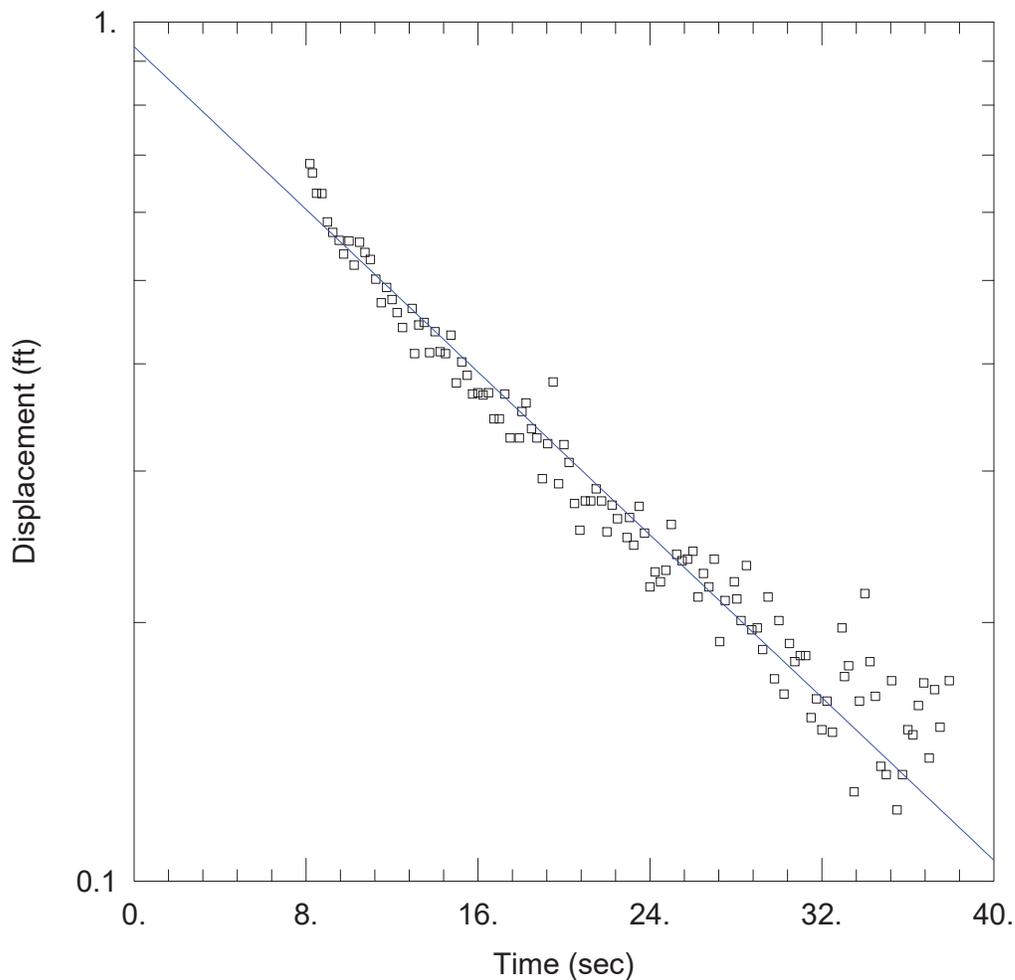
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.734 ft/day

Solution Method: Hvorslev
 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 (K_z/K_r): 1.

WELL DATA (JR MW-16007)

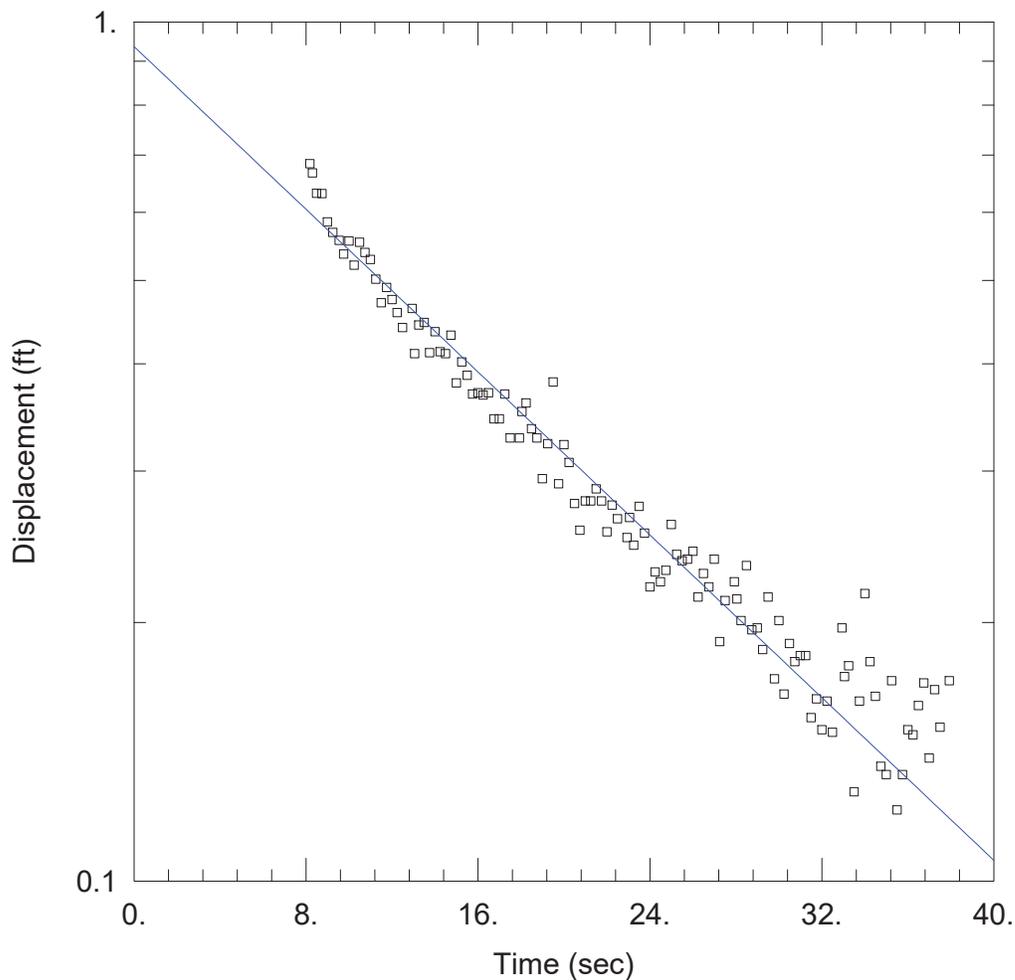
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 $K = 2.889$ ft/day

Solution Method: Bower-Rice
 $y_0 = 0.9357$ 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 (K_z/K_r): 1.

