US EPA Coal Combustion Residual Rule

Groundwater Monitoring Network Evaluation Addendum for FAR I – Residual Solid Waste Landfill

Cardinal Operating Company – Cardinal Power Plant
306 County Road 7E
Brilliant, Ohio

May 2, 2022

Submitted to:

Cardinal Operating Company
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Brilliant, Ohio 43913

Submitted by:

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Cox-Colvin & ASSOCIATES, INC. ENVIRONMENTAL SERVICES

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1.0 Introduction

Cox-Colvin & Associates, Inc. (Cox-Colvin) is pleased to provide Cardinal Operating Company (Cardinal) with this Groundwater Monitoring Network Addendum for the Fly Ash Reservoir I - Residual Solid Waste Landfill (FAR I/RSW) located at the Cardinal Power Plant, 306 County Road 7E, Brilliant, Ohio.

This report was prepared in accordance with the Federal Coal Combustion Residual (CCR) rules in 40 Code of Federal Regulations (CFR) 257 Subpart D. It is intended as an addendum to the initial Groundwater Monitoring Network Evaluation.[1]

2.0 Background / Purpose of Addendum

The initial Groundwater Monitoring Network Evaluation was prepared in 2016. A copy is included as Appendix A. The evaluation included a single potentiometric surface map based upon September 2014 water level measurements. Although monitoring wells S-2 and S-19A had higher elevations than downgradient monitoring wells S-1 and S-20, there was some uncertainty regarding flow direction between S-2 and S-19A. Figure 3-1 of the evaluation omitted potentiometric lines in the area of these wells (they were not shown to be either upgradient or downgradient). Based upon the limited data available at the time, monitoring wells S-2 and S-19A were conservatively presumed to be downgradient wells in Section 3.3.1 of the 2016 text.

Additionally, Section 3.3.1 of the 2016 text incorrectly referenced monitoring well S-19, which had been replaced by S-19A in 2007 (S-19A was correctly referenced elsewhere in the report).

Background monitoring was performed from June 2016 through August 2017. Detection monitoring commenced in September 2017. By the time the 2018 annual report was completed,[2] additional data had provided a better understanding of groundwater flow. Where there had been uncertainty regarding the potentiometric surface during the September 2014 sampling event, subsequent data consistently demonstrated that monitoring wells S-2 and S-19A, which are located along a ridgetop, are in the vicinity of a groundwater divide and should be used as upgradient background wells rather than downgradient compliance wells. **This was stated in Section 3 of the 2018 annual report and the wells have been treated as upgradient wells since that time.**

[1] *Groundwater Monitoring Network Evaluation; Cardinal Site – Former Fly Ash Reservoir I – Residual Solid Waste Landfill; Brilliant, Ohio.* Geosyntec Consultants Project No. CHE8126L, August 2016.
[2] *2018 Annual Groundwater Monitoring Report; Federal CCR Rule; Cardinal Plant – Residual Solid Waste Landfill; Brilliant, Ohio*. Geosyntec Consultants Project No. CHA8468, January 2019.

Although the upgradient designation was made during 2018 annual reporting, the change to the groundwater monitoring network was not certified by a Professional Engineer (P.E.). Because the initial groundwater system must be certified by a P.E. in accordance with Section 257.91(f) of the CCR Rules, it is presumed that changes to the groundwater system should also be certified by a P.E. This addendum summarizes the basis for the change and provides certification by an Ohio P.E.

3.0 Evaluation of Groundwater Flow

Figures 1 and 2 show the potentiometric surface during the most recent 2021 sampling events. As shown in the figures, the lower groundwater elevation at monitoring well S-19A relative to monitoring well S-2 is explained by a groundwater divide mimicking surface topography around the west and south side of the FAR I/RSW. Elevations at both wells are significantly higher than downgradient monitoring wells S-1 and S-20, confirming that groundwater in the Shallow Aquifer is flowing towards, rather than away from, the FAR I/RSW at the nearest waste boundary to monitoring wells S-2 and S-19A.

Review of groundwater potentiometric maps compiled from assessments conducted between 2014 and 2021 (Appendix B) confirm that this groundwater divide has been consistently present over time, despite it not being immediately recognized at the start of CCR monitoring.

4.0 Monitoring Network

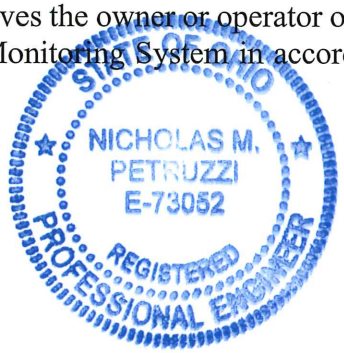
With this addendum, the groundwater monitoring network consists of nine wells located upgradient (0AE 2005 10C, CA-0623A, S-GS-3, S-2, S-4, S-5, S-6, S-17, S-19A) and seven wells located downgradient (S-GS-1, S-GS-2, S-1, S-7, S-10, S-18, S-20) of the FAR I / RSW.

This network provides detection monitoring for the uppermost aquifer (Shallow Aquifer). The changes outlined in this addendum (classifying S-2 and S-19A as upgradient rather than downgradient wells) does not reduce the effectiveness of the groundwater monitoring network. There is no change to the number of wells in the program, and groundwater in the Shallow Aquifer does not flow from the FAR I/RSW towards either S-2 or S-19A. Consistent with CCR Rules §257.91(c), the groundwater monitoring network has a minimum of one upgradient and three downgradient wells that accurately represent the quality of both background groundwater and groundwater passing the waste boundary of the FAR I/RSW.

5.0 Professional Engineer Certification

The undersigned P.E. registered in the State of Ohio is familiar with the requirements of 40 CFR part 257, subpart D and has visited and examined the facility. The undersigned P.E. attests that this Groundwater Monitoring Network Addendum for the Cardinal FAR I/RSW CCR Unit has been prepared in accordance with good engineering practice, including the design and construction to meet the requirements of §257.91, for the facility to the best of his knowledge. The minimum number of wells specified in §257.91(c)(1) has been met, as documented in Section 4.0 of this report.

This certification in no way relives the owner or operator of the facility of the duty to fully implement this Groundwater Monitoring System in accordance with the requirements of 40 CFR 257 subpart D.



5/2/22

Nick M. Petruzzi, PE, CPG
Principal Engineer
Registration No. E-73052 (Ohio)
Cox-Colvin & Associates, Inc.

Date

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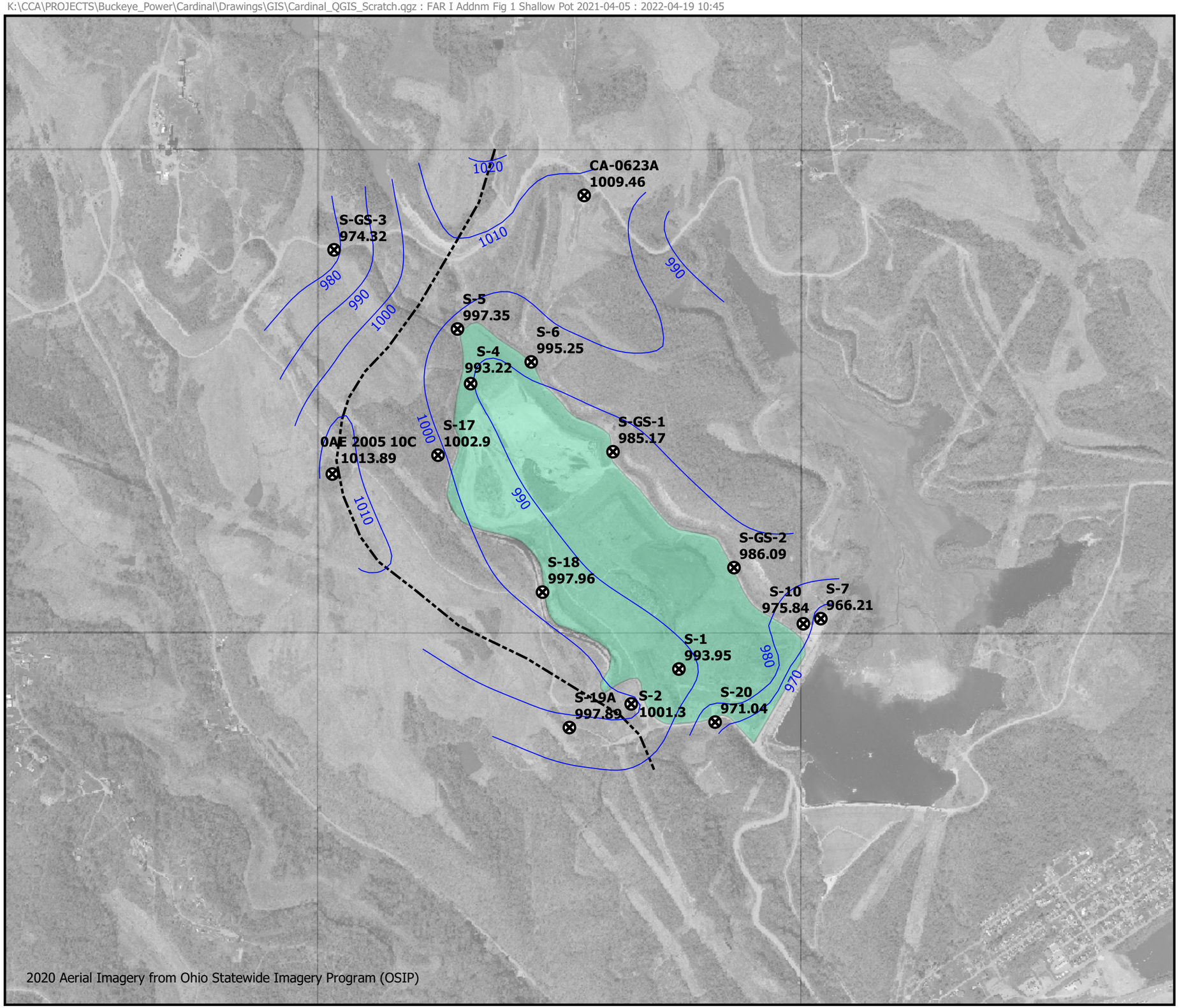
Figures



Legend

- FAR I Network Monitoring Well and Groundwater Elevation
- Groundwater Elevation Contour
- FAR I RSW Landfill
- Approximate Location of Groundwater Divide

N

0 1,000 2,000 3,000 ft

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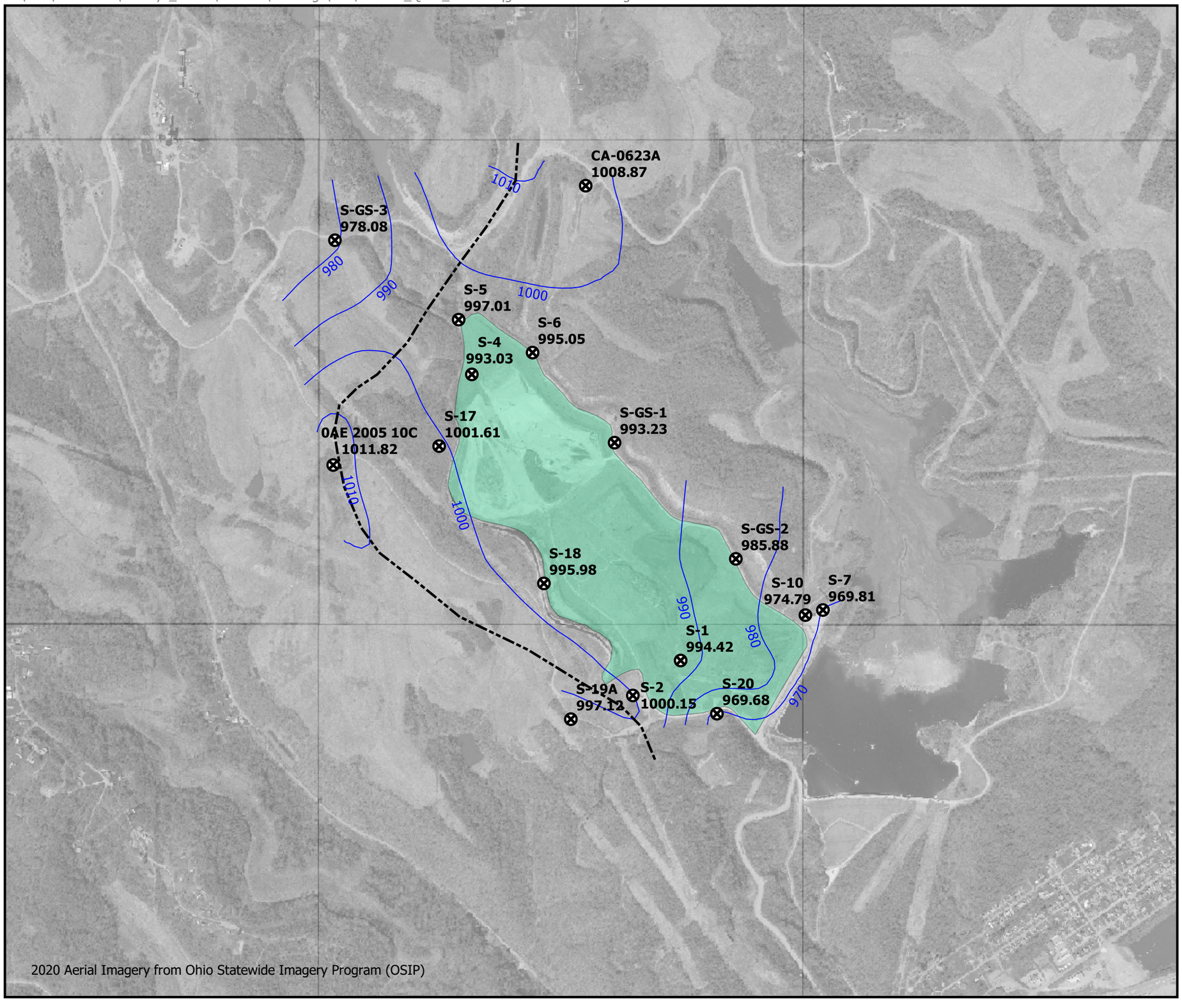
Figure

1

Potentiometric Surface Map - Shallow Aquifer
FAR I RSW Landfill - April 5, 2021
Cardinal Plant
Brilliant, Ohio

K:\CCA\PROJECTS\Buckeye_Power\Cardinal\Drawings\GIS\Cardinal_QGIS_Scratch.qgz : FAR I Addnm Fig 2 Shallow Pot 2021-10-11 : 2022-04-19 10:45



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- FAR I Network Monitoring Well and Groundwater Elevation
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N

0 1,000 2,000 3,000 ft

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Figure

2

Potentiometric Surface Map - Shallow Aquifer
FAR I RSW Landfill - October 11, 2021
Cardinal Plant
Brilliant, Ohio

Appendix A

2016 Groundwater Monitoring Network Evaluation

Prepared for

American Electric Power

1 Riverside Plaza
Columbus, Ohio 43215

GROUNDWATER MONITORING NETWORK EVALUATION

CARDINAL SITE – FORMER FLY ASH RESERVOIR I - RESIDUAL SOLID WASTE LANDFILL

BRILLIANT, OHIO

Prepared by

1420 Kensington Road, Suite 103
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Geosyntec Project No.: CHE8126L

August 2016

GROUNDWATER MONITORING NETWORK EVALUATION
CARDINAL FAR 1 RSW LANDFILL
BRILLIANT, OHIO

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LIST OF ACRONYMS

AEP	American Electric Power
BAC	Bottom Ash Complex
BAP	Bottom Ash Pond
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAD	Fly Ash Dam
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
MCL	Maximum Contaminant Level
MW	Megawatts
MW	Monitoring Well
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PE	Professional Engineer
PVC	Poly Vinyl Chloride
RCP	Recirculation Pond
RSB	Recompacted Soil Barrier
RSL	Recompacted Soil Liner
RWL	Residual Waste Landfill
SCR	Selective Catalytic Reduction
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency

1. OBJECTIVE

1.1 Purpose

The purpose of this report is to provide an assessment of the groundwater monitoring network associated with the former Fly Ash Reservoir I Residual Solid Waste Landfill (FAR 1 RSW Landfill) at the Cardinal Operating Company Cardinal Plant relative to its compliance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule section 40 CFR 257.91.

1.2 Organization of Report

- Section 2 presents background information on the power plant and CCR unit;
- Section 3 presents and evaluation of the existing monitoring well network; and
- Section 4 provides a certification from a qualified Professional Engineer (PE).

1.3 Coordinate System and Datum

The horizontal coordinate values provided in this report are based upon the North American Datum of 1927 (NAD27). The vertical datum utilized for reporting the elevations within this report is National Geodetic Vertical Datum of 1929 (NGVD 29).

2. BACKGROUND INFORMATION

2.1 Facility Location Description

The Cardinal Plant is located approximately one-mile south of Brilliant, Ohio in Jefferson County along the Ohio River (Figure 2-1). The generating station consists of three units with a nominal capacity of 1,830 megawatts (MW). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. All three units are coal-powered, with an average annual coal use of 5.2 million tons for the entire plant (AEP, 2005a).

Fly ash was formerly sluiced to the Fly Ash Reservoir 1 (former FAR I), which was filled to capacity in 1998 and began the closure process in 1990. Fly ash is currently sluiced to Fly Ash Reservoir 2 (FAR II), which is impounded by Fly Ash Dam II (FAD II) and located adjacent to the former FAR I. The Residual Solid Waste Landfill (RSW Landfill) Facility began construction in 2006, partially located on top of the former FAR I, as a permitted landfill for the disposal of solid wastes. The Cardinal Plant currently utilizes three coal combustion residuals (CCR) storage units: the Bottom Ash Complex (BAC), the FAR I RSW Landfill, and the FAR II reservoir. These units are shown in Figure 2-2.