WELL DATA (JR MW-16007)

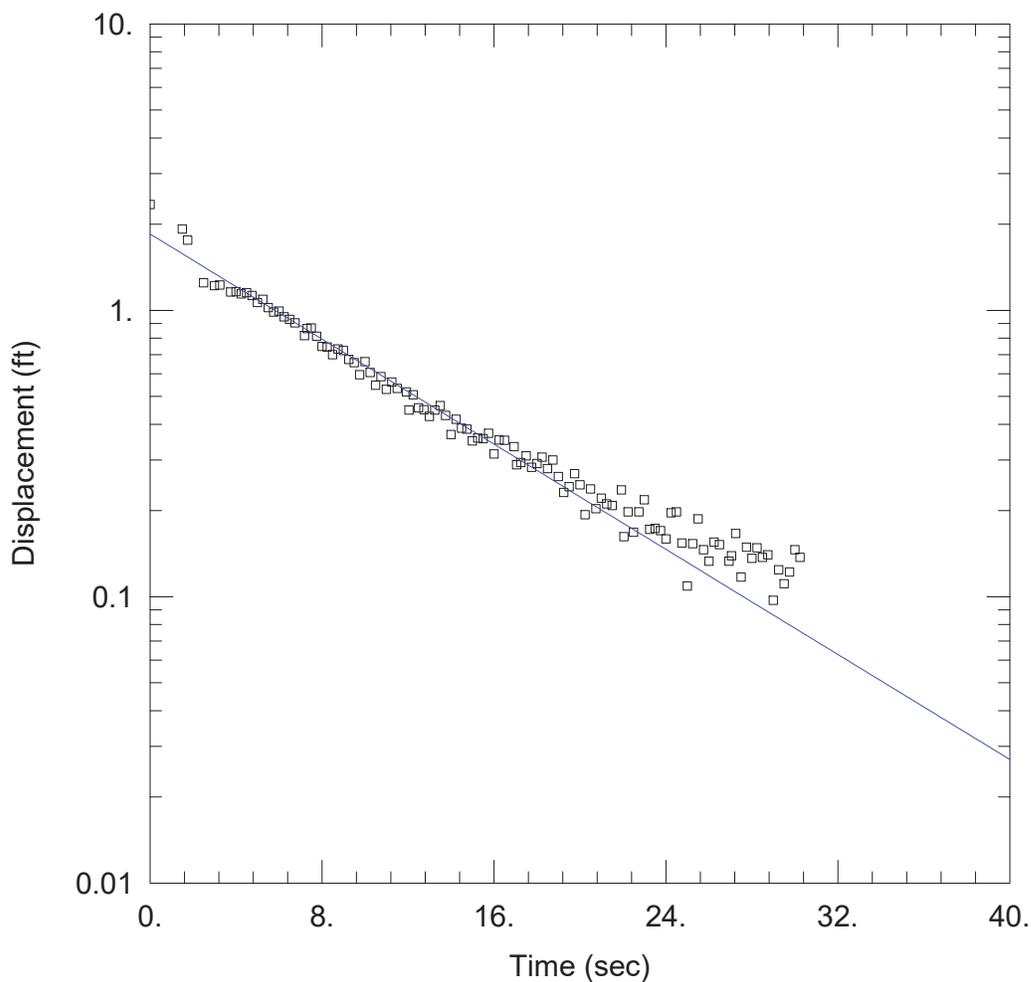
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 14. ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 73. ft
 Screen Length: 10. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 3.671 ft/day

Solution Method: Hvorslev
 y_0 = 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)

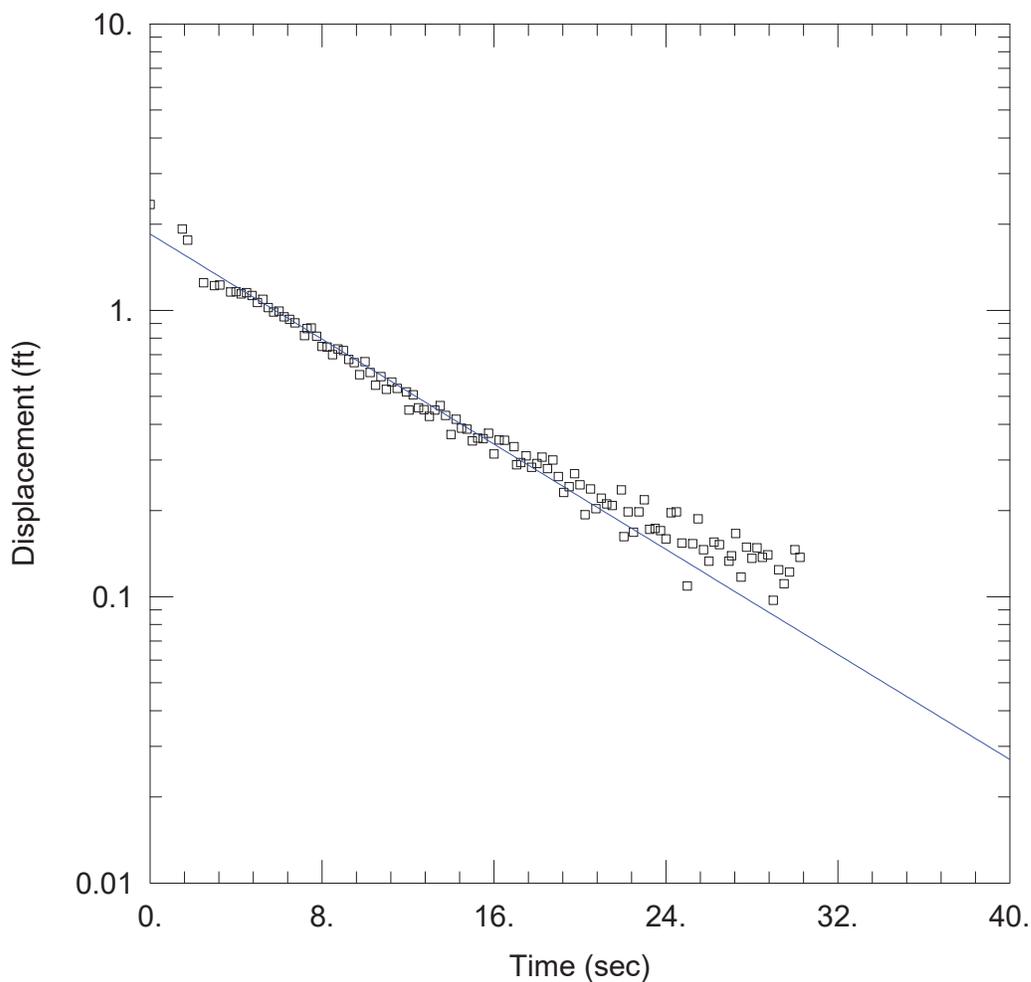
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 8.826 ft/day

Solution Method: Bouwer-Rice
 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 (K_z/K_r): 1.

WELL DATA (JR MW-16008)

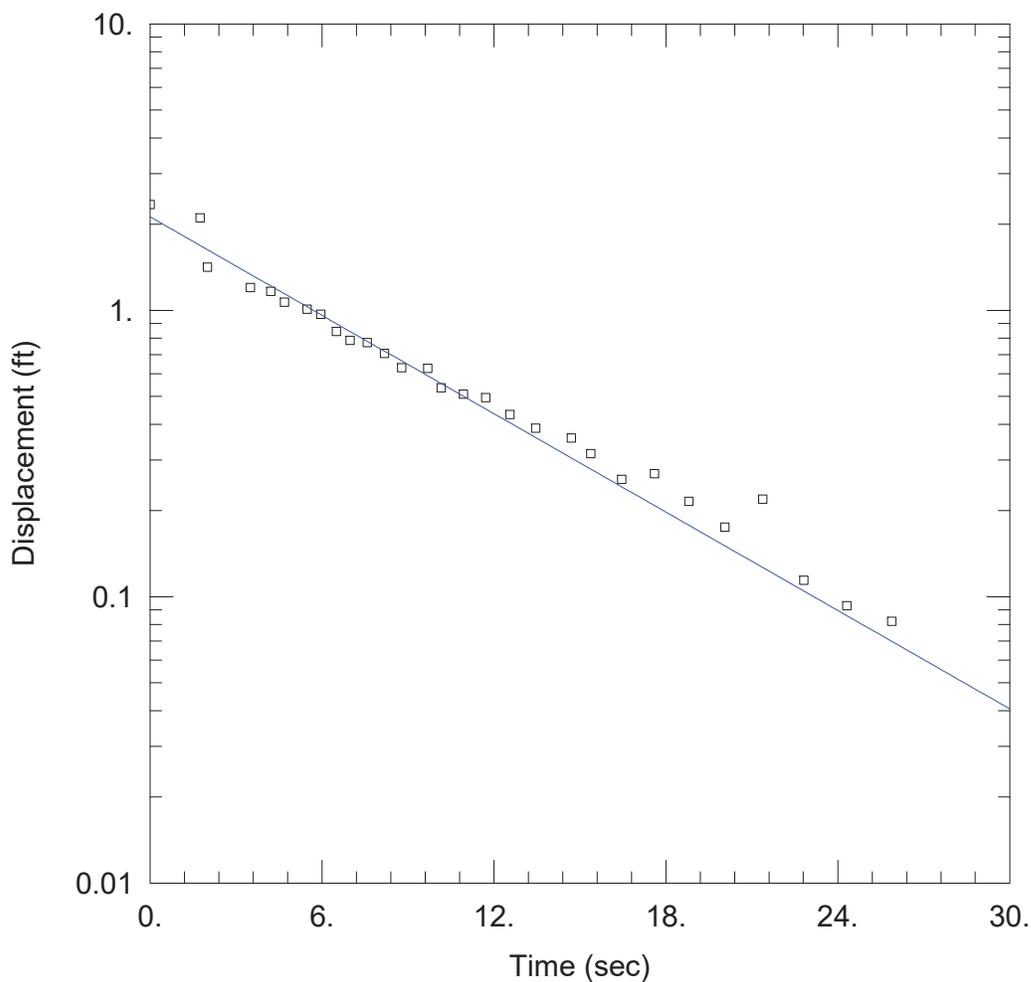
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 11.56 ft/day

Solution Method: Hvorslev
 y_0 = 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)

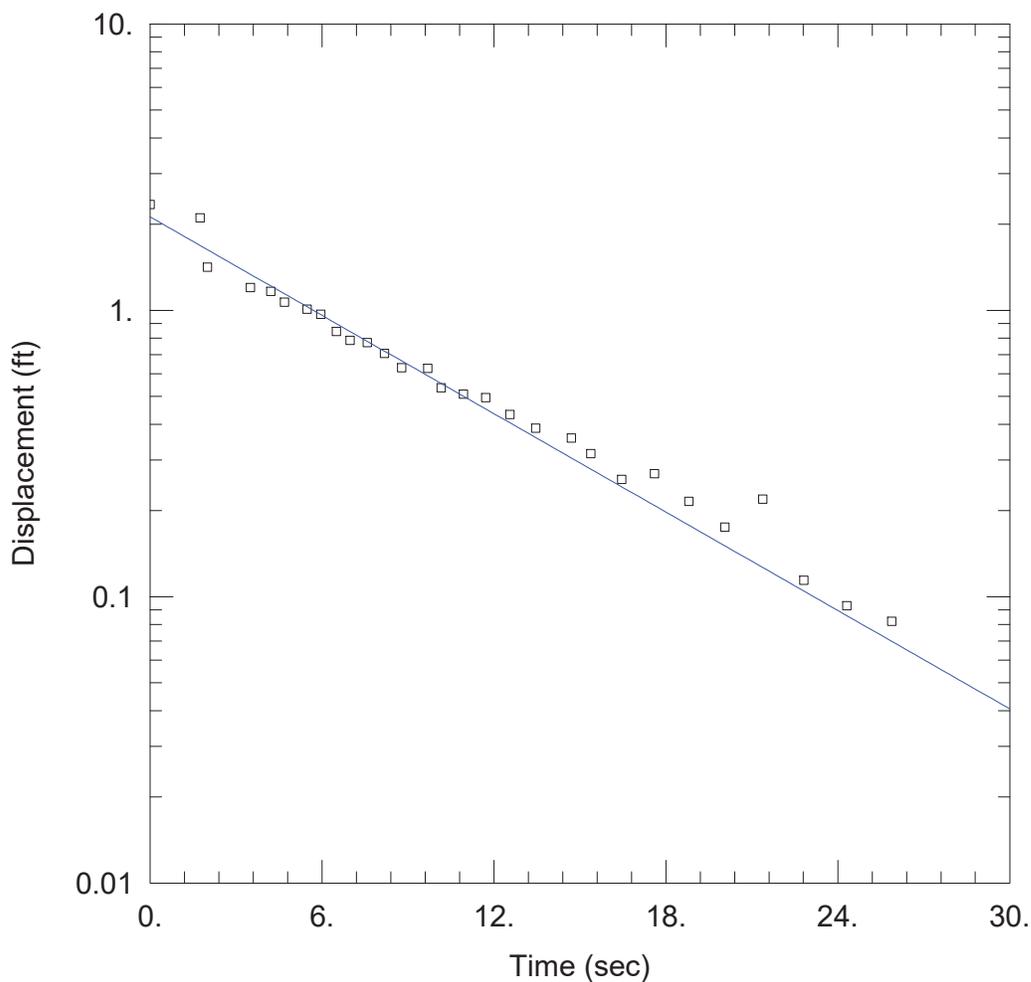
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 11.02 ft/day

Solution Method: Bouwer-Rice
 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)

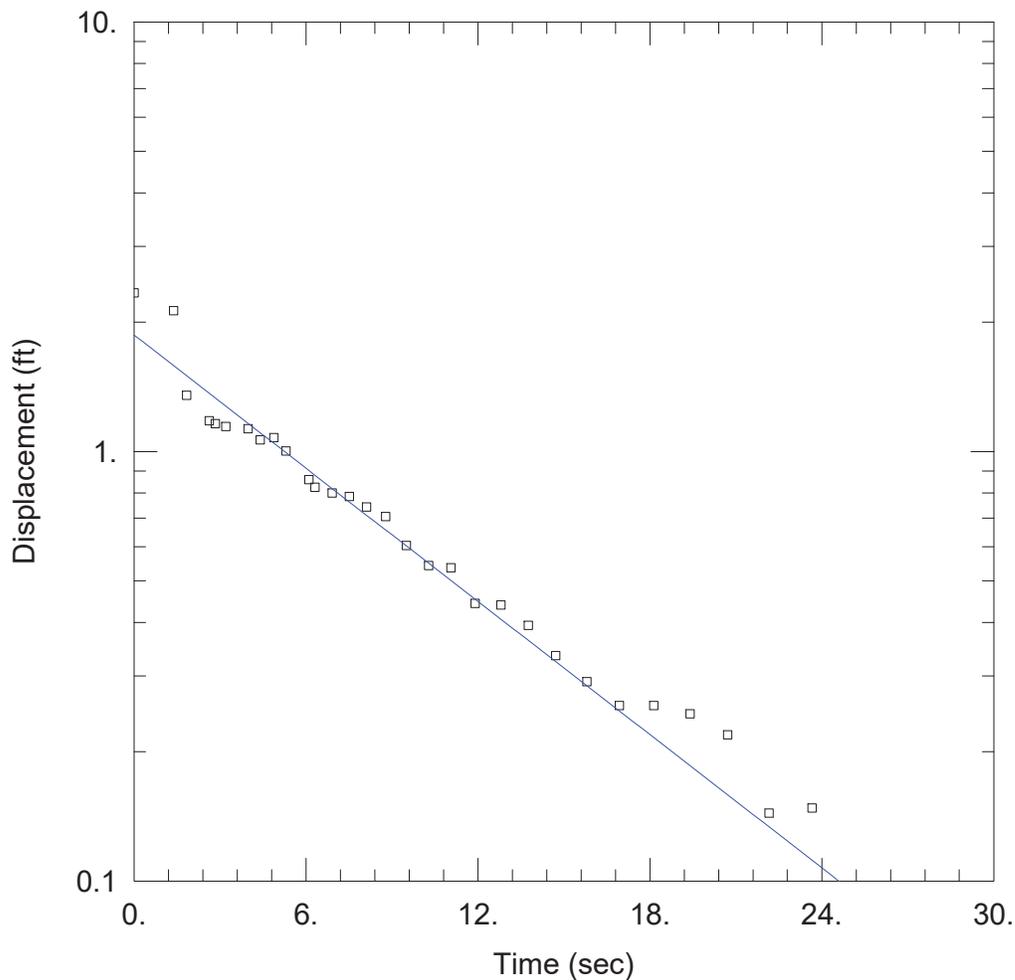
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 14.44 ft/day