2.2 Description of CCR Unit

The FAR I RSW Landfill unit is a dry landfill disposal facility located approximately one-mile north of the plant site in a portion of Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) that was formally surface mined for the Pittsburgh No. 8 coal. The footprint of the landfill overlies approximately 75 acres of the former FAR I. The FAR I RSW Landfill is an existing, active CCR landfill which receives gypsum waste and which may also receive solid waste from the Bottom Ash Pond (BAP). Two of the six cells of the landfill were in operation at the time of the CCR Rule became effective. Construction of remaining future cells would be considered lateral expansions. The landfill uses FAR II as its leachate and stormwater collection pond.

2.2.1 Embankment Configuration

The FAR I RSW Landfill is an existing, active dry landfill that overlies the former FAR I and minespoil bench. The landfill was permitted in 2007 and is composed of six internal cells. The landfill was designed with a five-foot thick compacted layer of added geologic material (referred to as the isolation clay layer) placed to separate the landfill lining system from the subgrade fill and uppermost shallow aquifer. The landfill cells that have been constructed (Cells 1 and 3) are under filling operations and have been lined with 1.5 ft of recompacted soil liner (RSL) material and a 30-mil thick polyvinyl chloride (PVC) geomembrane, except along the southwestern perimeter highwall. At the highwall location, Cell 1 and Cell 2 are immediately adjacent and in contact with the rock highwall where the lining fill adjacent to the highwall includes a highwall drainage layer, a

5-ft thick isolation layer, and a 3-ft thick RSL (AEP, 2005a; AEP, 2007). Cell 2 has not been constructed. Future cell construction will be considered lateral expansions and will need to be redesigned and constructed to meet the CCR Rule requirements (AEP, 2006; AEP, 2010).

2.2.2 Area and Volume of CCR Units

The FAR 1 RSW Landfill Facility is approximately 348 acres. A total of 127 acres will be used for residual waste placement. The remaining 221 acres are occupied by associated facilities, including leachate and stormwater conveyance, FAR II (described in a separate CCR report), haul roads, and groundwater monitoring wells. The gross volume of waste which can be contained by the landfill facility is approximately 18,244,000 cubic yards.

2.2.3 Construction and Operational History

Construction of the FAR I RSW Landfill began in 2006 with general site excavation and Stage A construction beginning in 2007. The sequential development of the landfill was altered in a permit modification in April 2008. Site preparation and waste filling is ongoing, and development occurs in two phases (i.e., Phase 1 and Phase 2) according to the permit (AEP, 2006). Phase 1 (which includes Cells 1 and 3) of the landfill was developed at the northwest end along the excavated minespoil bench area and the southern portion of the 14-acre Tidd Plant Pressurized Fluidized Bed Combustion (PFBC) ash placement area (AEP, 2005a; AEP, 2006). Phase 2 (which includes Cells 2, 4, 5 and 6) will be developed over the former FAR I and the excavated minespoil bench and will also proceed from the northwest to the southeast to allow for a period of continuous preloading advancement of the Phase 2 cells that lie over the FAR I ash. The development of Cells 1 and 3 containments have been completed and under filling operations with FGD gypsum. Preloading of Cells 4, 5 and 6 is occurring with preload fill and temporary stockpiles of material.

2.2.4 Surface Water Control

Surface water control at the FAR I RSW Landfill directs all runoff to FAR II. The active surface of the landfill within the waste limits is graded with slopes at a minimum of two percent to provide drainage to the perimeter of the area and to chimney drains where both are transferred into the leachate collection system which is gravity piped to FAR II. Permanent and temporary ditches located outside the contained limit of waste and at the perimeter of the facility collect surface runoff and redirects the flow by ditch and pipe to FAR II. The surface water control system was designed to convey the peak discharge from a 25-year, 24-hour storm event.

Surface water draining into FAR II is collected within the main (north) branch of Blockhouse Hollow and contained by Fly Ash Dam 1 (FAD 1) and Fly Ash Dam 2 (FAD 2). Discharge of the collected surface water occurs as part of the ash reservoir water discharge through the FAD 2 principal or service spillway.

2.3 Previous Investigations

Several geotechnical and hydrogeologic investigations were completed in advance of the development of the FAR I RSW Landfill. These investigations and assessments include:

- Geotechnical Investigation Report: Permit-to-Install Application Cardinal FAR I Residual Waste Landfill Facility. May 2006. AEP and Geosyntec Consultants.
- Draft Engineering Feasibility Study for the Cardinal Plant FGD Project: FAR I Landfill Evaluation and Design. April, 2004. AEP and Geosyntec Consultants.
- Stability Analysis Report: Permit-to-Install Application: Cardinal FAR I Residual Waste Landfill Facility. August, 2005. AEP and Geosyntec Consultants.
- Hydrogeologic Investigation Report: Permit-to-Install Application Cardinal FAR I Residual Waste Landfill Facility. May 2006. AEP and Geosyntec Consultants

2.4 Hydrogeologic Setting

2.4.1 Climate and Water Budget

The major drainage feature of the FAR I RSW Landfill and FAR II sites is Blockhouse Run, which drains into the Ohio River. Approximately one mile upstream, Blockhouse Run splits into the East Branch and West Branch. The West Branch drains the western watershed and was dammed to form the former FAR I, while the East Branch drains the eastern watershed. The FAR II inundates the East Branch, and runoff from the western watershed drains into the FAR II. The total area of the western watershed is 677 acres, while the eastern watershed is 675 acres. Additional details are available in Section 3 and Appendix C of the Dam Raising Design Summary (S&ME, 2012).

The 2015 average monthly temperature and precipitation values for the Brilliant, Ohio area are presented in the table below (NOAA, 2016). The climatological data was collected from the nearest weather station (USC00338025) located in Steubenville, OH.

NOAA Climatological Summary (2015)		
Month	**Average Temperature (°F)**	**Average Precipitation (inches)**
January	23.0	2.16
February	16.0	1.34
March	30.9	4.02
April	51.1	3.60

May	64.6	2.95
June	70.0	10.69
July	71.4	4.66
August	70.5	2.81
September	69.3	6.70
October	53.2	2.56
November	47.8	1.17
December	46.6	3.24

2.4.2 Regional and Local Geologic Setting

The geology at the former FAR I RSW Landfill and the vicinity consists of nearly horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Permian-age Dunkard Group occurs only on the tops of some ridges above an elevation of approximately 1,250 feet (ft), northwest and west of landfill and FAR II sites.

The Monongahela Group is up to 230 feet thick in Jefferson County, consisting of shale, sandstone, limestone, coal claystone and siltstone. These rocks form much of the slopes above the current levels of the FAR I RSW Landfill and FAR II sites. Below the Monongahela Group is the Conemaugh Group, which is generally over 500 feet thick in Jefferson County. The Conemaugh Group consists of shale, sandstone, limestone, coal, and claystone, including the Morgantown Sandstone, which is a developed aquifer in the area. Beneath the Morgantown Sandstone is a sequence of the Conemaugh Group including the Elk Lick Limestone, the Skelly Limestone and shale, the Ames Limestone, several thick shale sequences, and the Cow Run Sandstone (AEP, 2005a).

2.4.3 Surface Water and Surface Water-Groundwater Interactions

The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR I RSW Landfill was historically re-routed during surface mining operations and flows in a constructed stream channel along the bottom of the highwall slope north of the landfill and former FAR I. Blockhouse Hollow then drains into FAR II. Surface water northeast of the landfill flows to, or is collected and drained to, Blockhouse Hollow. Drainage from the highwall adjacent to Cells 1 & 2 of the landfill is collected in an engineered highwall drainage layer and conveyed through the landfill subsurface drainage layer and piping to a perimeter solid wall transmission pipe that discharges into the Blockhouse Hollow channel draining to FAR II (AEP, 2006; AEP, 2007). Perimeter landfill and final cover system surface water will be collected and conveyed in piping to either Blockhouse Hollow or piping that drains directly to FAR II. Landfill contact stormwater is collected and transferred to the landfill leachate collection system. Both surface stormwater and

leachate are transferred to FAR II as FAR II serves as the facilities sedimentation pond and leachate collection pond.

2.4.4 Water Users

According to water well records obtained from the Ohio Department of Natural Resources (ODNR), the nearest water supply well is located approximately 3,000 feet east of the landfill. Additionally, ODNR records indicate a series of water supply wells in the Tidd-Dale Subdivision of Brilliant, Ohio, approximately 4,000 to 5,000 feet southeast of the former FAR I RSW Landfill. These water supply wells are developed in the deeper Buffalo Sandstone, which underlies the uppermost aquifer.

Approximately one mile west of the former FAR I RSW Landfill, a series of water supply wells develop several limestone horizons, apparently the Arnoldsburg and Benwood Limestone units. These well logs report pumping rates ranging from approximately 1.0 gpm to 8.0 gpm with significant drawdown (AEP, 2006).

According to the Jefferson County Water and Sewer District, there are no surface water intakes supplying water to the town of Brilliant, Ohio. Brilliant's water source comes from two groundwater wells located at a water treatment plant approximately 1.25 mile east of the FAR I RSW Landfill. ODNR records indicate these wells are screened within the alluvial deposits of the Ohio River and exhibit pumping rates of up to 700 gpm.

3. MONITORING NETWORK EVALUATION

3.1 Hydrostratigraphic Units

3.1.1 Horizontal and Vertical Position relative to CCR Unit

The hydrogeology at the former FAR I RSW Landfill Facility is characterized by an uppermost aquifer system comprised of sandstone and limestone units, specifically the Connellsville Sandstone, Summerfield Limestone, and Bellaire Sandstone, which lie above the shale aquitard that caps the Morgantown Sandstone. The landfill is situated horizontally and vertically within the upper sandstone and limestone units and above the former FAR I. The landfill is separated from FAR I by a base liner system and five feet of geologic material. The existing monitoring network includes wells located upgradient and downgradient of the landfill facility that are screened within the uppermost aquifer system, referred to as the Shallow Aquifer. Geologic cross-sections illustrating the horizontal and vertical position of FAR II relative to the uppermost aquifer are provided in Appendix B.

3.1.2 Overall Flow Conditions

Based on monitoring well data in the vicinity of the former FAR I RSW Landfill site, the uppermost aquifer system is under water table conditions. This uppermost aquifer includes unconsolidated mine waste, sandstone, and limestone beds with a range of hydraulic conductivity from 1×10^{-1} to 1×10^{-4} centimeters per second (cm/sec) (AEP, 2006). This water table zone generally flows toward the FAR I RSW Landfill from the east and west, while flowing south towards the Ohio River on the south side of the FAR I RSW Landfill. The shale aquitard where present above the Morgantown Sandstone has very low hydraulic conductivity values, in the range of 1×10^{-7} to 1×10^{-9} cm/sec. Contours depicting the groundwater elevations in the Shallow Aquifer are shown in Figure 3-1.

Historical groundwater elevation data for the Shallow Aquifer show water table elevations in the range of 1000 to 1010 ft upgradient and approximately 960 feet on the downgradient side of the FAR I RSW Landfill. The groundwater elevation data indicates a regular seasonal variation, with spring water levels up to several feet higher than fall water levels. Seasonal variation appears somewhat more pronounced on the upgradient side of the FAR I RSW Landfill (AEP, 2006).

3.2 Uppermost Aquifer

3.2.1 CCR Rule Definition

According to the 2015 CCR rule, the term “uppermost aquifer” has the same provisions as in §257.40: “The geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility’s property boundary. This definition includes a shallow, deep, perched, confined, or unconfined aquifer, provided that it yields usable water” (40 CFR 257.60).

For the purposes of this report, it is assumed that the uppermost useable aquifer has the following characteristics: (1) groundwater production rate over a 24-hour period of at least 0.1 gallons per minute (gpm); and (2) groundwater quality with total dissolved solids (TDS) less than 10,000 milligrams per liter (mg/L).

3.2.2 Identified Onsite Hydrostratigraphic Unit

The FAR I RSW Landfill overlies the former FAR I reservoir, which had surface elevations from approximately 990 ft. to 1,020 ft. Based upon these elevations and the elevations of the material underlying the original FAR I topography, the uppermost aquifer consists of saturated unconsolidated material, limestone, and sandstone sedimentary units.

Based on ODNR water well logs, the nearest wells with a recorded pumping rate (not including wells screened in the alluvial sediments near the Ohio River) occur approximately one mile west of FAR I RSW Landfill. These wells are screened within limestone and shale units, and at a similar elevation to the upper aquifer system at the FAR I RSW Landfill. These wells have recorded pumping rates ranging from 1.0 to 8.0 gpm.

Based on the information gathered from ODNR, geological and hydrogeologic conditions at the FAR I RSW Landfill, the uppermost aquifer is considered to be the unconsolidated material, limestone, and sandstone sedimentary units (Shallow Aquifer) which lie above the shale aquitard and Morgantown Sandstone.

3.3 Review of Existing Monitoring Network

3.3.1 Overview

The groundwater monitoring network is shown in Figure 3-2 and consists of seven (7) wells located upgradient (0AE 2005 10C, CA-0623A, S-GS-3, S-4, S-5, S-6 and S-17) and nine (9) monitoring wells located downgradient (S-GS-1, S-GS-2, S-1, S-2, S-7, S-10, S-18, S-19 and S-20) of the former FAR I RSW Landfill. The network will provide detection monitoring for the uppermost aquifer (Shallow Aquifer). The number, spacing, and depth of groundwater monitoring wells included in the groundwater monitoring network are based on site-specific geochemical, geologic and hydrogeologic information and span the full thickness of the uppermost aquifer system. Well construction details are summarized in Table 3-1. Boring and well construction logs for the groundwater monitoring well network wells are provided in Appendix C and Appendix D, respectively.

3.3.2 Compliance Assessment

Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of the former FAR I RSW Landfill indicates that the monitoring well network consists of a sufficient number of wells installed at the appropriate depths to collect groundwater samples from the uppermost aquifer system that accurately represent the

groundwater quality upgradient and downgradient of the former FAR I RSW Landfill. The groundwater monitoring well network is also capable of providing upgradient background groundwater quality and downgradient detection monitoring for a potential contaminant release to the uppermost aquifer (Shallow Aquifer) nearest the waste boundary. Based on the above review, the groundwater monitoring network around the Cardinal former FAR I RSW Landfill meets the requirements of 40 CFR 257.91.

4. CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

By means of this certification, I certify that I have reviewed the groundwater monitoring network and well construction details in the vicinity of the former Fly Ash Reservoir 1 Residual Solid Waste Landfill at the AEP Cardinal Plant and it meets the requirements of section 40 CFR 257.91.

Daniel G. Bodine

Printed Name of Registered Professional Engineer

Daniel G. Bodine

Signature

E-61363 | Ohio | August 1, 2016

Registration No. | Registration State | Date

TABLES

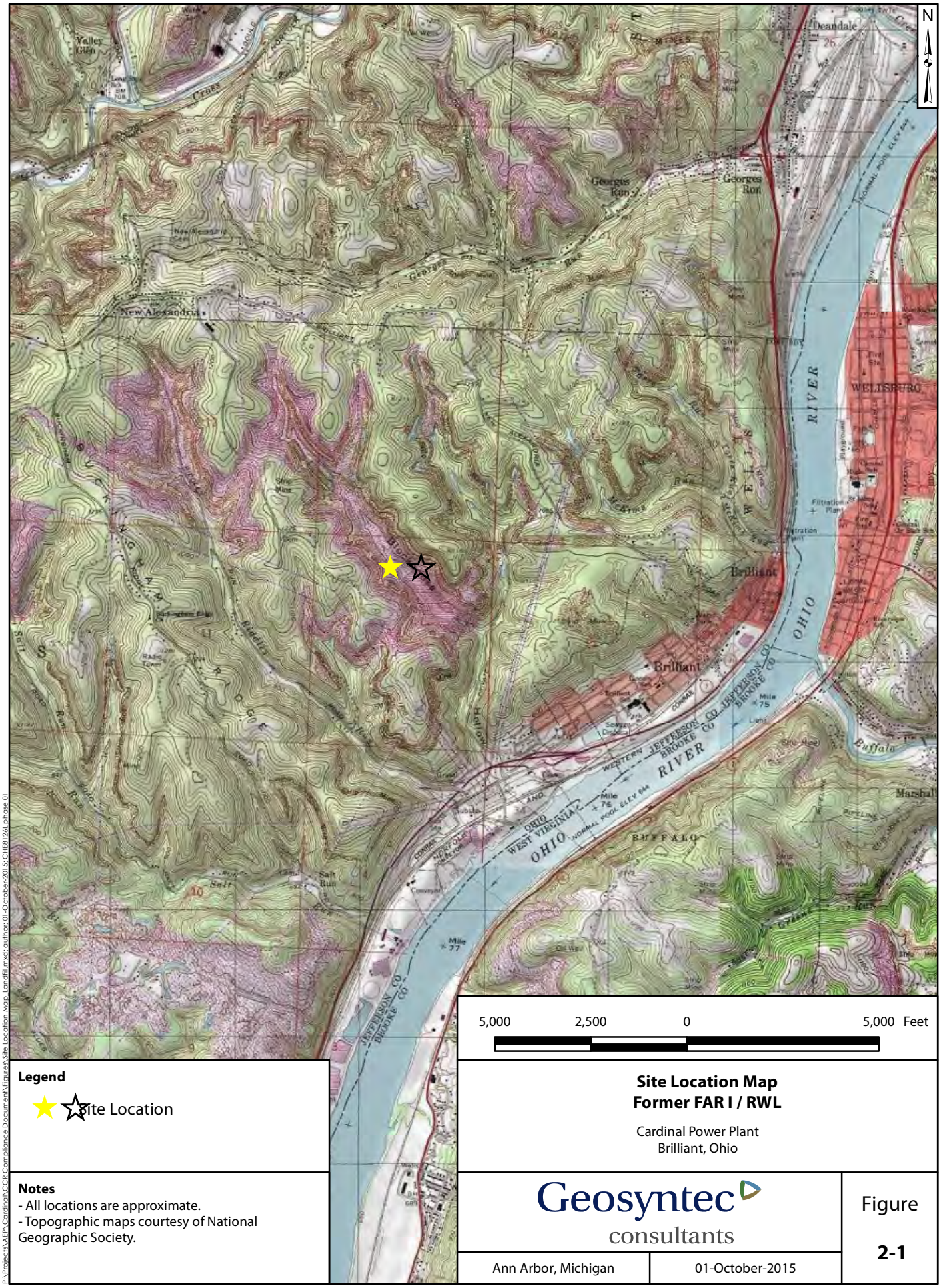
Table 3-1. Groundwater Monitoring Well Network Construction Details