Solution Method: Hvorslev
 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)

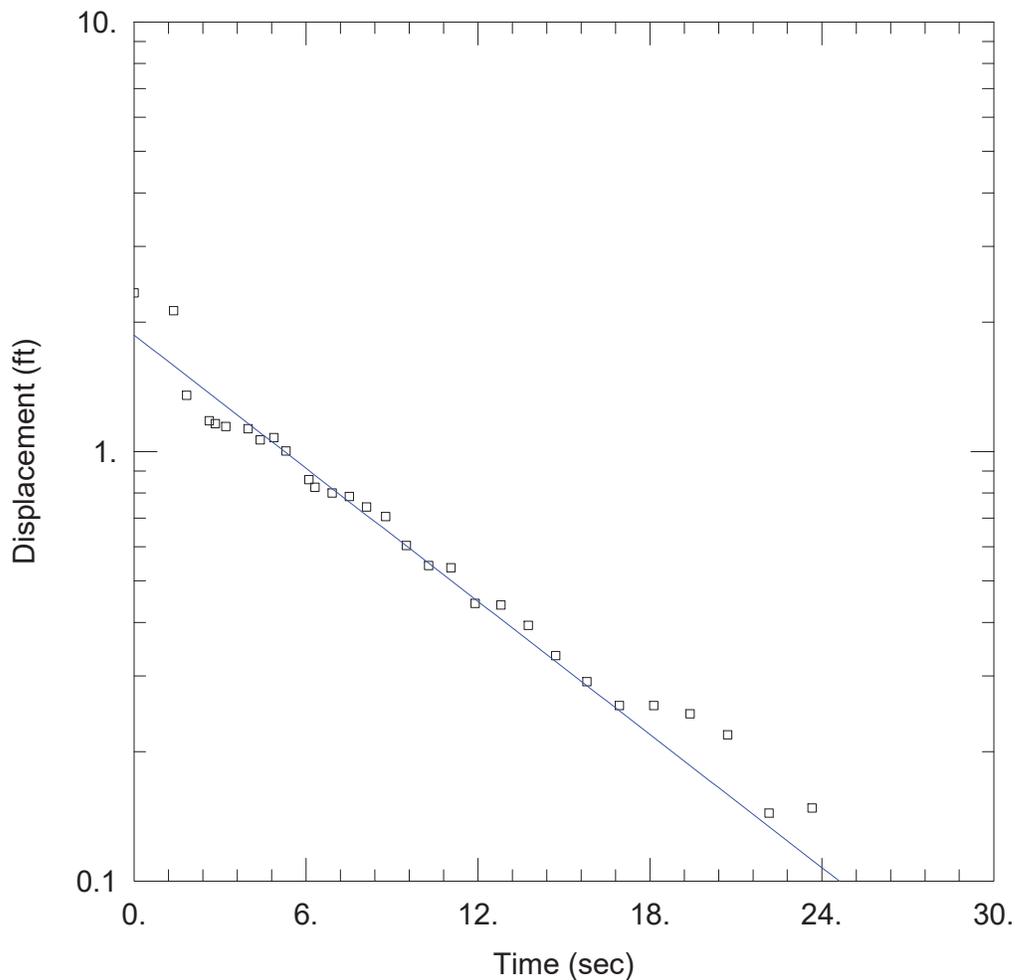
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 9.947 ft/day

Solution Method: Bouwer-Rice
 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)

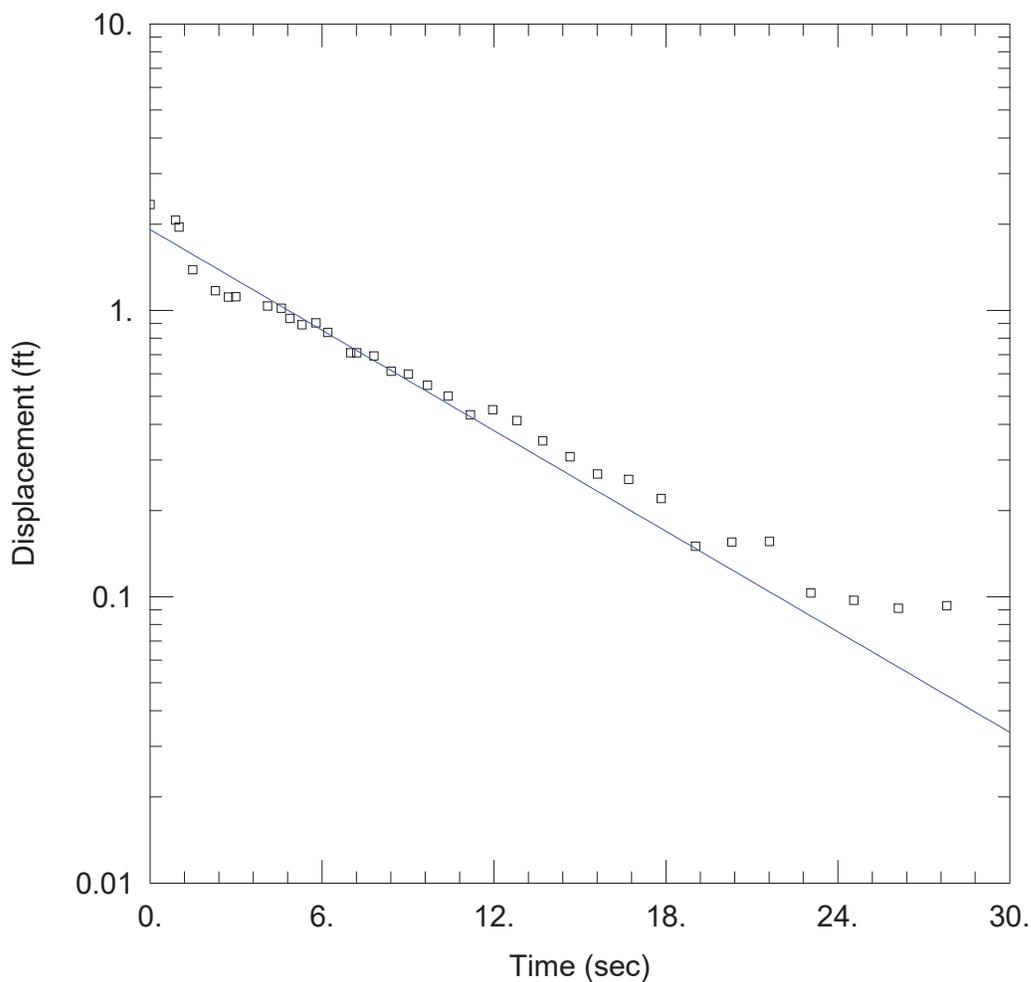
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 13.02 ft/day

Solution Method: Hvorslev
 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)

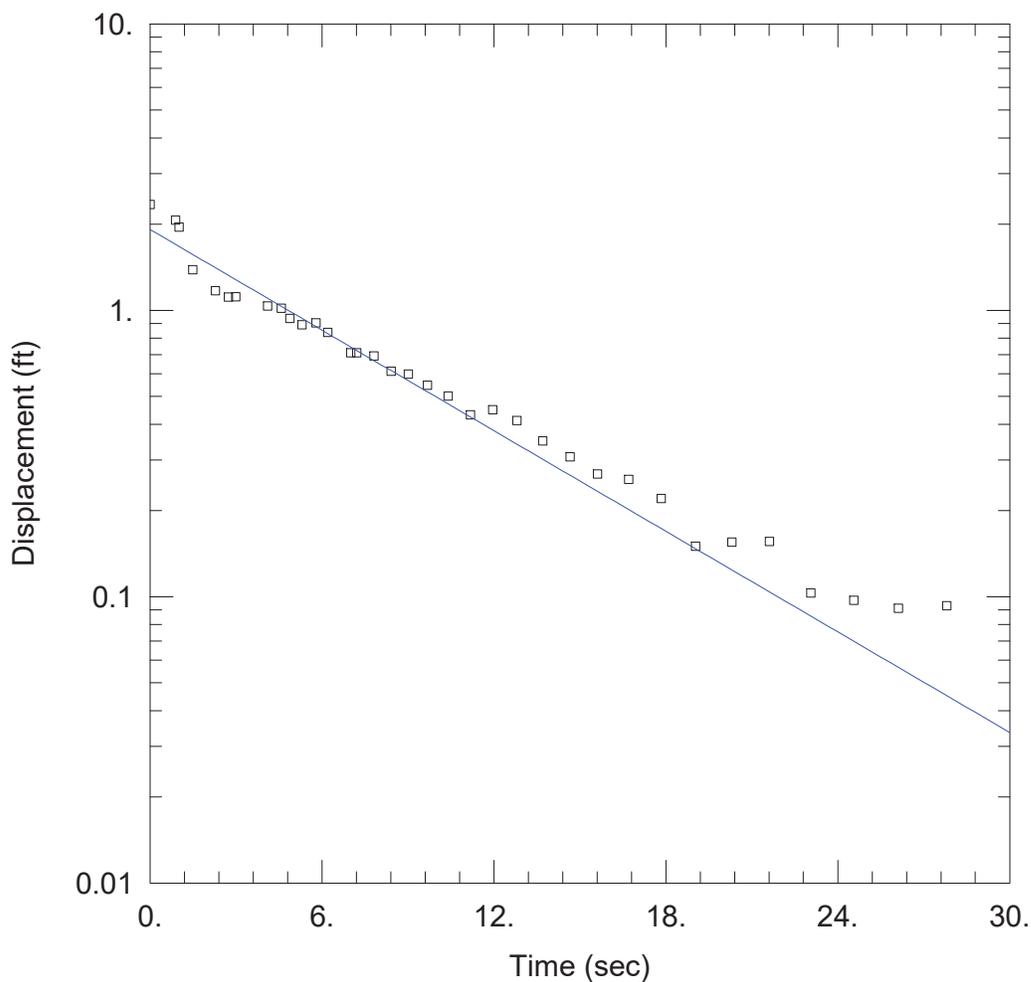
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 11.26 ft/day

Solution Method: Bouwer-Rice
 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)

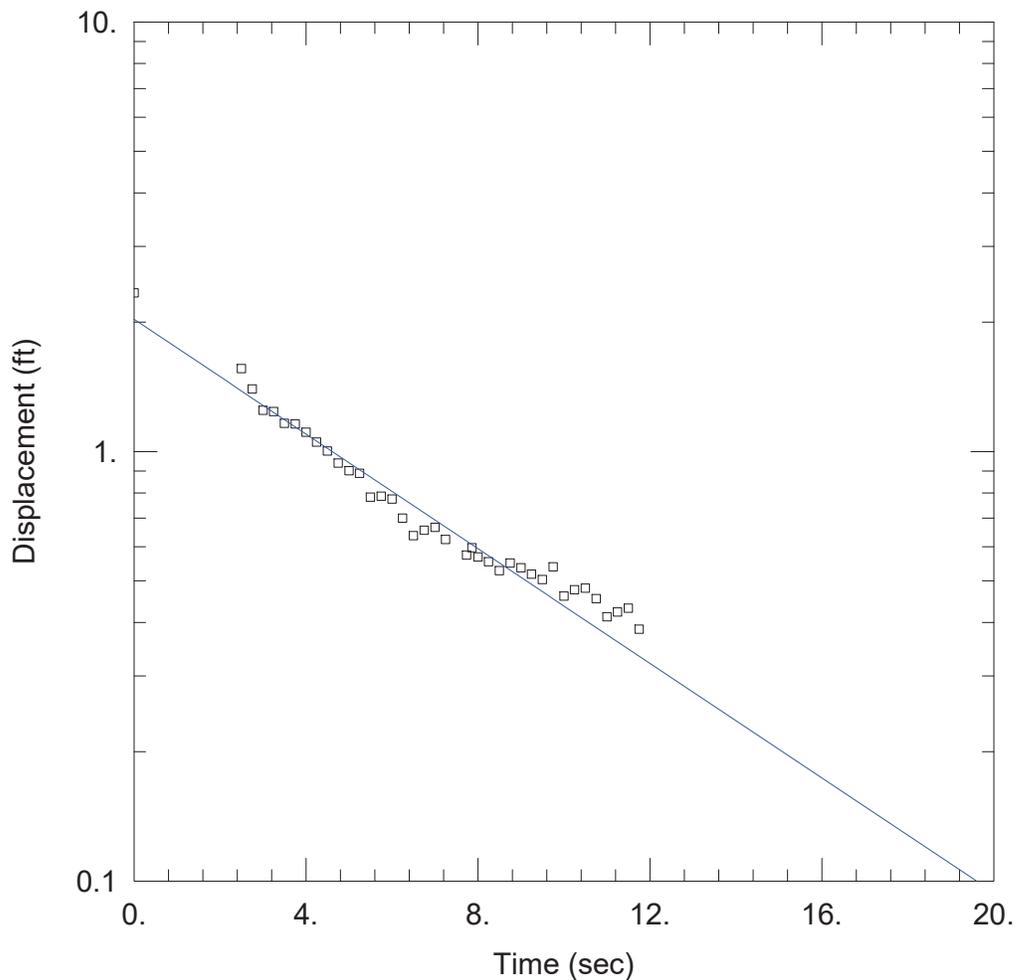
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 10.5 ft
 Casing Radius: 0.0833 ft

Static Water Column Height: 67.2 ft
 Screen Length: 5. ft
 Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
 K = 14.76 ft/day

Solution Method: Hvorslev
 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)