Former Fly Ash Reservoir I - Residual Solid Waste Landfill
Cardinal Power Plant
Brilliant, Ohio

Monitoring Well Number	Boring Number	Date Installed	Northing (OH State Plane South (ft.) NAD 27/NGVD 29)	Easting (OH State Plane South (ft.) NAD 27/NGVD 29)	Top of Casing (ft.)	Ground Elevation (ft.)	Top of Bentonite Seal (ft.)	Top of Gravel Pack (ft.)	Top of Screen (ft.)	Bottom of Screen (ft.)	Bottom of Gravel Pack (ft.)	Bottom of Bore Hole (ft.)	Total Well Depth From TOC (ft.)	Casing Type (PVC)	Casing Diameter (In.)	Borehole Diameter (In.)	Hydrologic Unit
0AE 2005 10C	0AE-610C	2/16/2006	N 833,417.27	E 2,511,621.45	1240.85	1237.93	1013.83	1008.23	1002.53	997.53	996.83	996.83	243.32	SCH. 40	2.00	6.00	Shallow
CA-0623A	CA-0622	8/16/2016	N 836,300.1	E 2,514,227.5	1162.72	1159.62	1012.62	1007.62	1005.62	995.62	995.62	995.62	164.00	SCH. 40	2.00	6.00	Shallow
S-1	8502 / PFBC-2	12/12/1985	N 831,399.1	E 2,515,207.8	1002.41	999.50	970.70	965.50	935.00	931.00	929.50	929.50	66.10	SCH. 80	1.25	3.00	Shallow
S-10	CA-0607	1/9/2007	N 831,867.6	E 2,516,495.5	1005.19	1002.48	980.38	973.68	962.78	943.78	941.08	902.68	61.41	SCH. 40	2.00	6.00	Shallow
S-17	CA-0601	6/12/2007	N 833,612.2	E 2,512,715.1	1198.00	1195.63	1013.83	1008.43	1005.33	995.83	993.33	780.13	202.17	SCH. 40	2.00	6.00	Shallow
S-18	CA-0603	8/22/2007	N 832,194.6	E 2,513,796.2	1155.37	1153.26	1012.86	1003.26	999.46	989.96	987.86	987.86	165.41	SCH. 40	2.00	6.00	Shallow
S-19A	CA-0606A	7/28/2011	N 830,793.8	E 2,514,074.6	1098.60	1095.98	1015.98	1001.08	995.98	985.98	984.98	984.28	114.32	SCH.40	2.00	6.00	Shallow
S-2	8503 / PFBC-3	12/17/1985	N 831,038.3	E 2,514,714.2	1039.45	1038.60	998.10	992.10	959.10	954.10	948.60	948.50	80.79	SCH. 80	1.25	3.00	Shallow
S-20	CA-0619	8/24/2006	N 830,850.2	E 2,515,582.3	1005.88	1003.43	963.13	957.93	943.43	918.43	916.43	916.43	87.45	SCH. 40	2.00	6.00	Shallow
S-4	88-5-6 / PFBC-5	10/1/1988	N 834,352.3	E 2,513,052.2	1012.94	1010.90	983.90	978.90	930.90	928.90	926.90	805.90	81.64	SCH. 80	1.00	3.00	Shallow
S-5	88-7-8 / PFBC-7	10/1/1988	N 834,917.6	E 2,512,916.2	1002.20	1000.20	980.60	975.60	929.60	927.60	925.60	805.40	71.94	SCH. 80	1.00	3.00	Shallow
S-6	88-9-10 / PFBC-9	10/1/1988	N 834,577.4	E 2,513,679.4	1006.66	1010.90	971.20	966.20	919.20	917.20	916.20	780.90	92.37	SCH. 80	1.00	3.00	Shallow
S-7	90CA22-S / CA-22S	8/14/1990	N 831,920.17	E 2,516,676.41	1010.61	1008.52	975.42	969.62	942.42	939.92	937.92	937.92	68.04	SCH. 80	1.00	3.00	Shallow
S-GS-1	S-GS-1	04/12/2016	N 833647.71	E 2514525.68	1014.57	1012.81	952.81	946.81	944.81	934.81	931.78	905.81	80.09	SCH. 40	2.00	6.00	Shallow
S-GS-2	S-GS-2	04/12/2016	N 832448.38	E 2515777.51	1011.75	1009.07	942.07	937.07	935.07	925.07	923.04	915.07	87.01	SCH. 40	2.00	6.00	Shallow
S-GS-3	S-GS-3	04/05/2016	N 835737.21	E 2511639.37	1039.42	1036.93	913.93	908.93	906.93	896.93	894.90	833.43	142.82	SCH. 40	2.00	6.00	Shallow

Notes:
Elevation datum is National Geodetic Vertical Datum of 1929 (NGVD29).
Well S-19 replaced by S-19A in 2007.
Well CA-0623 was over-drilled and replace with CA-0623A on 8/16/2016

FIGURES



Legend

★ ☆ Site Location

Notes
- All locations are approximate.
- Topographic maps courtesy of National Geographic Society.

Site Location Map
Former FAR I / RWL

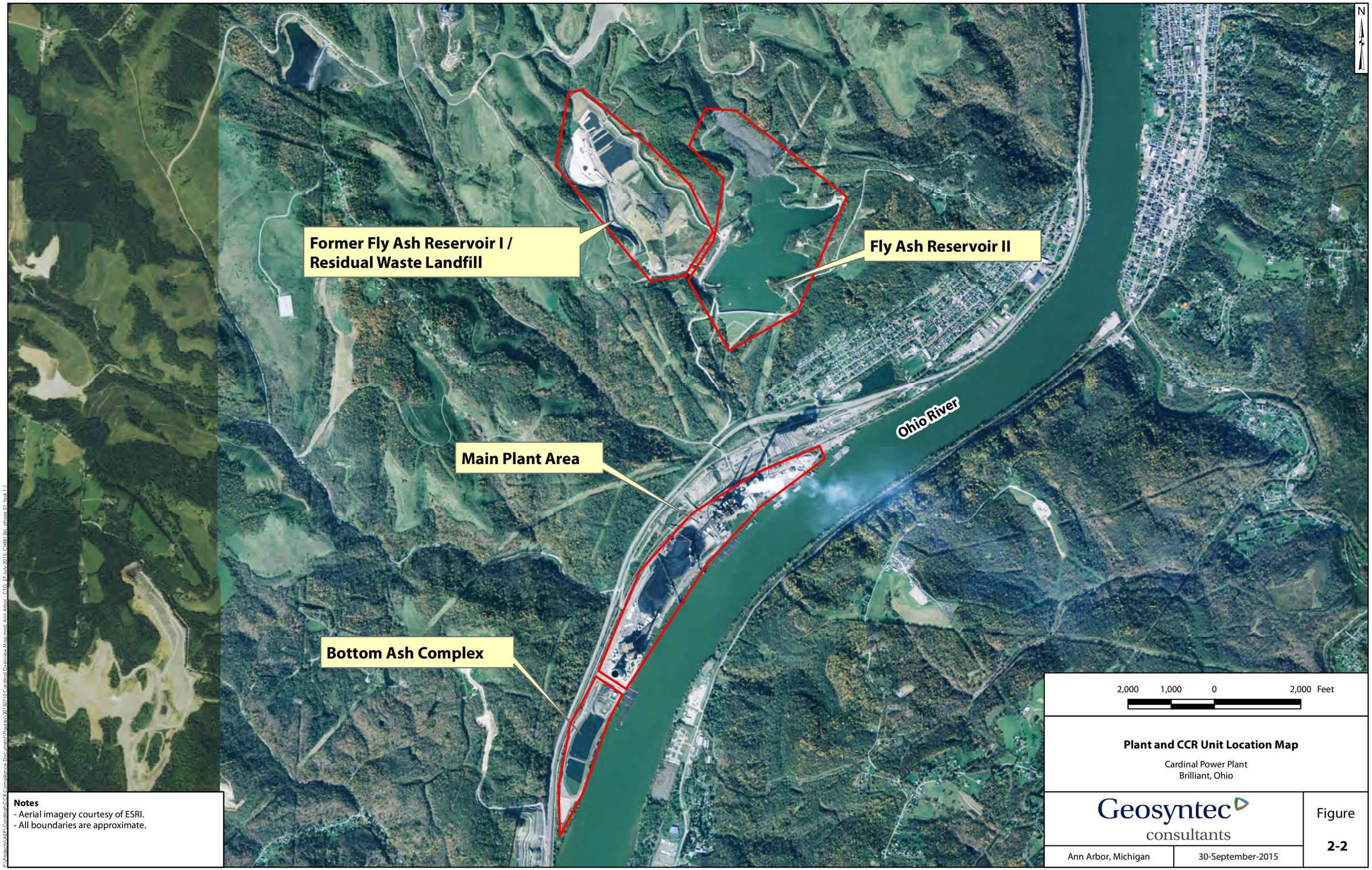
Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 01-October-2015

Figure **2-1**

P:\Projects\AEP\Cardinal\CCR Compliance Document\Figures\Site Location Map_Landfill.mxd; author: 01-October-2015; CHE8126A phase 01



Notes
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.

Plant and CCR Unit Location Map

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 30-September-2015

Figure **2-2**

P:\Projects\AEP\Cardinal\CCR Compliance Document\Figures\20150710 Cardinal Overview Main.mxd; Ann Arbor - CTG; 27-July-2015; CH2M 2Kb; phase 01; task 1.1

CA-0623
1088.05

S-GS-3

S-5
996.94

S-6
1000.77

S-4

S-17
1001.56

S-GS-1

0AE 2005,10C
1012.49

Former Fly Ash Reservoir I /
Residual Waste Landfill

S-GS-2

S-18
995.72

S-10
968.19

Fly Ash Reservoir II

S-7
963.56

S-1
991.57

S-2
999.02

S-19A
997.75

S-20
969.25

Ohio River

1010
1000
990
980
970

N

Legend

- Existing Monitoring Well Network (Shallow Aquifer)
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Aerial imagery courtesy of ESRI.
- All locations are approximate.
- Groundwater levels measured on 15 September 2014.
- Groundwater contours based on Shallow Water Table Map (AEP, 2014).
- Only wells within the shallow aquifer and with static water level measurements during this event are shown.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Aquifer
Former FAR I RSW Landfill

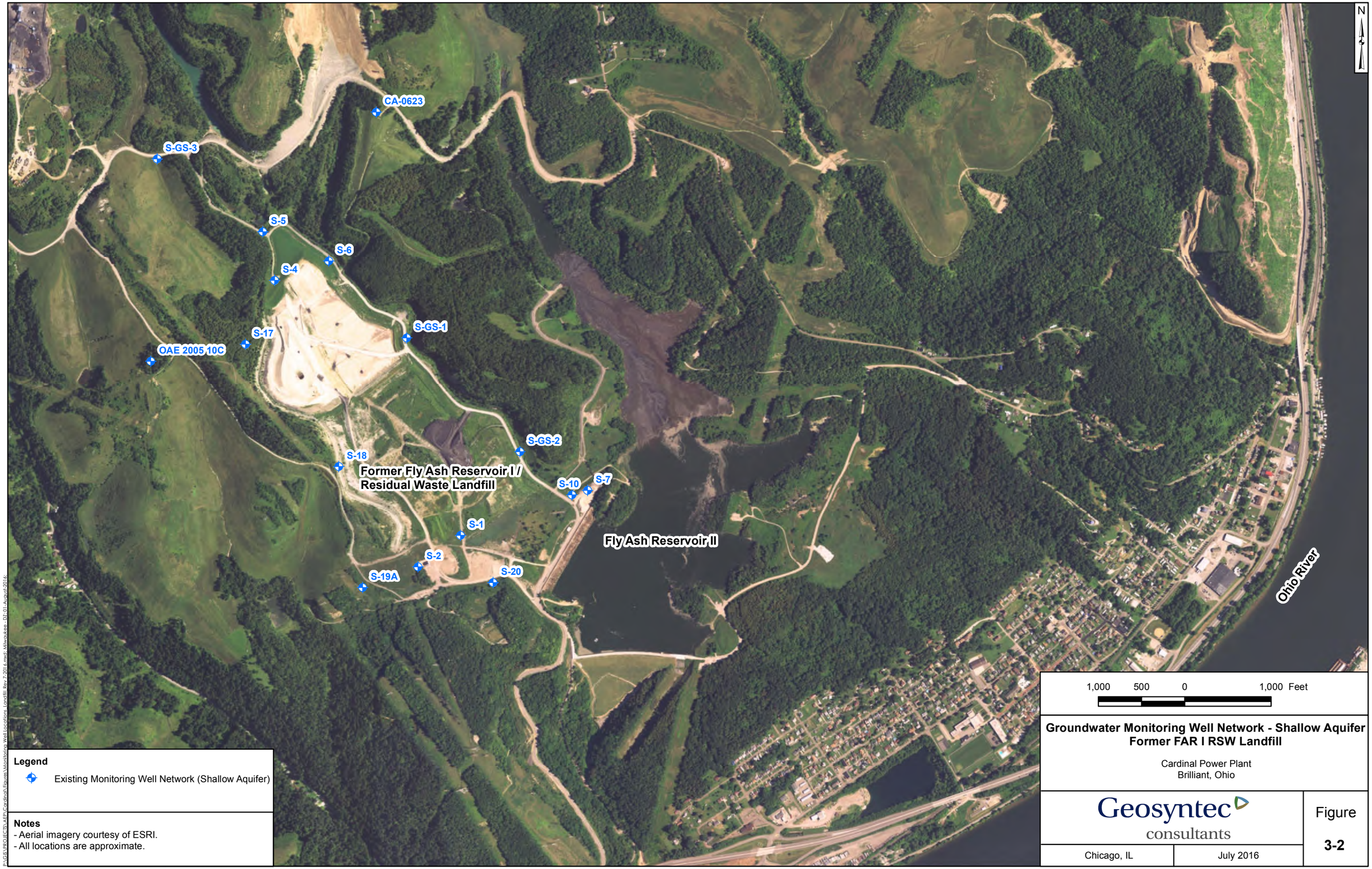
Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Chicago, IL | July 2016

Figure
3-1

P:\GIS\PROJECTS\AEP\Cardinal\Figures\GW Contours\Shallow F201.4 Rev. 7-2016.mxd; Milwaukee - DZ; 01-August-2016;CH2E8126A\01/1.3/1810



Legend

Existing Monitoring Well Network (Shallow Aquifer)

Notes

- Aerial imagery courtesy of ESRI.
- All locations are approximate.

Groundwater Monitoring Well Network - Shallow Aquifer
Former FAR I RSW Landfill

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Chicago, IL | July 2016

Figure **3-2**

P:\GIS\PROJECTS\AEP\Cardinal\Figures\Monitoring Well Locations_Landfill_Rev 7-2016.mxd; Milwaukee - DZ; 01-August-2016;

APPENDIX A

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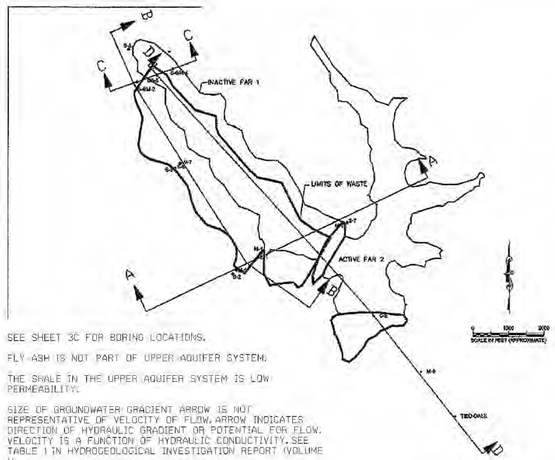
APPENDIX B

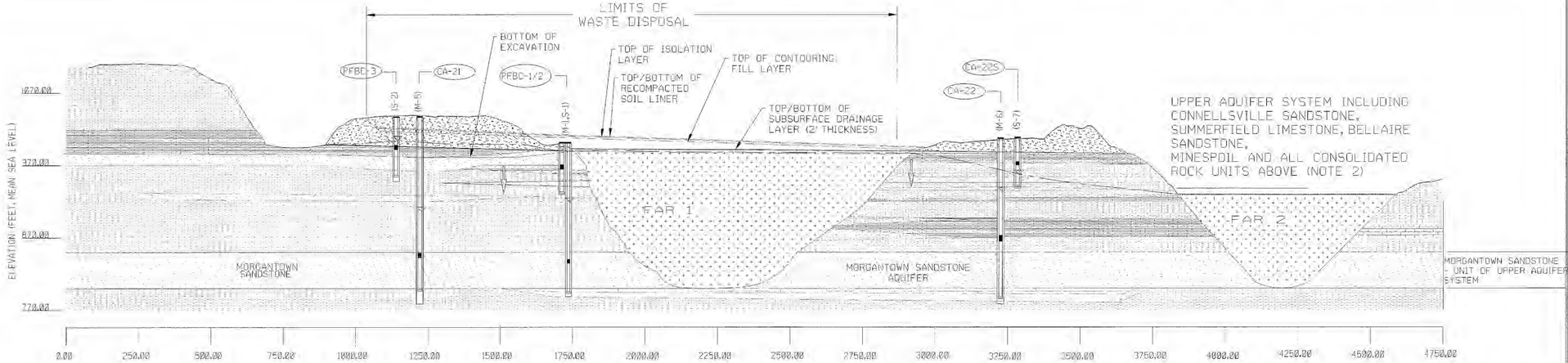
GEOLOGIC CROSS SECTIONS

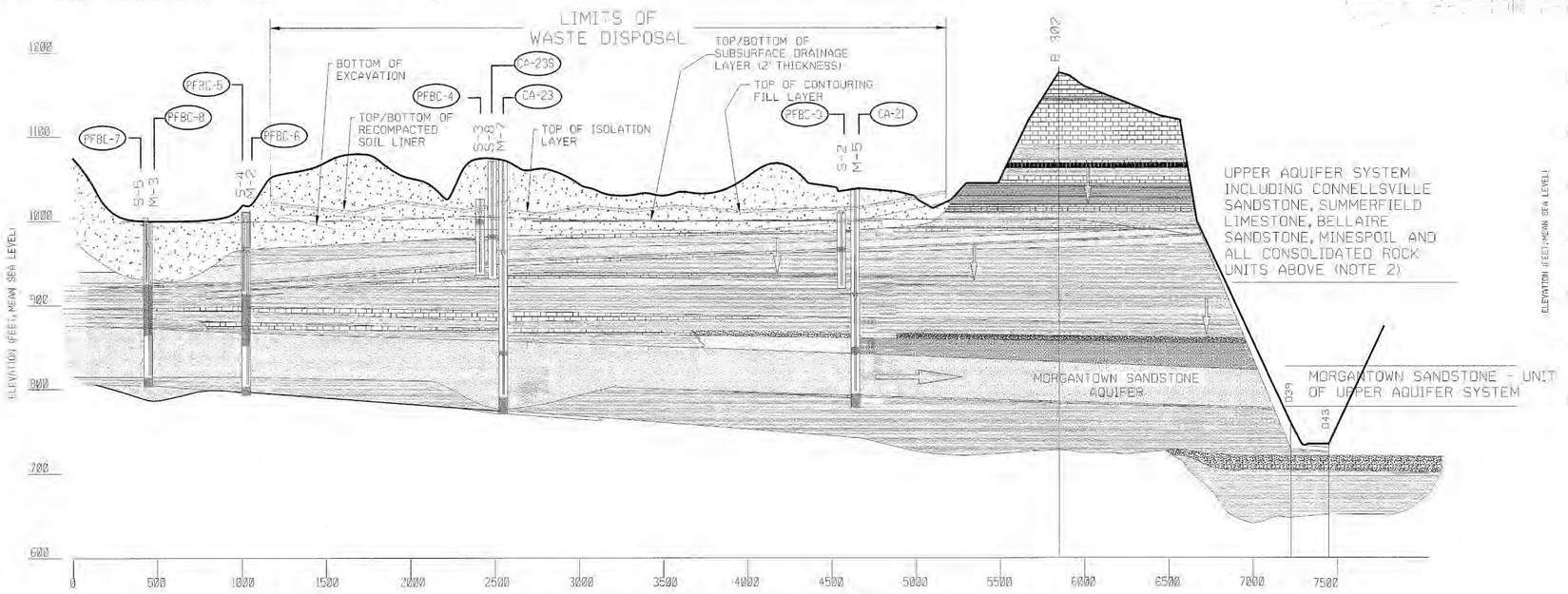
DWG. NO. - 13-30100-5A

SECTION LOCATION PLAN

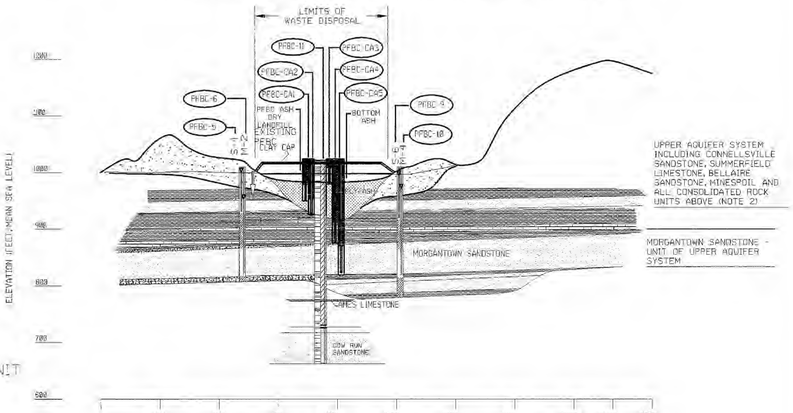


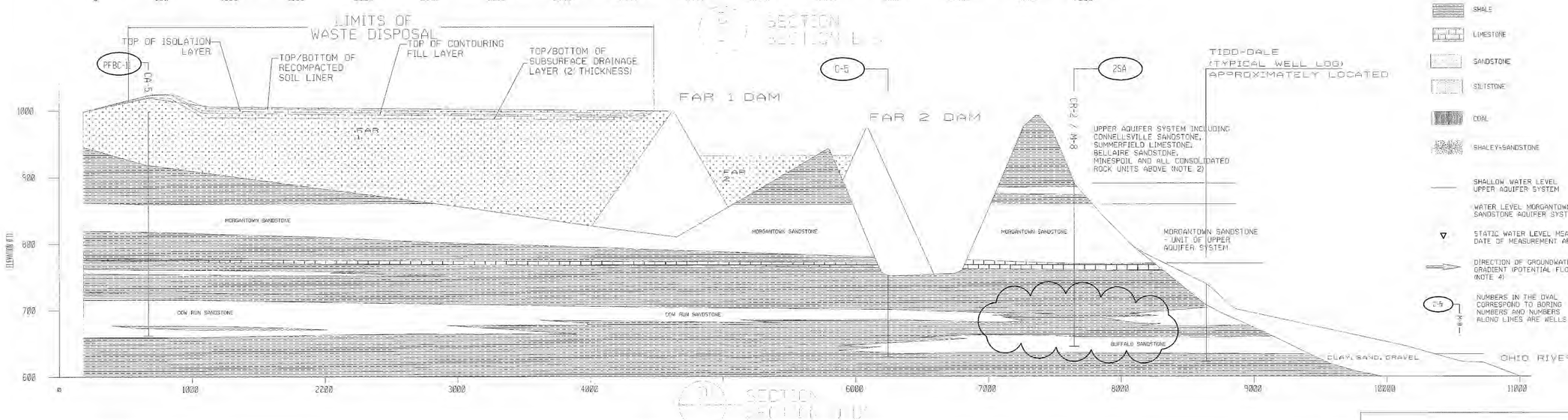
1. SEE SHEET 3C FOR BORING LOCATIONS.
2. FLY-ASH IS NOT PART OF UPPER AQUIFER SYSTEM.
3. THE SHALE IN THE UPPER AQUIFER SYSTEM IS LOW PERMEABILITY.
4. SIZE OF GROUNDWATER GRADIENT ARROW IS NOT REPRESENTATIVE OF VELOCITY OF FLOW, ARROW INDICATES DIRECTION OF HYDRAULIC GRADIENT OR POTENTIAL FOR FLOW. VELOCITY IS A FUNCTION OF HYDRAULIC CONDUCTIVITY. SEE TABLE 1 IN HYDROGEOLOGICAL INVESTIGATION REPORT (VOLUME 1).





NOTE: SEE DRAWING 13-30560 FOR EXTENSION OF THIS SECTION FROM RIDDLES RUN TO CROTS CREEK.





SECTION SECTION L

SECTION SECTION M

SECTION SECTION N

LEGEND

- FLY ASH
- MINESPOIL
- SHALE
- LIMESTONE
- SANDSTONE
- SILTSTONE
- COAL
- SHALEY SANDSTONE
- SHALLOW WATER LEVEL UPPER AQUIFER SYSTEM
- WATER LEVEL MORGANTOWN SANDSTONE AQUIFER SYSTEM
- STATIC WATER LEVEL MEASUREMENTS DATE OF MEASUREMENT APR 21, 2004
- DIRECTION OF GROUNDWATER GRADIENT (POTENTIAL FLOW) (NOTE 4)
- C-5 — NUMBERS IN THE OVAL CORRESPOND TO BORING NUMBERS AND NUMBERS ALONG LINES ARE WELLS

NO.	DATE	DESCRIPTION	APPD.
0	SEPT 24 2008	ISSUED FOR PERMIT	SDB
B	NOV 25 2008	REVISED PER I RESPONSE	SDB
C	NOV 17 2008	REVISED - NCD & RESPONSE	DSB
D	3/6/12	REVISED PER REF FOR SECTION C-C' TO SHOW SHALE STRATA SEPARATING COW RUN FROM BUFFALO SANDSTONE	HFZ

REVISIONS

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CARDINAL OPERATING COMPANY

BRILLIANT OHIO

TITLE: CARDINAL FAR 1 RESIDUAL WASTE LANDFILL GEOLOGIC/HYDROGEOLOGIC CROSS SECTIONS

DWG. NO. 13-30100-5A-D

SCALE:	CIVIL ENGINEERING DIVISION
CH.	
CH.	
ENG.	
PROJ. MGR.	
DWN.	
DATE:	

APPROVED BY: Pedro J. Camaya

PROJECT NO. EMERSON
FILE NO.
DRAWING: 5E, 5F, 5H

AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE:

APPENDIX C

BORING LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,291.1 E 2,514,223.8**

GROUND ELEVATION **1159.2** SYSTEM _____

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0622** DATE **7/17/15** SHEET **1** OF **16**

BORING START **4/10/06** BORING FINISH **6/1/06**

PIEZOMETER TYPE _____ WELL TYPE _____

HGT. RISER ABOVE GROUND **2.281** DIA _____

DEPTH TO TOP OF WELL SCREEN **354.9** BOTTOM **359.9**

WELL DEVELOPMENT _____ BACKFILL _____

FIELD PARTY **DLB / MCR / MWJ** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		0.0	10.0									**GROUNDING PROCEDURES NOT IN USE ON THIS BORING. BLIND DRILLED FROM GRADE TO 10' WITH 3 7/8" ROLLER BIT & SET 3" PVC CASING. STARTED CORING AT 10.0'**
1	NQ	10.0	13.9		3.3		10			**HARD N8 VERY LIGHT GRAY LIMESTONE** w/ 1/2" clay bands in bottom 0.3'		
2	NQ	13.9	18.9		5.0		15			**HARD N8 VERY LIGHT GRAY LIMESTONE**		
										SOFT 5G 6/1 GREENISH GRAY SHALE		
3	NQ	18.9	23.9		4.7					**HARD 5R 4/2 GRAYISH RED SHALE**		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER _____

AEP_CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **2** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5G 6/1 GREENISH GRAY LIMESTONE fractured throughout		
										5GY 6/1 GREENISH GRAY SHALE		
4	NQ	23.9	33.9		9.7		25			**5B 5/1 MEDIUM BLUISH GRAY SHALE** fractured		
										N7 LIGHT GRAY LIMESTONE		
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY LIMESTONE fractured		
							30			**5G 6/1 GREENISH GRAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE		
5	NQ	33.9	43.9		9.8		35			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** fractured in bottom 1.5'		
							40					
6	NQ	43.9	46.9		3.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
							45					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **3** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
7	NQ	46.9	53.9		7.0		50					
										5B 5/1 MEDIUM BLUISH GRAY SHALE		
8	NQ	53.9	63.9		9.6		55			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
9	NQ	63.9	73.9		10.0		60					
							65			**HARD 5B 5/1 MEDIUM BLUISH GRAY to N6 MEDIUM LIGHT GRAY SHALE**		
										HARD N4 MEDIUM DARK GRAY SHALE small coal band @ 73.8		
							70					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **4** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	NQ	73.9	83.9		10.0		75			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ coal band @ 74.4, angle fracture @ 75.7		
										SOFT N4 MEDIUM DARK GRAY SHALE		
							80			**HARD N2 GRAYISH BLACK SHALE**		
										COAL		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE		
11	NQ	83.9	93.9		10.0					**HARD N5 MEDIUM GRAY SHALE**		
							85					
							90			**HARD 5B 7/1 LIGHT BLUISH GRAY MIXED w/ N6 MEDIUM LIGHT GRAY SHALE** w/ limestone nodules		
12	NQ	93.9	103.9		10.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							95					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **5** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5B 7/1 LIGHT BLUISH GRAY SHALE w/ sandstone streaks, angle fracture @ 98.5		
13	NQ	103.9	113.9		10.0		100			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks, bottom 0.5 carbonious		
							105					
							110			**N8 VERY LIGHT GRAY LIMESTONE**		
										HARD N3 DARK GRAY SHALE		
										N7 LIGHT GRAY LIMESTONE w/ 0.2 5B 5/1 medium bluish gray shale band @ 111.6		
14	NQ	113.9	123.9		10.0					**N7 LIGHT GRAY LIMESTONE**		
							115			**HARD 5GY 4/1 DARK GREENISH GRAY SHALE**		
										5GY 4/1 DARK GREENISH GRAY SHALE		
							120			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **6** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	NQ	123.9	133.9		10.0		125			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** bottom 0.8 N3 dark gray carbonious		
							130			**N5 MEDIUM GRAY FINE GRAIN SANDSTONE** w/ shale band		
16	NQ	133.9	143.9		10.0					**HARD N5 MEDIUM GRAY SHALE**		
							135			**COAL** w/ hard shale bands		
							140			**N4 MEDIUM DARK GRAY SHALE** w/ 0.5 of carbonious shale at 142.0, bottom 1.9 hard		
17	NQ	143.9	153.9		10.0					**HARD N6 MEDIUM LIGHT GRAY SHALE**		
							145			**N8 VERY LIGHT GRAY LIMESTONE**		
										HARD N6 MEDIUM LIGHT GRAY SHALE		
										N8 VERY LIGHT GRAY LIMESTONE w/ 0.3 shale bands @ 147.8 & 152.4		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **7** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	153.9	163.9		6.2	68	155			**HARD N6 MEDIUM LIGHT GRAY LIMESTONE**		**SWL 21.4' on 04/17/06 w/ NQ HOLE TO 153.9'. USED ±4,000 GALS. WATER TO THIS POINT**
										HARD N6 MEDIUM LIGHT GRAY FRACTURED LIMESTONE		
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
										SOFT N5 MEDIUM GRAY SHALE/LIMESTONE		**LOST ALL WATER RETURN AT 157.8'. HYD. PUSH - NO ROTATION FROM 163.9' - 165.9' (VOID)**
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
19	NQ	163.9	168.9		1.9	84	160			**VOID**		
							165			**SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
20	NQ	168.9	170.9		1.3	0				**SOFT N5 MEDIUM GRAY SHALE** wet		
21	NQ	170.9	178.9		7.9	67	170			**HARD N6 MEDIUM LIGHT GRAY SHALE**		**Stopped after going through mine void. Started drilling HW casing and cleaning inside of casing w/ 4" roller bit. At 155', roller bit broke off inside casing. It was decided to abandon and grout this boring. Moved east +/- 5" and started drilling new boring w/ 6" air**
										SOFT N4 MEDIUM DARK GRAY SHALE fractures throughout		
										HARD N6 MEDIUM LIGHT GRAY SHALE fractured		
							175					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **8** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY SHALE		**hammer and inserted HW casing to bottom old mine floor @ 173.3'. This boring was drilled through mine piller; no camera work done on this boring. Coal seam estimated @ +/- 165.0'-17**
22	NQ	178.9	186.9		6.6	56				**SOFT N7 LIGHT GRAY SHALE** w/ fracture		
							180			**SOFT N6 MEDIUM LIGHT GRAY SHALE**		
										SOFT N6 MEDIUM LIGHT GRAY SHALE w/ fracture, wet		
										HARD N7 LIGHT GRAY SHALE dry		
										N7 LIGHT GRAY CLAY SHALE dry		
										HARD N7 LIGHT GRAY CLAY SHALE		
							185			**N4 MEDIUM DARK GRAY SHALE**		
23	NQ	186.9	189.4		2.5	88				**VERY HARD N6 MEDIUM LIGHT GRAY SHALE** w/ trace of fine limestone		**Resumed coring and logging core @ 186.9'**
24	NQ	189.4	194.4		5.0	40				**N5 MEDIUM GRAY SHALE** fracture, wet		
							190			**N6 MEDIUM LIGHT GRAY SHALE/LIMESTONE**		
										SOFT MEDIUM GRAY SHALE wet		
										MEDIUM LIGHT GRAY SHALE		
										SOFT N5 MEDIUM GRAY SHALE moist		
25	NQ	194.4	204.4		10.0	83				**5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							195			**HARD N5 MEDIUM GRAY SHALE** fracture		
										HARD N5 MEDIUM GRAY SHALE		
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **9** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SHALE fracture, wet		
										HARD N5 MEDIUM GRAY SHALE		
26	NQ	204.4	214.4		8.7	64	205			**HARD N4 MEDIUM DARK GRAY SHALE**		
										5G 6/1 GREENISH GRAY SHALE w/trace of fine imestone, wet		
										N2 GRAYISH BLACK SHALE fractured		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										N2 GRAYISH BLACK SHALE fracture		
										N5 MEDIUM GRAY SHALE fracture, wet		
							210			**5G 6/1 GREENISH GRAY SHALE**		
										5G 6/1 GREENISH GRAY SHALE wet		
27	NQ	214.4	219.4		5.0	66				**5GY 6/1 GREENISH GRAY SHALE/LIMESTONE**		
							215			**N5 MEDIUM GRAY SHALE**		
										SOFT 5YR 6/1 LIGHT BROWNISH GRAY SANDY SHALE		
28	NQ	219.4	229.4		9.9	81	220			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures		
										5B 5/1 MEDIUM BLUISH GRAY SHALE w/limestone		
							225			**N4 MEDIUM DARK GRAY SHALE** fractured, wet		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **10** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
29	NQ	229.4	238.8				230			**5B 5/1 MEDIUM BLUISH GRAY SHALE/ LIMESTONE** fracture **N4 MEDIUM DARK GRAY SHALE** fractured **HARD MEDIUM DARK GRAY SHALE** w/limestone		
30	NQ	238.8	244.4				235 240			**MEDIUM DARK GRAY LIMESTONE** shale fractures **HARD DARK GRAY LIMESTONE** **HARD N4 MEDIUM DARK GRAY SHALE**		
31	NQ	244.4	254.4				245 250			**N2 GRAYISH BLACK COAL** fracture **SOFT N4 MEDIUM DARK GRAY SHALE** **HARD N4 MEDIUM DARK GRAY SHALE/LIMESTONE** **5B 5/1 MEDIUM BLUISH GRAY SHALE** **5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures **SOFT 5GY 6/1 GREENISH GRAY SHALE** w/limestone, wet **N5 MEDIUM GRAY & 5YR 4/1 BROWNISH GRAY SHALE** **5B 5/1 MEDIUM BLUISH GRAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **11** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
32	NQ	254.4	264.4				255			**SOFT MEDIUM BLUISH GRAY SHALE**		
										HARD 5GY 6/1 GREENISH GRAY SHALE w/fractures of limestone		
							260			**5YR 4/1 BROWNISH GRAY RED SHALE**		
										MEDIUM BLUISH GRAY SHALE w/fractures of limestone		
33	NQ	264.4	274.4				265			**N4 MEDIUM DARK GRAY SHALE**		
										SOFT N4 MEDIUM DARK GRAY SHALE wet		
							270					
34	NQ	274.4	284.4				275			**SOFT N4 MEDIUM DARK GRAY SHALE**		
										N7 LIGHT GRAY & N4 MEDIUM DARK GRAY SHALE w/trace of limestone		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **12** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N4 MEDIUM DARK GRAY SHALE/LIMESTONE		
35	NQ	284.4	294.4				285			**HARD SHALE** **N4 MEDIUM DARK GRAY SHALE** w/fractures of limestone		
										HARD N3 DARK GRAY SHALE		
36	NQ	294.4	304.4				290					
							295			**HARD N4 MEDIUM DARK GRAY SHALE**		
							300					
37	NQ	304.4	314.4		10.0	100	305					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **13** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310					
38	NQ	314.4	324.4		10.0		315			**N4 MEDIUM DARK GRAY SHALE**		
										N4 MEDIUM DARK GRAY & N6 MEDIUM LIGHT GRAY SHALE w/fine sandstone		
							320			**N4 MEDIUM DARK GRAY SHALE** w/traces of fine standstone lens		
										N5 MEDIUM GRAY SHALE w/trace of fine sandstone		
39	NQ	324.4	334.4		10.0		325			**HARD MEDIUM GRAY & MEDIUM DARK GRAY SHALE** w/trace of coarse sandstone		
							330			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of sandstone		
										N5 MEDIUM GRAY COARSE GRAIN		**MORGANTOWN**