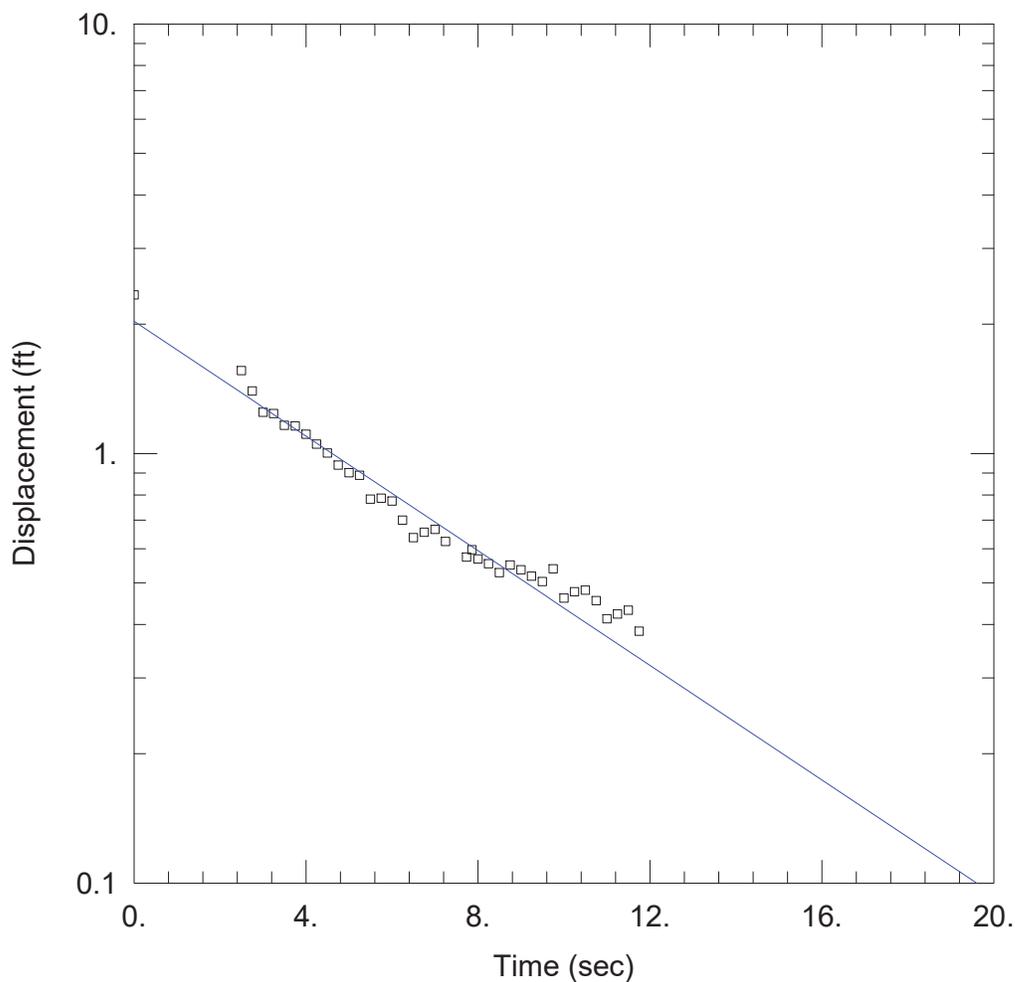
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 8.415 ft/day

Solution Method: Bouwer-Rice
 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)

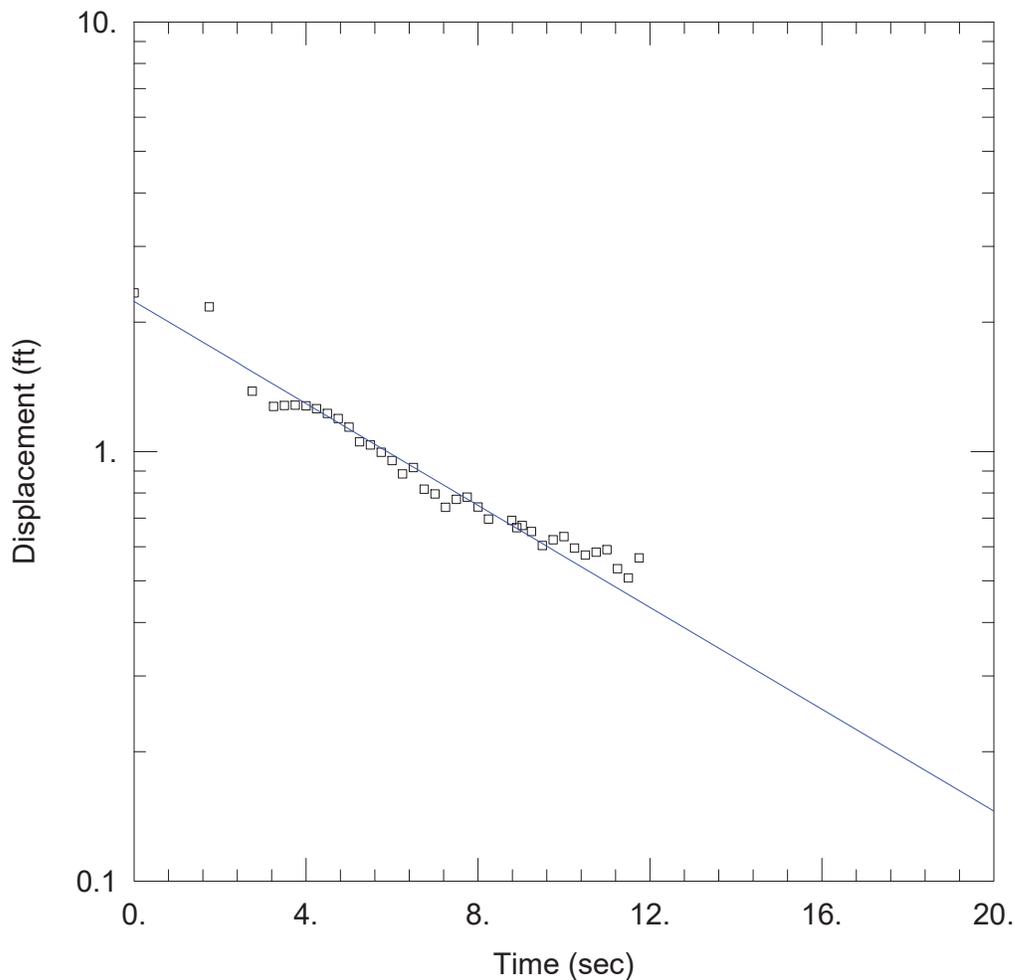
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 12.29 ft/day

Solution Method: Hvorslev
 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)