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **14** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SANDSTONE Morgantown sandstone starts @ 331.5'		**SANDSTONE STARTS @ 331.5'**
40	NQ	334.4	344.4		10.0		335			**N6 MEDIUM LIGHT GRAY SANSDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of fine sandstone		
										N2 GRAYISH BLACK SHALE		
							340			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE**		
										HARD N2 GRAYISH BLACK SHALE w/trace of fine sandstone		
41	NQ	344.4	354.4		9.8	92	345			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE** w/trace of dark shale		
										HARD N4 MEDIUM DARK GRAY SHALE w/trace of fine sandstone		
							350					
										MEDIUM GRAY SANDSTONE w/dark shale fractures		
42	NQ	354.4	364.4		9.7	91	355			**N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE**		
										GRAYISH BLACK COAL fracture		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **15** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE		
							360			**N5 MEDIUM GRAY SHALE**		
43	NQ	364.4	373.4		10.0	90	365			**N6 MEDIUM LIGHT GRAY SILTSTONE**		
							370			**HARD N5 MEDIUM GRAY SHALE**		
44	NQ	373.4	383.4		10.0	81				**HARD N3 DARK GRAY CLAY SHALE**		
							375			**N2 GRAYISH BLACK CLAY SHALE SEAM**		
										N1 BLACK COAL SEAM		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							380					**STOPPED BORING**

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **16** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												@ 383.4'. SET 1" GEOMON WELL

AEP CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,612.2 E 2,512,715.1**

GROUND ELEVATION **1195.6** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0601** DATE **7/17/15** SHEET **1** OF **17**

BORING START **6/5/07** BORING FINISH **6/12/07**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.369** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **190.3** BOTTOM **199.8**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / MWJ** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					GROUNDING PROCEDURES NOT IN USE ON THIS BORING; WATER FOR DECONNING AND DRILLING FROM CARDINAL FIRE PROTECTION SYSTEM; DECONED RIG & TOOLS 05/05/07; BLIND DRILLED HW 4" CASING TO START CORING @ 14.0'; MOVED +/- 6' NORTH WHERE TOM DICK HAD THE BORING STAKED.
							10					
1	NQ	14.0	15.5							**SOFT 5Y 6/1 LIGHT OLIVE GRAY CLAY**		
2	NQ	15.5	25.5		3.6	42	15			**SOFT CLAYEY LIMESTONE** **HARD 10YR 7/4 GRAYISH ORANGE LIMESTONE**		LOST ALL WATER RETURN @ 19.0'

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AEP CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **2** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
3	NQ	25.5	35.5		2.1	48	25			**5YR 6/4 LIGHT BROWN SANDY SHALE**		
										HARD N8 VERY LIGHT GRAY LIMESTONE		
										HARD N8 VERY LIGHT GRAY LIMESTONE w/iron staining		
							30			**SOFT 5YR 4/1 BROWNISH GRAY SHALE**		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
4	NQ	35.5	45.5				35			**5YR 5/6 LIGHT BROWN SAND**		
										SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE		
							40			**HARD N6 MEDIUM GRAY SHALE**		
										HARD N6 MEDIUM GRAY SHALE w/iron staining		
										HARD N7 MEDIUM LIGHT GRAY LIMESTONE		
5	NQ	45.5	52.5		6.5	42	45			**5YR 7/2 GRAYISH ORANGE PINK**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **3** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										LIMESTONE vertical fracture w/iron staining		
										SOFT 5G 6/1 GREENISH GRAY SHALE		
										SOFT 5G 6/1 GREENISH GRAY SHALE w/iron staining		
										SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE		
							50					
6	NQ	52.5	58.5		6	52				**HARD 5B 5/1 MEDIUM BLUISH GRAY LIMESTONE** w/ vertical fracture		SWL DRY; NQ HOLE TO 52.5
										5YR 4/4 MODERATE BROWN SANDY SHALE w/iron staining		
										N5 MEDIUM GRAY SHALE		
							55			**MEDIUM LIGHT GRAY LIMESTONE**		
										VERY SOFT MEDIUM GRAY SHALE		
										HARD MEDIUM GRAY SHALE		
7	NQ	58.5	60.5		2	25				**HARD MEDIUM LIGHT GRAY SHALE**		
							60					
8	NQ	60.5	70.5		10	70				**N5 MEDIUM GRAY SHALE**		
										N5 MEDIUM GRAY SHALE w/ vertical fracture		
										LIMESTONE		
							65					
							70					
9	NQ	70.5	76.5		6	47				**HARD N5 MEDIUM GRAY SHALE**		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **4** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY LIMESTONE w/ vertical fracture		
10	NQ	76.5	85.5		9	44	75			**N4 MEDIUM DARK GRAY SHALE** w/iron staining **N7 LIGHT GRAY LIMESTONE** **HARD N4 MEDIUM GRAY CLAY SHALE**		
							80			**N4 MEDIUM GRAY CLAY SHALE** w/ broken areas		
11	NQ	85.5	95.5		9	82	85			**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
							90			**BROKEN CLAY SHALE** **HARD N6 BROKEN CLAY SHALE** **BROKEN CLAY SHALE**		
12	NQ	95.5	105.5		10	60	95			**HARD N6 BROKEN CLAY SHALE** w/vertical fracture **HARD N5 MEDIUM GRAY SHALE** **N5 MEDIUM GRAY BROKEN CLAY SHALE** **HARD 5YR 4/1 BROWNISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **5** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
										5YR 4/1 BROWNISH GRAY LIMEY CLAY SHALE		
13	NQ	105.5	111.5		5.6	54	105			**SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
										N1 BLACK COAL		
14	NQ	111.5	120.5		9		110			**N2 GRAYISH BLACK CLAY SHALE** **SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
							115			**N2 GRAYISH BLACK CLAY SHALE** **N4 MEDIUM DARK GRAY CLAY SHALE**		
							120			**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
15	NQ	120.5	130.5		10.3	51				**N6 LIGHT GRAY LIMESTONE** **N4 MEDIUM DARK GRAY CLAY SHALE** **N6 LIGHT GRAY LIMESTONE**		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **6** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125			**SOFT N5 MEDIUM DARK GRAY CLAY SHALE**		
										N6 FINE GRAIN SANDSTONE		
										N6 FINE GRAIN SANDSTONE & CLAY SHALE		
16	NQ	130.5	140.5		10	37	130			**MEDIUM DARK GRAY SILTY CLAY SHALE**		
							135					
							140			**N7 LIGHT GRAY LIMESTONE**		
17	NQ	140.5	150.5		10	60				**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
										SOFT N6 MEDIUM LIGHT GRAY CLAY SHALE		
							145					
										HARD N6 MEDIUM LIGHT GRAY CLAY SHALE		

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **7** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	150.5	160.5		10	80				**HARD N5 MEDIUM GRAY CLAY SHALE**		
							155					
										N4 MEDIUM DARK GRAY SILTY CLAY SHALE		
							160					
19	NQ	160.5	170.5		10	11				**N4 MEDIUM DARK GRAY SILTY CLAY SHALE**		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										N5 MEDIUM GRAY SILTY CLAY SHALE		
							165					
										N1 BLACK COAL		
										N2 GRAYISH BLACK DARK CLAY SHALE		
							170			**N1 BLACK COAL**		
20	NQ	170.5	180.5		10	71				**N2 GRAYISH BLACK CLAY SHALE**		
										SOFT N2 GRAYISH BLACK CLAY SHALE		
										HARD N4 MEDIUM DARK GRAY CLAY SHALE		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
							175					
										SOFT N5 MEDIUM GRAY CLAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **8** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N7 LIGHT GRAY LIMESTONE		
21	NQ	180.5	190.5		10	70	180			**N5 MEDIUM LIGHT GRAY LIMESTONE**		
										HARD N5 MEDIUM GRAY CLAY SHALE		
										N7 LIGHT GRAY LIMESTONE		
							185			**N6 MEDIUM LIGHT GRAY LIMEY CLAY SHALE**		
										HARD N5 MEDIUM GRAY CLAY SHALE		
										SOFT N5 MEDIUM GRAY LIMEY CLAY SHALE		
22	NQ	190.5	200.5		10	18	190			**SOFT N5 MEDIUM GRAY LIMEY CLAY SHALE**		
										N4 MEDIUM DARK GRAY to BLACK CLAY SHALE		
										SOFT N6 MEDIUM LIGHT GRAY LIMEY CLAY SHALE		
										N4 MEDIUM DARK GRAY to BLACK CLAY SHALE		
							195			**N1 BLACK COAL**		
							200			**N2 GRAYISH BLACK CLAY SHALE**		
23	NQ	200.5	210.5		10	80				**N5 MEDIUM GRAY LIMEY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **9** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY LIMESTONE		
							205			**SOFT N5 MEDIUM GRAY CLAY SHALE**		
										N7 LIGHT GRAY CLAYEY LIMESTONE w/pyrite		
24	NQ	210.5	220.5		10	83	210			**N6 MEDIUM LIGHT GRAY LIMESTONE**		
							215			**N4 MEDIUM DARK GRAY CLAY SHALE**		
										N7 LIGHT GRAY FINE GRAIN SILTSTONE		
										N7 LIGHT GRAY CLAY SHALE/SILTSTONE		
25	NQ	220.5	230.5		10	79	220			**SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
										N6 MEDIUM LIGHT GRAY SILTY CLAY SHALE		
										N6 LIGHT GRAY CLAY SHALE/SILTSTONE		
							225			**N6 MEDIUM LIGHT GRAY SILTY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **10** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					
26	NQ	230.5	240.5		10	47				**N6 MEDIUM LIGHT GRAY CLAY SHALE/ SILTSTONE**		
										N4 MEDIUM DARK GRAY CLAY SHALE		
							235			**N6 MEDIUM LIGHT GRAY CLAY SHALE** w/ siltstone		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
										N4 MEDIUM DARK CLAY SHALE		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
							240					
27	NQ	240.5	249.5		9	44				**N6 MEDIUM LIGHT GRAY SILTSTONE**		
										N7 LIGHT GRAY LIMEY CLAY SHALE		
							245			**SOFT N5 MEDIUM GRAY CLAY SHALE**		
										N5 MEDIUM GRAY LIMEY CLAY SHALE		
										HARD N5 MEDIUM GRAY CLAY SHALE		
28	NQ	249.5	255.5		6	55	250			**N5 MEDIUM GRAY LIMEY CLAY SHALE**		
										5RP 4/2 GRAYISH RED PURPLE CLAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **11** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							255			**N5 MEDIUM GRAY CLAY SHALE**		
29	NQ	255.5	265.5		10	90				**5G 6/1 GREENISH GRAY LIMEY SILTSTONE** w/clay shale		SWL 187.4'; NQ HOLE TO 255.5'
							260			**5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/ siltstone		
30	NQ	265.5	275.5		10	68	265			**N6 MEDIUM LIGHT GRAY SILTY FINE GRAIN SANDSTONE**		
							270			**SOFT BROWNISH GRAY SANDY CLAY SHALE**		
										MEDIUM GRAY LIMEY CLAY SHALE		
										VERY SOFT 5YR 4/1 BROWNISH GRAY CLAY SHALE		
							275			**5GY 6/1 GREENISH GRAY LIMEY CLAY SHALE**		
31	NQ	275.5	285.5		10	53				**5RP 4/2 GRAYISH RED PURPLE RED CLAY SHALE**		
										N5 MEDIUM GRAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **12** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5RP 4/2 GRAYISH RED PURPLE CLAY SHALE		
										N6 MEDIUM LIGHT GRAY CLAY SHALE		
							285					
32	NQ	285.5	295.5		10	72				**VERY SOFT 5YR 3/2 GRAYISH BROWN CLAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
							290					
							295					
33	NQ	295.5	305.5		10	84				**N5 MEDIUM GRAY CLAY SHALE**		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
							300					
										5YR 4/1 BROWNISH GRAY CLAY SHALE		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
										N7 LIGHT GRAY LIMESTONE		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							305					
34	NQ	305.5	310.5		5	58						

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **13** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310			**HARD 5YR 3/2 GRAYISH BROWN CLAY SHALE**		
35	NQ	310.5	315.5		5	58				**5R 4/2 GRAYISH RED RED CLAY SHALE**		SWL 185.3'; NQ HOLE TO 310.5'; 50 hr reading
										N4 MEDIUM DARK GRAY CLAY SHALE		
36	NQ	315.5	325.5		10	95	315					
							320			**N6 MEDIUM LIGHT GRAY SILTSTONE** w/limestone nodules		
							325					
37	NQ	325.5	335.5		10	100				**HARD N6 MEDIUM LIGHT GRAY SILTSTONE** w/limestone nodules		
							330					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **14** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY FINE GRAIN SANDSTONE		
										HARD N5 MEDIUM GRAY SILTSTONE		
38	NQ	335.5	345.5		10	97	335					
										MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE w/crossbedding throughout		
							340					
							345					
39	NQ	345.5	355.5		10	97				**HARD N4 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
							350					
							355			**N2 COAL PARTING GRAYISH BLACK**		
40	NQ	355.5	365.5		10	94				**HARD N4 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										N2 GRAYISH BLACK COAL PARTING		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **15** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							360			**HARD N5 MEDIUM GRAY MEDIUM GRAIN STANDSTONE**		
										HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE		
										HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE w/coal partings		
41	NQ	365.5	375.5		10	92	365			**HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										GRAYISH BLACK COAL PARTING		
							370			**HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/coal partings throughout		
										HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE		
42	NQ	375.5	385.5		10	92	375			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/crossbeddings throughout		SWL 190.7'; NQ HOLE TO 375.5
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE		
							380			**N4 MEDIUM DARK GRAY MEDIUM GRAIN SANDSTONE** w/crossbeddings throughout		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **16** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							385			**N6 MEDIUM LIGHT GRAY LIMESTONE**		
43	NQ	385.5	395.5		10	91				**N5 MEDIUM GRAY FINE GRAIN SILTY SANDSTONE**		
							390					
										HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE		
44	NQ	395.5	405.5		10	94	395			**HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
							400					
							405					
45	NQ	405.5	415.5		10	70				**HARD MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
										N4 MEDIUM DARK GRAY CLAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **17** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							415					STOPPED BORING @ 415.5'; FLUSHED W/~700 GALS WATER; GEO PHYSICAL LOGGED; INSTALLED 1" GEOMON TYPE WELL

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,867.6 E 2,516,495.5**

GROUND ELEVATION **1002.5** SYSTEM

Water Level, ft	▽	▼	▼
TIME			
DATE			

BORING NO. **CA-0607** DATE **7/17/15** SHEET **1** OF **5**

BORING START **1/9/07** BORING FINISH **1/9/07**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **2.704** DIA **2**

DEPTH TO TOP OF WELL SCREEN **39.7** BOTTOM **58.7**

WELL DEVELOPMENT BACKFILL

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
	AUGER	0.0	14.0							Grounding procedures not in use on this boring. Deconned rig & tools 01/03/07. Decon & drilling water used from cardinal plant fire protection system. Blind drilled 3.25" HSA's from 0' to 14.0'; started coring @ 14.0'		
1	NQ	14.0	19.0		1.8	72	5 10 15			**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
2	NQ	19.0	24.8		5.8	17				**HARD MEDIUM LIGHT GRAY LIMESTONE** w/iron staining and fractures		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **MCR**

AEP CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **2** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM HARD N5 MEDIUM GRAY CLAY SHALE		
3	NQ	24.8	34.8		9.9	51	25			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/high angle fracture, iron staining throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE w/high angle fracture, iron staining throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE w/high angle fracture, iron staining throughout		
							30					
										HARD 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE w/high angle fracture, iron staining throughout		
4	NQ	34.8	44.8		4.8	33	35			**MEDIUM TO SOFT N5 MEDIUM GRAY CLAY SHALE**		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
										MEDIUM TO SOFT N5 MEDIUM GRAY CLAY SHALE		
							40					
												Lost all water return @ 43.7'
5	NQ	44.8	54.8		9.8	54	45			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **3** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										w/iron staining		
							50			**HARD FINE 5B 7/1 LIGHT BLUISH GRAY WELL SEAMED SANDSTONE** w/iron staining		
6	NQ	54.8	64.8		10.0	20	55			**HARD 5GY 6/1 GREENISH GRAY SHALE**		
										HARD 56 5/1 MEDIUM BLUISH GRAY FINE SANDY SHALE		
							60					
										SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
7	NQ	64.8	74.8		10.0	55	65			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N5 MEDIUM GRAY SILTY CLAY SHALE w/fractures		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **4** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
8	NQ	74.8	84.8		9.7	41	75			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE** w/fractures throughout		
							80			**SOFT CLAY SHALE AREA**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE w/fractures throughout		
9	NQ	84.8	90.3		5.5	42	85			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE** w/fractures		
							90			**HARD N7 LIGHT GRAY LIMESTONE**		
10	NQ	90.3	99.8		8.3					**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE		
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **5** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												Stopped boring @ 99.8' on 01/04/07. Plugged NQ hole from 99.8' to 61.0' w/ bentonite pellets. Built 2" well.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,399.8 E 2,515,207.8**

GROUND ELEVATION **999.6** SYSTEM **STATE PLANE**

Water Level, ft	▽	▼	▼
TIME			
DATE			

BORING NO. **8502** DATE **7/17/15** SHEET **1** OF **3**

BORING START **12/9/85** BORING FINISH **12/12/85**

PIEZOMETER TYPE _____ WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.64** DIA **.75**

DEPTH TO TOP OF WELL SCREEN **64.5** BOTTOM **68.5**

WELL DEVELOPMENT _____ BACKFILL **GROUT**

FIELD PARTY **MCR-ML** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER _____

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8502** DATE **7/17/15** SHEET **2** OF **3**

PROJECT **CARDINAL PLANT** BORING START **12/9/85** BORING FINISH **12/12/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					28.8 TOP OF SEAL.
							35					34.0 TOP OF SAND.
							40					
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8502** DATE **7/17/15** SHEET **3** OF **3**

PROJECT **CARDINAL PLANT** BORING START **12/9/85** BORING FINISH **12/12/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	NQ	50.0	60.0		9.5	69	50			**LIGHT GREEN GRAY MEDIUM GRAY DARK GRAY SOME RED CLAY SHALE** Calcareous, fissile, soft, fresh, partings sandy.		
							55					
2	NQ	60.0	61.0		.6	33	60			**MEDIUM TO DARK GRAY CLAYEY LIMESTONE** Hard, fresh except oxidized orange on joints at 66.2.		
3	NQ	61.0	70.0		8.5	78				**MEDIUM GREEN GRAY CLAY SHALE** Fissile, calcareous with sand size limestone nodules, poorly cemented, soft, fresh.		63.9 CHECK VALVE. 64.5 TOP OF SCREEN. 68.5 BOTTOM OF SCREEN.
							65					
							70					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,038.2 E 2,514,714.2**

GROUND ELEVATION **1038.6** SYSTEM **STATE PLANE**

Water Level, ft	▽	▼	▼
TIME			
DATE			

BORING NO. **8503** DATE **7/17/15** SHEET **1** OF **4**

BORING START **12/12/85** BORING FINISH **12/17/85**

PIEZOMETER TYPE _____ WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.29** DIA **.75**

DEPTH TO TOP OF WELL SCREEN **80.5** BOTTOM **84.5**

WELL DEVELOPMENT _____ BACKFILL **GROUT**

FIELD PARTY **MCR-ML** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER _____

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **2** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
							40					40.5 TOP OF SEAL.
1	NQ	44.3	50.0		2.9	38	45			**MEDIUM BLUE GRAY CLAY SHALE** Calcareous , portions sandy with laminations fine grain light gray sand to 47.1. limestone nodules and streaks limestone, most		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **3** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										soft, sandy portions moderately hard. 55'-60' very calcareous, moderately hard, fresh.		46.5 TOP OF SAND.
2	NQ	50.0	60.0		10.0	92	50					
							55					
3	NQ	60.0	70.0		10.0	100	60			**MEDIUM TO DARK BLUE GRAY SHALE** Fissile, lenses and laminations of very fine grain light gray quartZ sandstone, portions calcareous, all fresh no joints visible, all core portions appears to be machine breaks. shale grades down to carbonaceous shale to 69', easily separates, sandy portions hard.		
							65					
4	NQ	70.0	71.5		1.3	87	70			**LIGHT GRAY CLAYEY LIMESTONE** Hard, fresh.		
5	NQ	71.5	80.0		8.3					**DARK BLUE GRAY SHALE** Blocky, calcareous , streaks and nodules, limestone, siderite portions of shale with >50% limestone, fresh **MEDIUM BLUE GRAY SHALE** CALCAREOUS		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **4** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										WITH LAMINATIONS, FINE GRAIN WHITE SAND, FRESH MODERATELY HARD.		
										DARK GRAY LIMESTONE Microcrystalline, fresh, hard.		
							75			**MOSTLY LIGHT BLUE GRAY TO LIGHT GREEN GRAY CLAY SHALE** Calcareous blocky, portions dark gray at 75' and 75.7', all soft, fresh , fresh slickenslided surfaces at various orientations. all calcareous with fine sand size to gravel size limestone nodules lenses shaley limestone at 75.-76.3 and 84.5-85.0.		
6	NQ	80.0	90.0		10.0		80					79.9 CHECK VALVE. 80.5 TOP OF SCREEN.
							85			**LIGHT BLUE GRAY SANDY SHALE** Fissile with laminations light gray fine grain quartz sand portions calcareous with streaks and nodules limestone, fresh. moderately hard.		84.5 BOTTOM OF SCREEN
							90					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,352.3 E 2,513,052.2**

GROUND ELEVATION **1010.9** SYSTEM **STATE PLANE**

Water Level, ft	▽ 20.3	▼ 20.0	▼
TIME	7:20	7:15	
DATE	8-16-88	8-17-88	

BORING NO. **88-5-6** DATE **7/17/15** SHEET **1** OF **9**

BORING START **8/11/88** BORING FINISH **8/16/88**

PIEZOMETER TYPE _____ WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT _____ BACKFILL **GROUT**

FIELD PARTY **MCR-TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												WATER IN CREEK pH 7.3 TESTED BY CARDINAL PLANT LAB PERSONAL.
1	SS	2.5	4.0	5-7-6	.5					**GRAY CLAY** With limestone and coal fragments (fill).		
2	SS	7.5	9.0	7-6-5	.4		5					7.8 LOST WATER IN CASING.
3	SS	12.5	12.5	50/.5	0		10					
4	SS	18.3	19.8	7-7-6	.2		15			**YELLOW CLAY** With coal and limestone fragments.		17.1 DRILLED 2 15/16" ROLLER BIT FROM 17.1 TO 18.3 THROUGH LIMESTONE BOLDERS.

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **2** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	SS	22.2	23.4	19-27-50/.2	.4		25			**GRAY LIMESTONE FRAGMENTS**		
6	SS	27.5	29.0	8-11-15	.5					**GRAY CLAY** With clay shale and limestone fragments.		27.0 TOP OF SEAL.
7	SS	32.5	34.0	5-12-13	.7		30					32.0 TOP OF SAND.
8	SS	37.5	39.0	6-9-13	.2		35			**SANDSTONE FRAGMENTS**		
9	SS	42.5	42.9	50/.4	.4		40			**.2 YELLOW SANDSTONE .2 LIMESTONE**		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **3** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	SS	47.5	49.0	20-15-16	0		50					
11	SS	52.5	53.3	27-50/.3	.2					**GREEN AND GRAY SANDY SHALE** Partially cemented.		
12	SS	57.5	57.8	50/.3	.2		55			**RED CLAY SHALE**		
13	NQ	58.0	61.6		.8					**RED AND GRAY CLAYSTONE** Soft.		58.0 SET CASING
14	NQ	61.6	65.0		3.4	88	60			**GRAY CLAYEY SANDSTONE** Hard, calcareous, grading to fine grain hard sandstone.		
15	NQ	65.0	71.7		6.6	89	65			**GRAY SANDSTONE** Fine, hard. **67.0-67.6 LIGHT BROWN** **68.5-70.0 LIGHT BROWN**		
							70			**71.9-73.0 LIGHT BROWN**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **4** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
16	NQ	71.7	75.0		3.3	67						1.7-75.0 LOST 50% DRILL WATER.
17	NQ	75.0	85.0		9.7	60	75			**77.2-77.6 LIGHT BROWN**		
										79.3-79.7 BROKEN WITH IRON STAIN ON SOFT.		79.4 CHECK VALVE.
							80			**GRAY CLAYSTONE** Calcareous, soft.		80.0 TOP OF SCREEN.
										GRAY , LIGHT BROWN LIMESTONE Hard.		82.0 BOTTOM OF SCREEN.
18	NQ	85.0	95.0		9.8	46	85			**GRAY CLAYSTONE** Calcareous, soft.		84.0 BOTTOM OF SAND.
							90			**GRAY LIMESTONE** Hard.		
										GRAY CLAYSTONE Calcareous, soft.		
19	NQ	95.0	105.0		9.8	62	95			**GRAY LIMESTONE** Hard.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **5** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100			**GRAY CLAYSTONE** Soft, calcareous, with calcite seams.		
										GRAY CLAY SHALE Soft with some red and gray layers.		
20	NQ	105.0	115.0		10.0	68	105					
							110			**GRAY CLAYSTONE** Soft.		
										GRAY LIMESTONE Changing to brown at 114.6. **SOFT CLAYSTONE LAYERS AT 112.1-112.3 AND 112.7-112.09**		
21	NQ	115.0	125.0		5.2	33	115			**RED CLAYSTONE** Calcareous, soft.		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **6** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125					
22	NQ	125.0	135.0		9.5	36				**GRAY CLAYSTONE** Soft, calcareous, with gray clay shale layers from 126.4-128.1		
							130			**GRAY SHALEY LIMESTONE** Hard.		
23	NQ	135.0	145.0		9.9	73	135			**GRAY CLAYSTONE** Soft with limestone nodules.		
							140			**GRAY SHALEY SANDSTONE** Soft, calcite seams.		
										GRAY SANDSTONE Fine grain.		
24	NQ	145.0	155.0		10.0	100	145					146.5 TOP OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **7** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
25	NQ	155.0	165.0		10.0	98	155					
							160					
26	NQ	165.0	175.0		10.0	98	165					
							170					
27	NQ	175.0	185.0		10.0	98	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **8** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
28	NQ	185.0	195.0		10.0	100	180					
							185					
							190					191.9 CHECK VALVE. 192.5 TOP OF SCREEN.
29	NQ	195.0	205.0		9.9	95	195			**GRAY SHALEY SANDSTONE** Soft.		194.5 BOTTOM OF SCREEN. 196.5 BOTTOM OF SAND.
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **9** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							205					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,917.6 E 2,513,916.2**

GROUND ELEVATION **1000.2** SYSTEM **STATE PLANE**

Water Level, ft	▽ 6.4	▼ 10.2	▼ 22.0
TIME	7:10	7:20	3:00
DATE	8-9-88	8-10-88	8-11-88

BORING NO. **88-7-8** DATE **7/17/15** SHEET **1** OF **8**

BORING START **8/8/88** BORING FINISH **8/10/88**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR=TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SS	2.7	4.2	10-12-14	.9					**GRAY FLY ASH BROWN CLAY**		
2	SS	7.7	9.2	14-3-5	.5		5			**GRAY FLY ASH AND ASPHALT FRAGMENT**		
3	SS	12.7	14.2	13-9-9	.5		10			**LIMESTONE AND GRAVEL FRAGMENTS**		
4	SS	17.7	19.2	9-11-11	.1		15			**LIMESTONE FRAGMENTS**		

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TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **2** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	SS	22.7	24.2	11-6-9	.3		25			**LIMESTONE FRAGMENTS**		20.0 TOP OF SEAL.
6	SS	27.7	29.2	10-10-13	.5		30			**LIMESTONE FRAGMENTS**		24.6 TOP OF SAND.
7	SS	32.7	32.7	50/0	0		35					
8	SS	37.7	39.2	8-12-9	.1		40			**LIMESTONE FRAGMENTS**		39.2 No samples were taken from 39.2' to 67.5'. material consisted of bolderss and soil. NQ core barrel was used to cut bolders and advanced casing.
		39.2	67.5				45					

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AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **3** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	NQ	67.5	69.8		2.3	0	70			**LIGHT GREEN SANDSTONE** Fine grain changing to gray at 69.8'.		
11	NQ	69.8	73.2		1.7	0				**GRAY CLAYSTONE** Soft.		70.0 CHECK VALVE. 70.6 TOP OF SCREEN.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **4** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	73.2	74.8		1.5	0				**LIGHT BROWN SILTY LIMESTONE** Hard.		72.6 BOTTOM OF SCREEN.
13	NQ	74.8	77.0		.7		75			**GRAY CLAYSTONE** Soft.		74.6 BOTTOM OF SAND.
14	NQ	77.0	79.8		2.4					**GRAY CLAYSTONE** Soft with limestone nodules.		
15	NQ	79.8	82.0		2.1	0	80					
16	NQ	82.0	83.2		1.0	0						
17	NQ	83.2	84.8		1.3	0				**RED AND GRAY CLAYSTONE** Soft, with calcite seams 90.0-93.0.		
18	NQ	84.8	87.2		2.1	0	85					
19	NQ	87.2	89.8		2.6	0						
20	NQ	89.8	94.8		4.9	92	90					
										GRAY CLAY SHALE Soft.		
21	NQ	94.8	99.8		4.7	78	95					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **5** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
22	NQ	99.8	101.9		2.1	0	100			**GRAY CLAYSTONE** Soft.		
23	NQ	101.9	102.5		.5	0				**GRAY LIMESTONE** Hard.		
24	NQ	102.5	104.8		2.1	51						
25	NQ	104.8	109.8		5.0	76	105			**GRAY CLAYSTONE** Soft, calcareous, changing to red at 105.1.		
26	NQ	109.8	114.8		4.6	46	110					
27	NQ	114.8	124.8		10.0	48	115			**GRAY CLAYSTONE** Soft with calcite seams.		
										GRAY SANDY SILTSTONE Hard.		
							120			**GRAY CLAYSTONE** Soft, with limestone nodules 121.3-124.1.		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **6** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
28	NQ	124.8	134.8		9.8	83	125					
										GRAY SANDY CLAYSTONE Calcareous grading to light fine grain sandstone at 143.7.		
							130					
29	NQ	134.8	144.8		10.0	100	135					134.7 TOP OF SAND.
							140					
										GRAY SANDSTONE Hard, fine grain, well cemented.		
30	NQ	144.8	154.8		10.0	89	145					

AEP CD SI.GPJ AEP.GDT 7/17/15

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **7** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
31	NQ	154.8	164.8		10.0	90	155					
32	NQ	164.8	174.8		10.0	98	160					
33	NQ	174.8	184.8		10.0	84	165					
							170					
							175					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **8** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					180.1 CHECK VALVE. 180.7 TOP OF SCREEN. 182.7 BOTTOM OF SCREEN
34	NQ	184.8	194.8		10.0	79	185			**GRAY CLAYSTONE** Soft, calcareous.		184.7 BOTTOM OF SAND.
										GRAY CLAYEY LIMESTONE		
										GRAY CLAYSTONE Calcareous, soft.		
							190			**GRAY SHALEY SANDSTONE** Calcareous.		