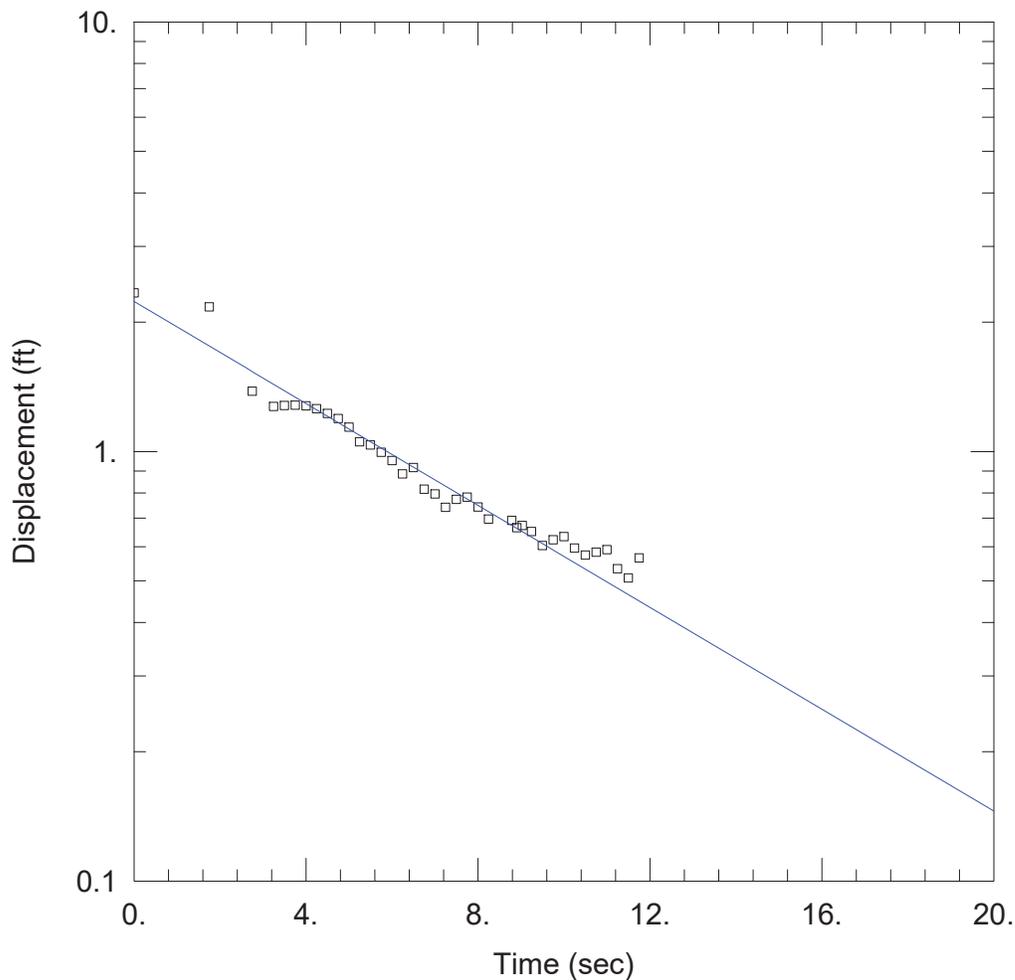
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 7.481 ft/day

Solution Method: Bouwer-Rice
 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)

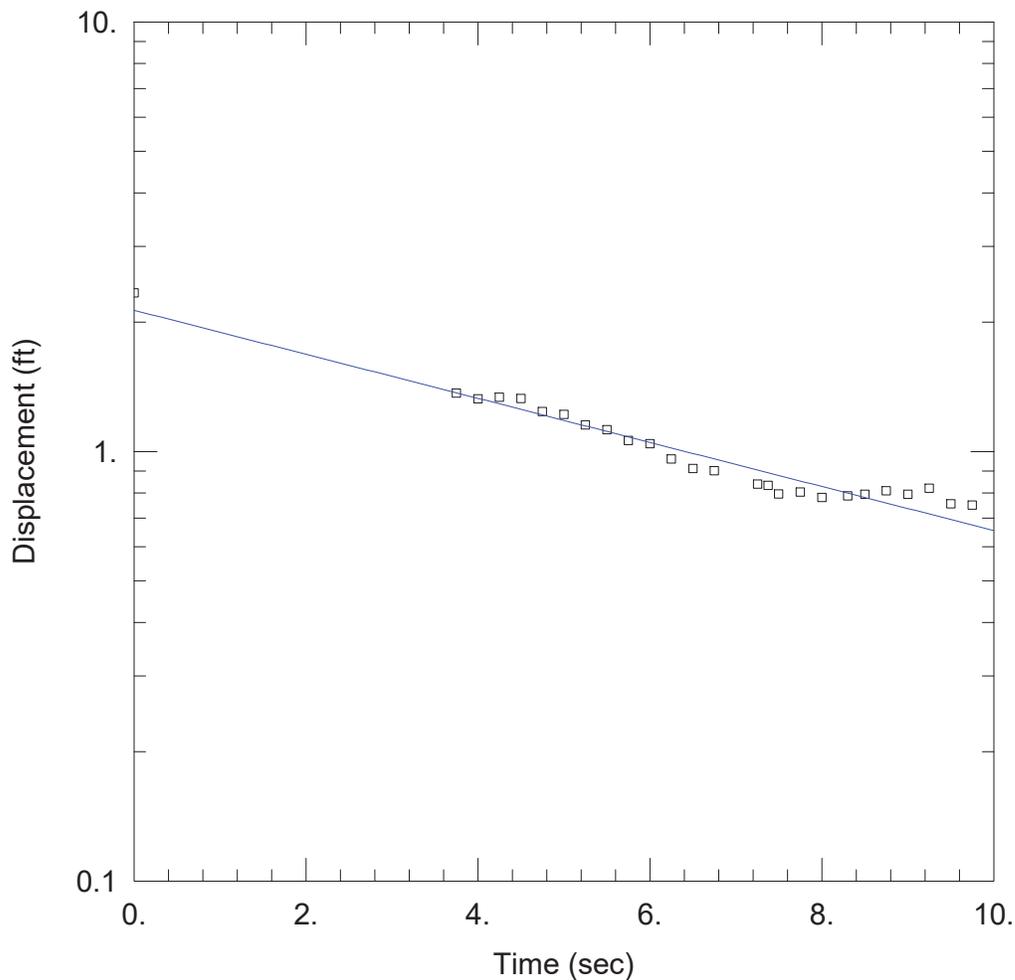
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 10.92 ft/day

Solution Method: Hvorslev
 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)

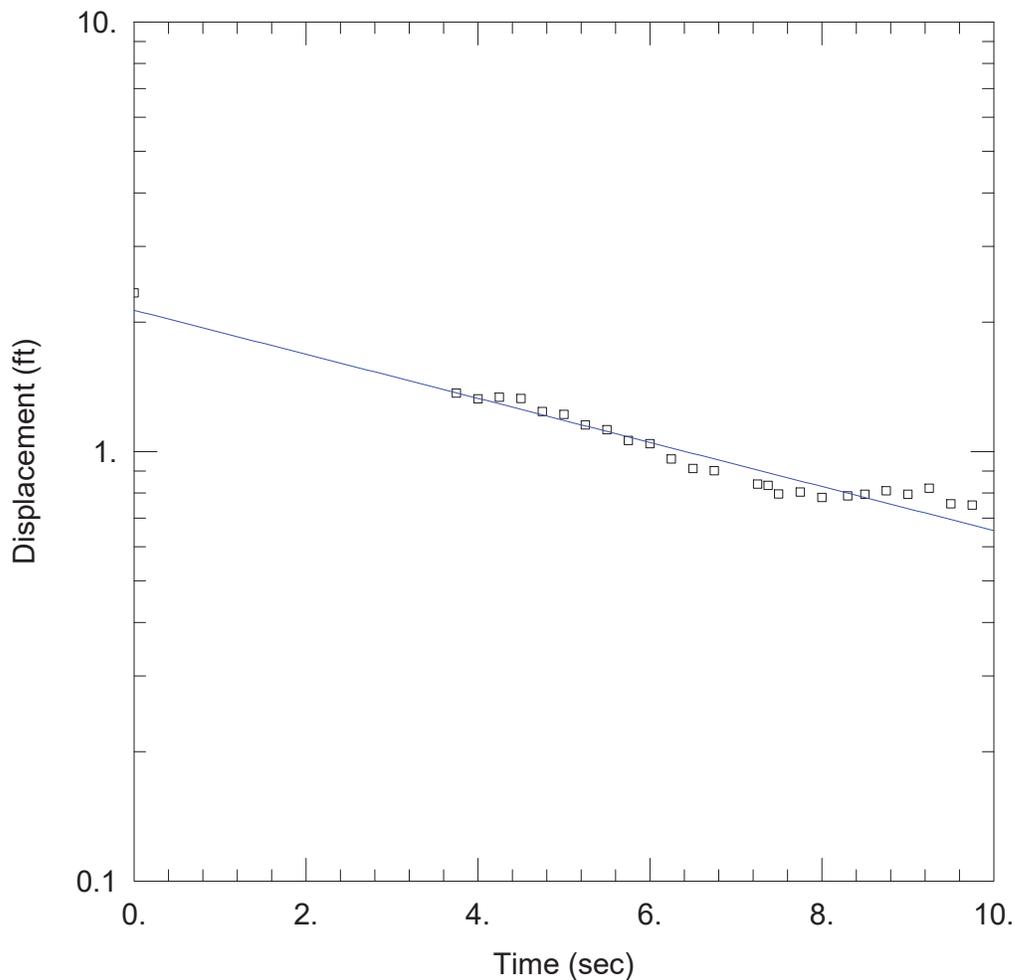
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 6.468 ft/day