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,577.4 E 2,513,679.4**

GROUND ELEVATION **1010.9** SYSTEM **STATE PLANE**

Water Level, ft	▽ 22.0	▼ 22.8	▼ 26.4
TIME	1:15	7:10	7:05
DATE	8-1-88	8-2-88	8-3-88

BORING NO. **88-9-10** DATE **7/17/15** SHEET **1** OF **10**

BORING START **7/28/88** BORING FINISH **8/4/88**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR-TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					DRILLED NW CASING TO 53.2'. DRILL WATER IN POND 7.36 TESTED BY CARDINAL PLANT PERSONAL.
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **2** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
							40					39.7 TOP OF SEAL.
							45					44.7 TOP OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **3** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	NQ	53.2	54.8		0	0	50					
2	NQ	54.8	59.8		1.6	0	55			**GRAY CLAYSTONE** Soft,broken, iron stain and calcareous at end of run.		
3	NQ	59.8	65.0		4.9	67	60			**GRAY SILTSTONE** Hard with calcite seams.		61.2 LOST DRILL WATER.
4	NQ	65.0	75.0		10.0	91	65			**GRAY SANDSTONE** Hard, v-fine grain, well cemented. **68.4-69.4 BROWN**		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **4** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	NQ	75.0	85.0		9.8	49	75			**GRAY SANDY SILTSTONE** Hard.		
										RED AND BROWN CLAYSTONE Soft.		
							80			**LIGHT GRAY LIMESTONE** Hard.		
										GRAY AND RED CLAYSTONE Limestone nodules, calcite seams.		
6	NQ	85.0	95.0		9.8	34	85					
							90					91.1 CHECK VALVE. 91.4 WASH WATER RETURNED. 91.7 TOP OF SCREEN.
												93.7 BOTTOM OF SCREEN.
7	NQ	95.0	105.0		9.8	83	95					94.7 BOTTOM OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **5** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAY CLAYSHALE Soft, changing to red and gray at 103.3.		
							100					
										GRAY CLAYSTONE ? Soft.		
8	NQ	105.0	108.0		1.9	0	105					
9	NQ	108.0	115.0		1.6	0				**1.3' of GRAY LIMESTONE** Hard.		108 PULLED NQ RODS TO REPAIR LANDING RING IN CORE BARREL. REASON FOR LOST CORE.
							110					
10	NQ	115.0	125.0		10.0	68	115			**GRAY AND RED CLAYSTONE** Soft, calcareous.		
										GRAY SILTY SANDSTONE Hard.		
							120			**RED AND GRAY CLAYSTONE** Hard.		
										GRAY CLAYSTONE Soft, limestone nodules,		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **6** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125			grading to fine grain clayey sandstone at133.4.		
11	NQ	125.0	135.0		8.2	57						
							130					
										GRAY CLAYEY SANDSTONE Hard, fine grain.		
12	NQ	135.0	145.0		9.9	90	135					
										GRAY SANDSTONE Hard, fine grain, well cemented.		
							140					
13	NQ	145.0	155.0		10.0	90	145					145.6 BOTTOM OF SEAL.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **7** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ	155.0	165.0		10.0	87	155			**158.0-158.6 DARK GRAY FINE GRAIN**		
							160					
15	NQ	165.0	175.0		10.0	90	165					
							170					
16	NQ	175.0	180.0		4.9	70	175					

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AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **8** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
17	NQ	180.0	185.0		5.0	98	180					
18	NQ	185.0	189.1		4.1	76	185					
19	NQ	189.1	195.0		5.9	81	190			**GRAY SANDY CLAYSTONE** Soft, calcite seams.		191.0 CHECK VALVE. 191.6 TOP OF SCREEN. 193.6 BOTTOM OF SCREEN.
20	NQ	195.0	195.2		.2	0	195			**DARK GRAY SANDSTONE** Hard, v-fine grain.		195.6 BOTTOM OF SAND.
21	NQ	195.2	195.4		.2	0						
22	NQ	195.4	196.4		.9	0						
23	NQ	196.4	205.0		8.5	96				**GRAY SANDSTONE** Fine grain, calcareous.		
							200			**GRAY SANDY SILTSTONE** Hard, calcareous.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **9** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
24	NQ	205.0	210.0		8.0	76	205					
25	NQ	210.0	215.0		5.0	86	210					
26	NQ	215.0	220.0		5.0	100	215			**GRAY SILTSTONE** Hard.		
27	NQ	220.0	230.0		10.0	70	220			**GRAY CLAYSTONE** Soft, calcareous.		
							225					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **10** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **OHIO POWER COMPANY**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

COORDINATES **N 831,920.2 E 2,516,676.4**

GROUND ELEVATION **1008.5** SYSTEM **STATE PLANE**

WATER LEVEL	▽ 52.7	▼	▼
TIME			
DATE			

BORING NO. **90CA22-S** DATE _____ SHEET **1** OF **2**

BORING START **08/13/90** BORING FINISH **08/14/90**

PIEZOMETER TYPE _____ WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.94** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **66.2** BOTTOM **68.2**

WELL DEVELOPMENT _____ BACKFILL **BENSEAL**

FIELD PARTY **MCR-JF** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5			NO SPT SAMPLES TAKEN SEATED CASING AT 18.1. LOST WATER DRILL NW CASING AT 9.7. NO WATER RETURN DURING DRILLING. NOT A GOOD SEAL AT CASING ROCK INTERFACE.		
							10					
							15					
1	NQ	18.1	25.6		5.0		20			GRAY SILTY CLAYSHALE Calcareous, vertical cracks 20.8-21.1, 21.6-21.8		
										GRAY SHALEY LIMESTONE Hard.		
2	NQ	25.6	28.6		2.6	0	25			GRAY SILTY SANDSTONE V-fine grain.		
3	NQ	28.6	35.6		7.0	80				GRAY LIMESTONE Hard, stain on joints and vertical cracks.		
							30			GRAY TO BLACK CLAYSHALE		
										GRAY SILTY SANDSTONE F-fine grain.		33.1 TOP OF SEAL.
4	NQ	35.6	45.6		?		35			vertical cracks		
							40			GRAY LIGHT GRAY CLAYSHALE Slightly sandy, calcareous.		38.6 TOP OF SAND.
										LIGHT GRAY SANDSTONE Silt crossbedding throughout, thin bedding at 43.1		
							45			GRAY TO LIGHT TO DARK GRAY CLAYSHALE Broken slightly calcareous.		
5	NQ	45.6	50.6		?					LIGHT GRAY LIMESTONE Vertical fracture from 46.0-46.9, calcite filled.		
										GRAY SANDY CLAYSHALE Broken, silty,		

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TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **JD**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **OHIO POWER COMPANY** BORING NO. **90CA22-S** DATE _____ SHEET **2** OF **2**

PROJECT **TIDD ASH POND SITE INVESTIGATION** BORING START **08/13/90** BORING FINISH **08/14/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	50.6	52.0		1.1	31				slightly calcareous.		
7	NQ	52.0	57.0		4.6	58				**DEEP MAROON PURPLE CLAYSHALE** Blocky, slightly calcareous, slightly weathered.		PLUGGED OFF.
							55			**LIGHT GREEN TO LIGHT GRAY CLAYSHALE** Slightly broken.		
8	NQ	57.0	65.6		8.6	100				**LIGHT TAN TO LIGHT GRAY SANDSTONE** Fine grain, silt bedding throughout.		PLUGGED OFF. AFTER PULLING NQ RODS SWL 52.7.
							60					
										RUST BROWN CLAYSHALE Iron precipitate staining throughout, broken, slightly sandy to very sandy, fine grained sand.		
9	NQ	65.6	70.6		5.0	43	65					66.0 CHECK VALVE. 66.6 TOP OF SCREEN. 68.6 BOTTOM OF SCREEN
										LIGHT GRAY SANDSTONE Very fine grain, silt partings and cross bedding throughout.		
							70					

Geosyntec consultants
engineers | scientists | innovators

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-1
Page: 1 of 6

Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants
engineers | scientists | innovators

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-1
Page: 2 of 6

Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25				Run 1			78/96	48	(25') SANDSTONE: strong to very strong, medium gray (N5), fine grained, fresh, competent, slightly fractured, locally silty, massive.	RQD and recovery incorrect in box pictures.	25
									(27') Sandy SHALE: moderately strong, light olive gray (5Y 5/2), moderately decomposed, intensely fractured.		
30				Run 2			102/180	31	(33') SILTSTONE: strong, medium light gray (N6), massive, limestone nodules, fresh, competent, slightly to moderately fractured.		30
35									(34.7') Silty SANDSTONE: strong, medium light gray (N6), massive, micaceous, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		35
									(38.2') SILTSTONE to CLAYSTONE: moderately strong, medium light gray (N6), calcite nodules, massive, locally fissile, moderately decomposed, moderately to		
40											40

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-1
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Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40									intensely fractured, at top of unit heavy clay infillings in fractures.		40
45				Run 3			175/ 180	41			45
50									(49') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		50
55											55
60											60

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
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Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									(59.7') MUDSTONE: very weak, greenish gray, massive, highly decomposed, highly disintegrated.		60
									(61.1') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		
				Run 4			144/ 156	64	(63') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured, medium dark gray calcareous veining lasts for 0.5 ft.		
65									(65.2') 0.5 ft of highly decomposed, intensely fractured.		65
									(69.2') SANDSTONE: strong, medium bluish gray (5B 5/1), massive, fine grained, limestone nodules, locally silty, fresh to slightly decomposed, competent, slightly to moderately fractured.		
70											70
									(74.2') 0.5 ft of moderately disintegrated, very intensely fractured.		
75				Run 5			162/ 180	47	(76') SILTSTONE: strong, medium gray, massive, slickensides, very intensely fractured, slightly decomposed, slightly disintegrated.		75
									(77.1') SANDSTONE: strong, medium bluish gray (5B 5/1), massive, fine to medium grained, limestone nodules for 1.6 ft from top of sandstone, fresh, competent, slightly fractured, micaceous.		
80											80

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
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Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(78.1') Cross-bedding appears for rest of unit. (80.6') 0.8 ft vertical fracture, grades to medium yellowish brown for 1.5 ft.		80
85									(82.9') SILTSTONE: strong, medium light gray (N6), massive, slightly to moderately decomposed, slightly disintegrated, moderately fractured, at top of unit 1.3 ft vertical fracture.		85
90				Run 6			99/ 132	24	(91') SILTSTONE: strong to very strong, light gray (N6), large limestone nodules, massive, local slickensides, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		90
95									(95.8') Becomes intensely fractured.		95
100									(97.8') MUDSTONE: weak, medium light gray (N6) and grayish brown (5YR 3/2), highly decomposed, highly disintegrated. [CLARKSBURGH RED BEDS]		100

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Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100											100
									End of borehole at 102 ft bgs. Well installed on 04/12/2016		
105											105

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-2
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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10											10
15											15
20											20

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-2
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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25				Run 1			72/72	13	(25') SANDSTONE: strong to very strong, medium light gray (N6), fine grained, massive, micaceous, slightly decomposed, slightly disintegrated, moderately fractured, redox staining in fractures. (27.2') 0.9 ft vertical fracture, becomes shaly.		25
30				Run 2			156/156	63	(28.1') Sandy CLAYSTONE: moderately strong, medium dark gray (N4) and grayish black (N2), locally sandy, micaceous, intensely fractured, moderately decomposed, moderately disintegrated. (31') SILTSTONE: strong, medium gray (N5), massive, some limestone nodules, fresh to slightly decomposed, competent, slightly fractured.		30
35									(34.8') Silty SANDSTONE: strong, medium gray (N5), fine grained, micaceous, cross bedding, slightly fractured, fresh, competent, mica content grades to more down unit. (37.4') MUDSTONE: dark greenish gray (5GY 4/1), highly decomposed. (37.9') Sandy SILTSTONE: strong, medium light gray (N6), locally sandy, slightly fractured, slightly to moderately decomposed,		35
40											40

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Client: AEP-Cardinal
Project: CHE8126L
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BORING LOG
Boring/Well No. S-GS-2
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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40									slightly to moderately disintegrated, massive.		40
									(42.5') Vertical fracture with calcite infillings for rest of unit, dusky yellow to light brown color change.		
				Run 3			180/ 180	69	(43.8') Silty SANDSTONE: strong, medium light gray (N6), fine grained, cross bedding, fresh, competent, slightly fractured.		
45									(44') SILTSTONE: strong, greenish gray (5G 6/1), massive, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		45
									(48.3') Sandy SILTSTONE: strong, greenish gray (5G 6/1), locally sandy, minor cross bedding in sandy sectors, massive, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		
50									(52.1') CLAYSHALE to CLAYSTONE: strong, greenish gray (5G 6/1), fissile, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		50
									(53.6') CLAYSHALE to CLAYSTONE: weak, dark greenish gray (5G 4/1), fissile, limestone nodules/veining in fractures, moderately to highly decomposed, moderately to highly disintegrated, intensely fractured.		
55									(56.4') SILTSTONE: strong to very strong, light gray (N7) to medium dark gray (N4), massive, moderately fractured, slightly decomposed, slightly disintegrated, minor quartz inclusions.		55
				Run 4			153/ 180	37	(59') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately		
60											60

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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									to intensely fractured, slightly decomposed, prominent calcareous nodules, clay infillings in fractures.		60
65									(66.7') MUDSTONE: dark reddish brown (10R 3/4), highly decomposed.		65
									(67.1') SILTSTONE to CLAYSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately to intensely fractured, slightly decomposed, prominent calcareous veining and some local nodules.		
70									(68.6') Veining grades out.		70
									(69.1') Grades to grayish red purple (5RP 4/2), moderately decomposed, locally fissile.		
									(70.1') Changes to slightly decomposed, medium light gray (N6).		
75				Run 5			180/ 180	64	(74') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately to intensely fractured, moderately decomposed, moderately disintegrated, clay infillings in fractures.		75
									(77') SANDSTONE: strong, medium gray (N5), massive, cross-bedding starts 2.2 ft down sandstone unit, limestone nodules for first 2.2 ft of unit, becomes micaceous after 2.2 ft of unit, unfractured, fresh, competent, fine grained.		
80											80

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Client: AEP-Cardinal
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BORING LOG
Boring/Well No. S-GS-2
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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80											80
									(80.7') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, unfractured to slightly fractured, fresh, competent, clay infillings in fractures, minor limestone nodules.		
85									(84.2') SANDSTONE: strong, medium gray (N5), massive, unfractured, fresh, competent, fine grained.		85
									(84.7') CLAYSTONE to CLAYSHALE: greenish gray, slightly decomposed, moderately to highly fractured, 0.5 ft LIMESTONE unit at 3.1 ft into unit.		
90									End of borehole at 89 ft bgs. Well installed on 04/12/2016		90
95											95
100											100

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3
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Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

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Boring/Well No. S-GS-3
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Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25											25
30											30
35											35
40											40

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BORING LOG
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Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40				Run 1			42/ 120	28	Overburden: See remarks.	Began coring at 40 ft bgs due to boulders in overburden that roller bit could not drill through.	40
									(42.3') LIMESTONE: strong, greenish black (5GY 2/2), microcrystalline, moderately fractured, slightly decomposed, slightly disintegrated, clay in fractures.	Bedrock begins @ 42.3 ft.	
45									(46.3') Weak, highly decomposed, intensely fractured.		45
									(49.2') Vertical fracture (0.8 ft long).		
50				Run 2			133/ 156	64	(51.1') CLAYSTONE: moderately strong, medium dark gray (N4), massive, moderately decomposed, intensely fractured.		50
									(51.6') Changes to very weak, highly decomposed.		
55									(52.2') Sandy silty SHALE: strong, medium light gray (N6), massive, becomes laminated 0.5 ft from top of unit, competent, fresh, slightly fractured, micaceous, sand lenses increase at bottom of unit.		55
									(57.8') CLAYSHALE: strong, medium dark gray (N4), massive, slightly decomposed, competent, moderately fractured.		
60									(58.7') LIMESTONE: strong, medium dark		60

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Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									gray (N3), microcrystalline, massive, fresh, competent, moderately fractured, limestone nodules.	Begin logging by C. Gregory.	60
				Run 3			131/ 144	44	(63') Sandy silty SHALE: strong, medium to dark gray (N3 to N4), moderately fractured, some fine sandy laminations, minor cross bedding.		
65									(65') CLAYSHALE: moderately strong, medium dark gray to dark greenish gray (5G 4/1), intensely fractured, moderately decomposed, calcareous nodules/lenses.		65
									(69') CLAYSTONE: weak, dark greenish gray (5G 4/1).		
70									(70.5') Sandy silty SHALE: strong, medium to dark gray (N3 to N4), moderately fractured, some fine sandy laminations, minor cross bedding.		70
75				Run 4			156/ 156	73			75
80											80

NOTES:

Geosyntec consultants
engineers | scientists | innovators

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3
Page: 5 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(80') Silty SANDSTONE: strong, light gray (N7), moderately fractured, fresh, cross-bedded, thinly bedded, very fine grained.		80
									(81') SILTSTONE: strong, medium dark gray (N4).		
									(82') CLAYSHALE: medium dark gray (N4), silty slightly pyritic, with dark greenish gray claystone lenses.		
85									(84-85') Very intensely fractured.		85
									(86') Silty SHALE: strong, medium dark gray, moderately fractured.		
									(87-88') Calcareous.		
				Run 5			58/60	55	(88') LIMESTONE: strong, greenish gray (5G 6/1), massive, intensely fractured, slightly decomposed.		
90									(90.5') Silty CLAYSTONE: moderately strong, medium dark gray to dark greenish gray, moderately decomposed.		90
				Run 6			168/180	79	(93') CLAYSTONE and CLAYSHALE: moderately strong, medium dark gray to dark greenish gray, moderately decomposed, moderately fractured, quartz veins (yellowish gray 5Y 8/1).		
95											95
100											100