Solution Method: Bouwer-Rice
 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)

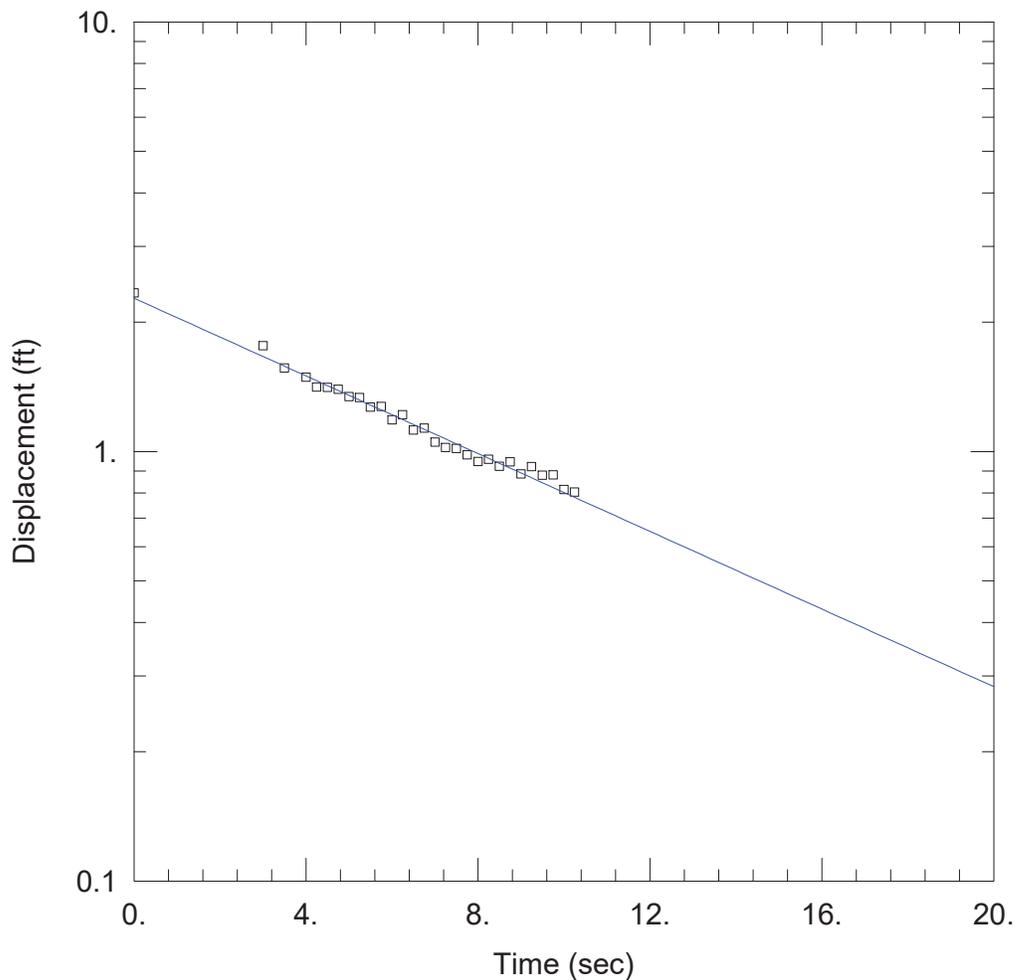
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 9.446 ft/day

Solution Method: Hvorslev
 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)

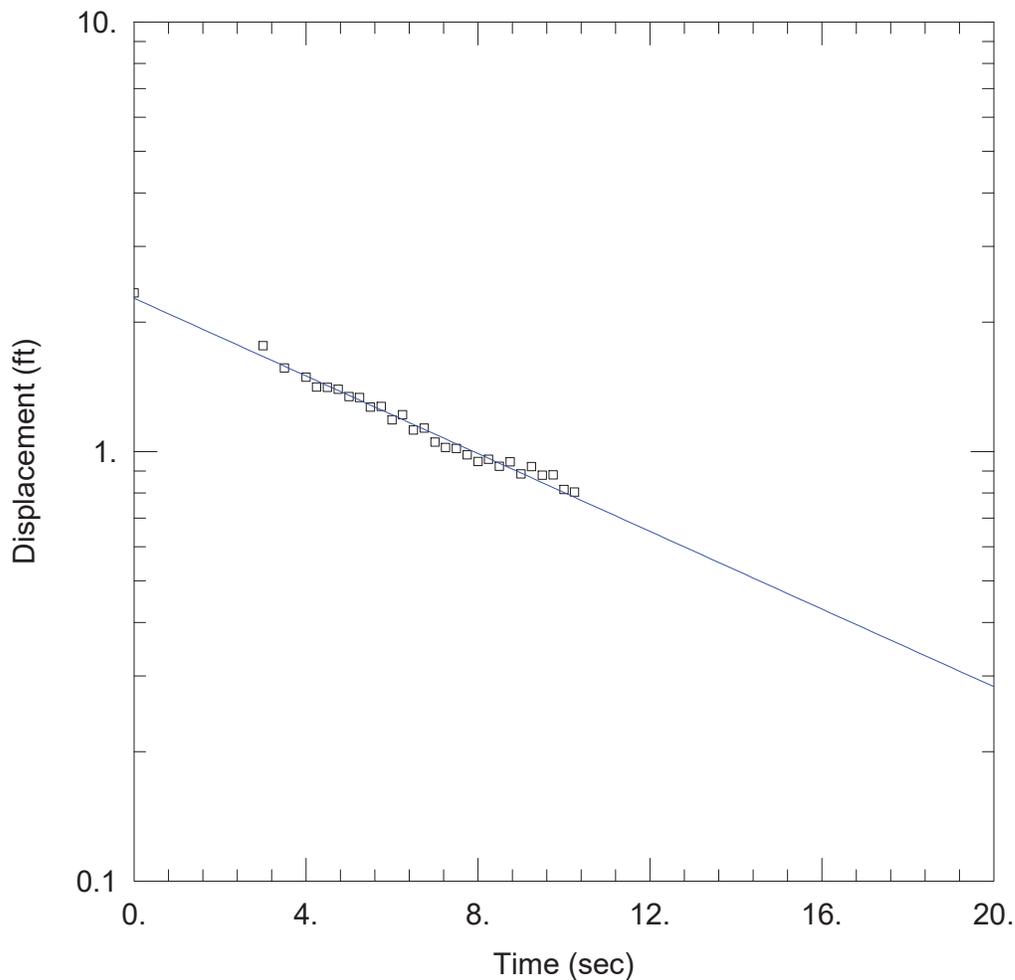
Initial Displacement: 2.34 ft
 Total Well Penetration Depth: 13.5 ft
 Casing Radius: 0.0833 ft

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

SOLUTION

Aquifer Model: Confined
 K = 5.703 ft/day

Solution Method: Bouwer-Rice
 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
 K = 8.327 ft/day

Solution Method: Hvorslev
 y0 = 2.273 ft