NOTES:

Geosyntec consultants
engineers | scientists | innovators

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3
Page: 6 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100									(101-101.5') Intensely fractured.		100
									(102.5-103') Intensely fractured, soft claystone seams.		
									(103') Silty SHALE: strong, medium dark gray (N4), few claystone lenses, moderately fractured, slightly decomposed.		
105											105
				Run 7			176/ 180	99	(108') Silty sandy SHALE: strong, medium dark gray, few yellowish gray areas, slightly fractured.		
110											110
115									(114.5') Silty SANDSTONE: strong, medium light gray (N6), few dark gray (N3) lenses, thinly bedded, cross-bedded, slightly micaceous, slightly fractured.		115
									(118') Sandy SHALE: strong, grayish black (N2) with few medium light gray sandstone lenses (N6), slightly fractured.		
120											120

NOTES:

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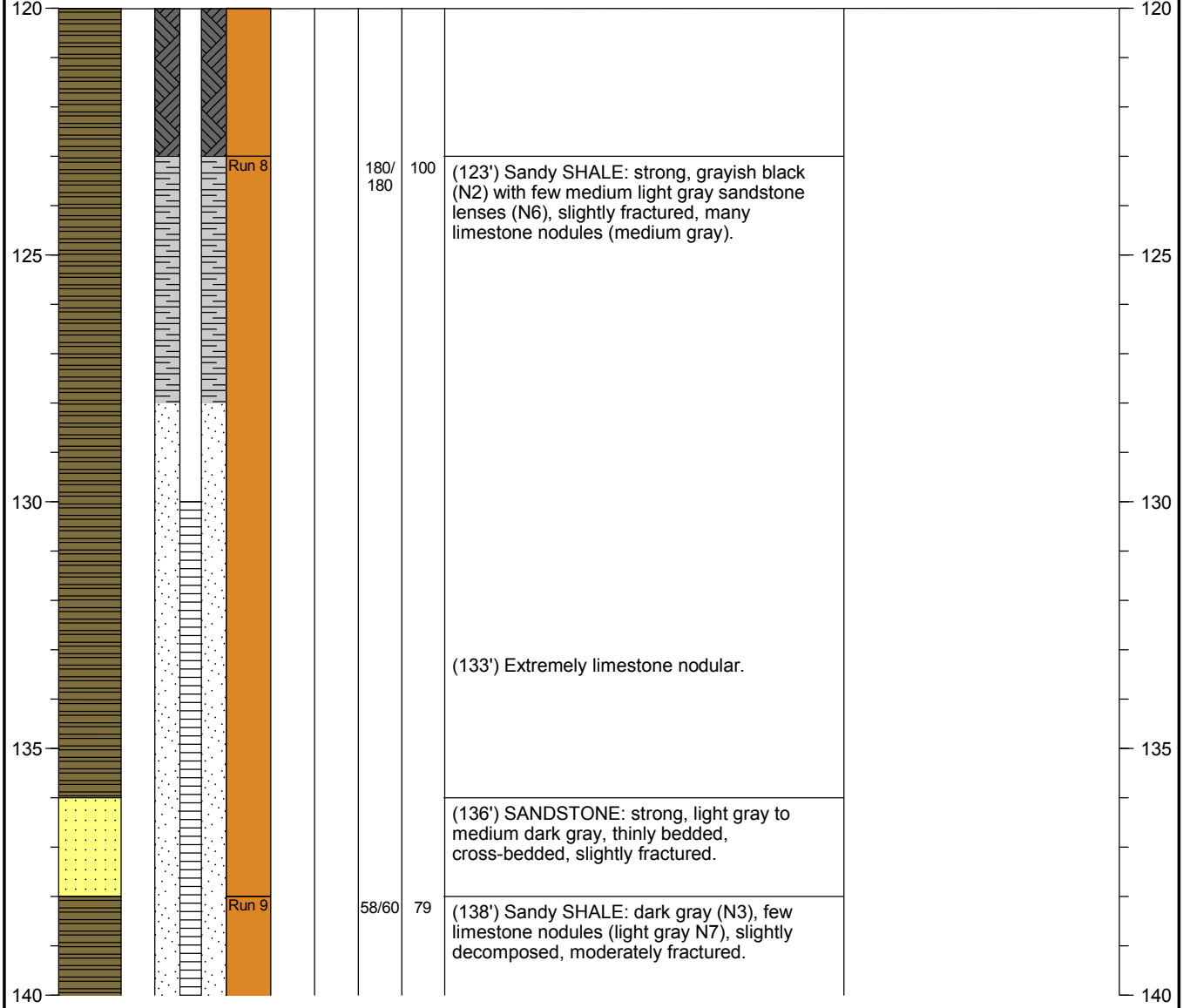
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3
Page: 7 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand



NOTES:

Geosyntec consultants
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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3
Page: 8 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140									(140.5') Silty SHALE: grayish black (N2), intensely fractured, moderately decomposed. (141-143') Medium gray, calcareous, massive.		140
145									End of borehole at 143 ft bgs. Well installed on 04/05/2016		145
150											150

NOTES:

APPENDIX D

WELL CONSTRUCTION LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

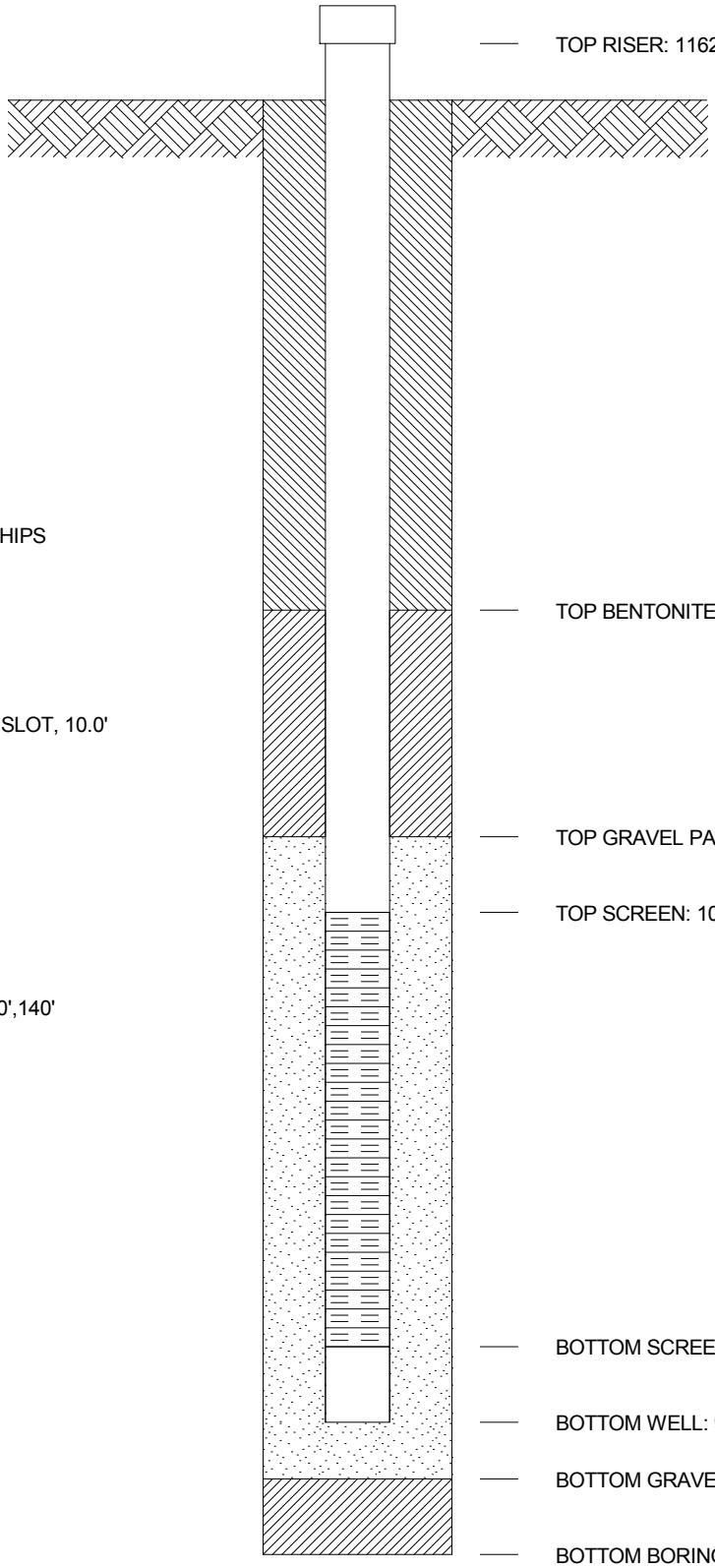
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **CA-0623A** BORING No. **CA-0623A** INSTALLED **8/16/16**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,300.1 E 2,514,227.5**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1159.62 FT.



GROUT SEAL: BENTONITE CHIPS

BENTONITE SEAL: PELLETS

SCREEN: 2" dia., U-PACK .10 SLOT, 10.0'

GRAVEL PACK:

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 20',60',100',140'

GEOMCNST CD_FGD_LANDFILL BORINGS & WELLS.GPJ AEP.GDT 8/22/16

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

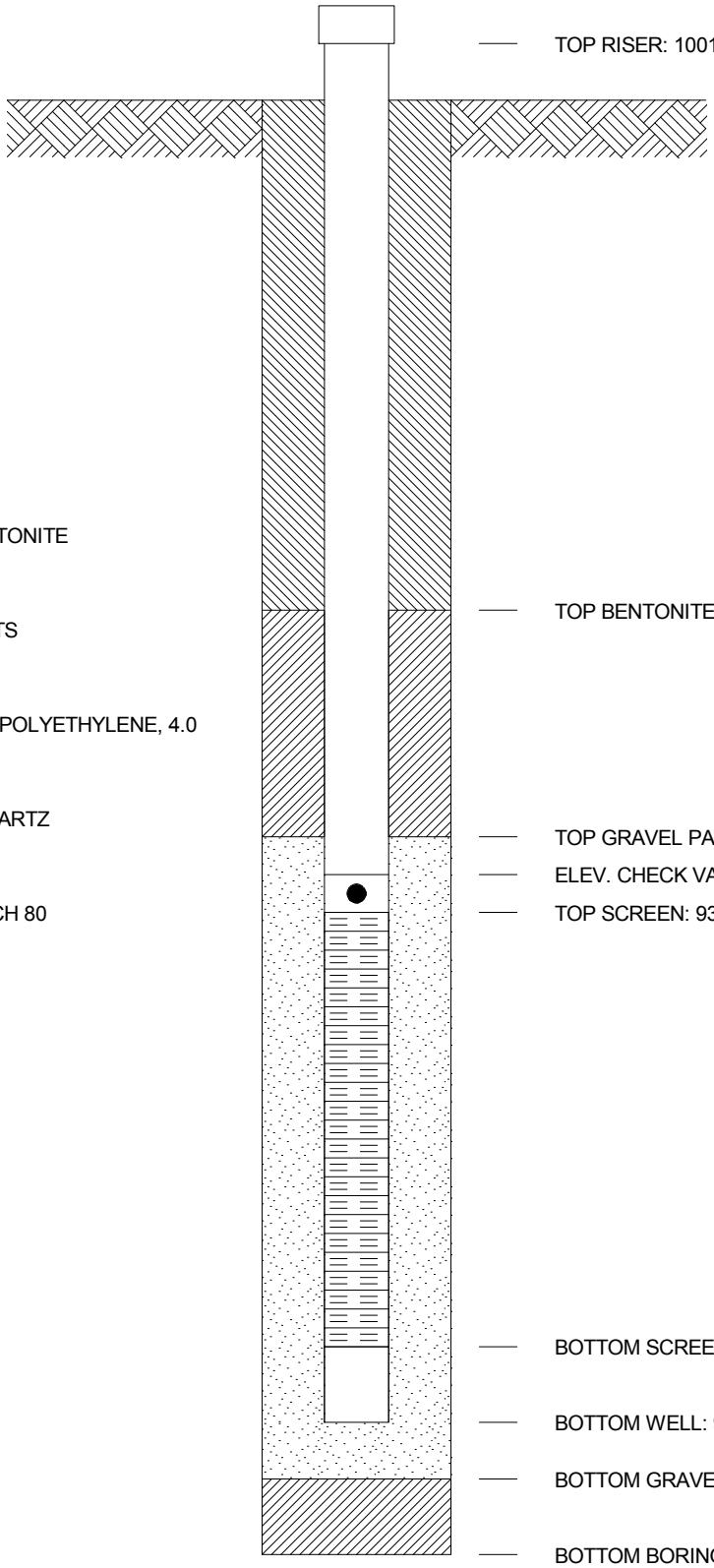
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-1** BORING No. **8502** INSTALLED **12/12/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,399.8 E 2,515,207.8**

SYSTEM **STATE PLANE**

GROUND ELEVATION 999.59 FT.



GROUT SEAL: CEMENT\BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., POROUS POLYETHYLENE, 4.0

GRAVEL PACK: # 4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

4' GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

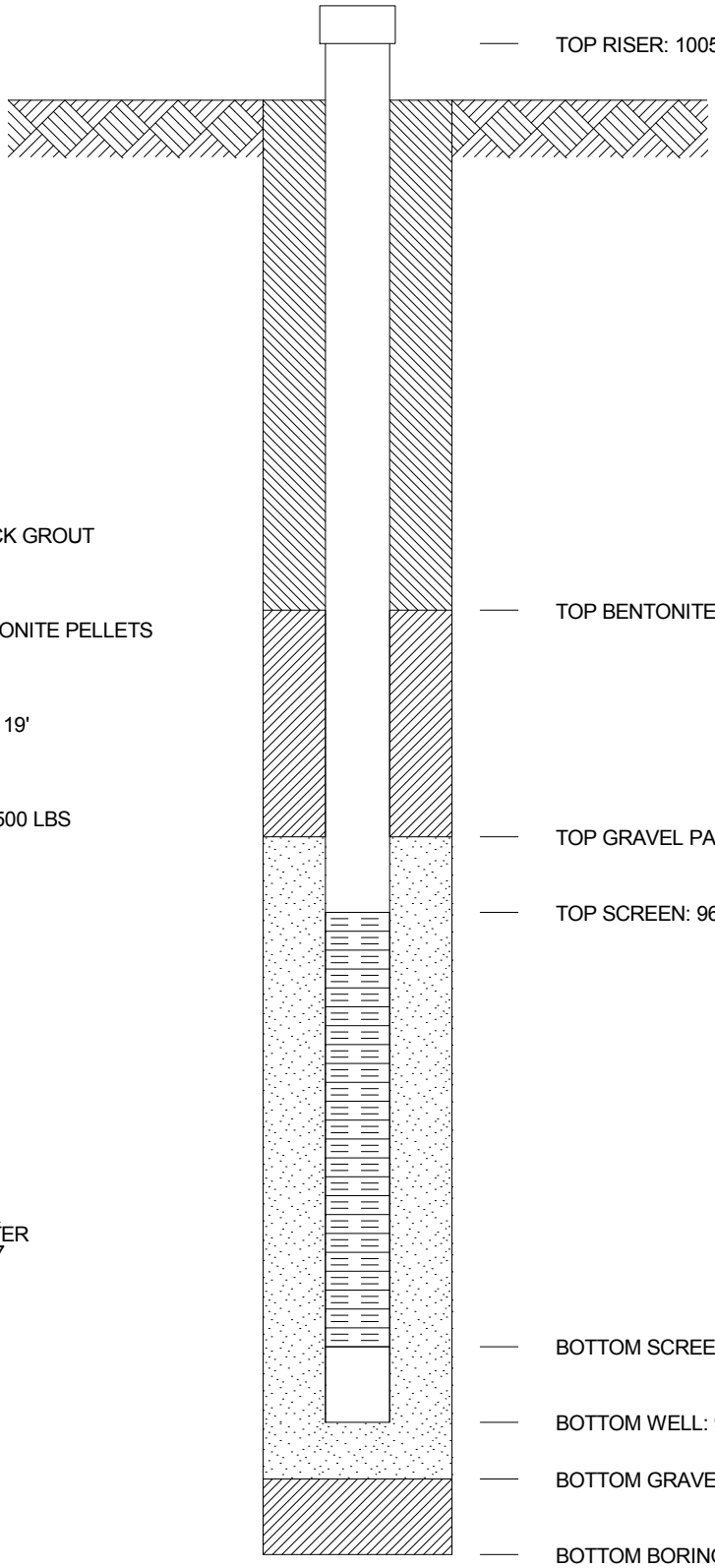
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-10** BORING No. **CA-0607** INSTALLED **1/9/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,867.6 E 2,516,495.5**

SYSTEM

GROUND ELEVATION 1002.48 FT.



GROUT SEAL: 75 GALS QUICK GROUT

BENTONITE SEAL: 100# BENONITE PELLETS

SCREEN: 2' dia., 0.20 SLOT, 19'

GRAVEL PACK: #4 QUARTZ 500 LBS

RISER PIPE: 1", dia., PVC

SPACERS, DEPTH: 51', 21'

-SWL @ INSTALL 44.8'
-DRILLED W/6" AIR HAMMER
-FLUSHED W/700 GALS WATER
-DECONNED TOOLS 01/08/07

-3' SS Pump Type
-Pump intake @ 56.1'

GEOMCNST CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

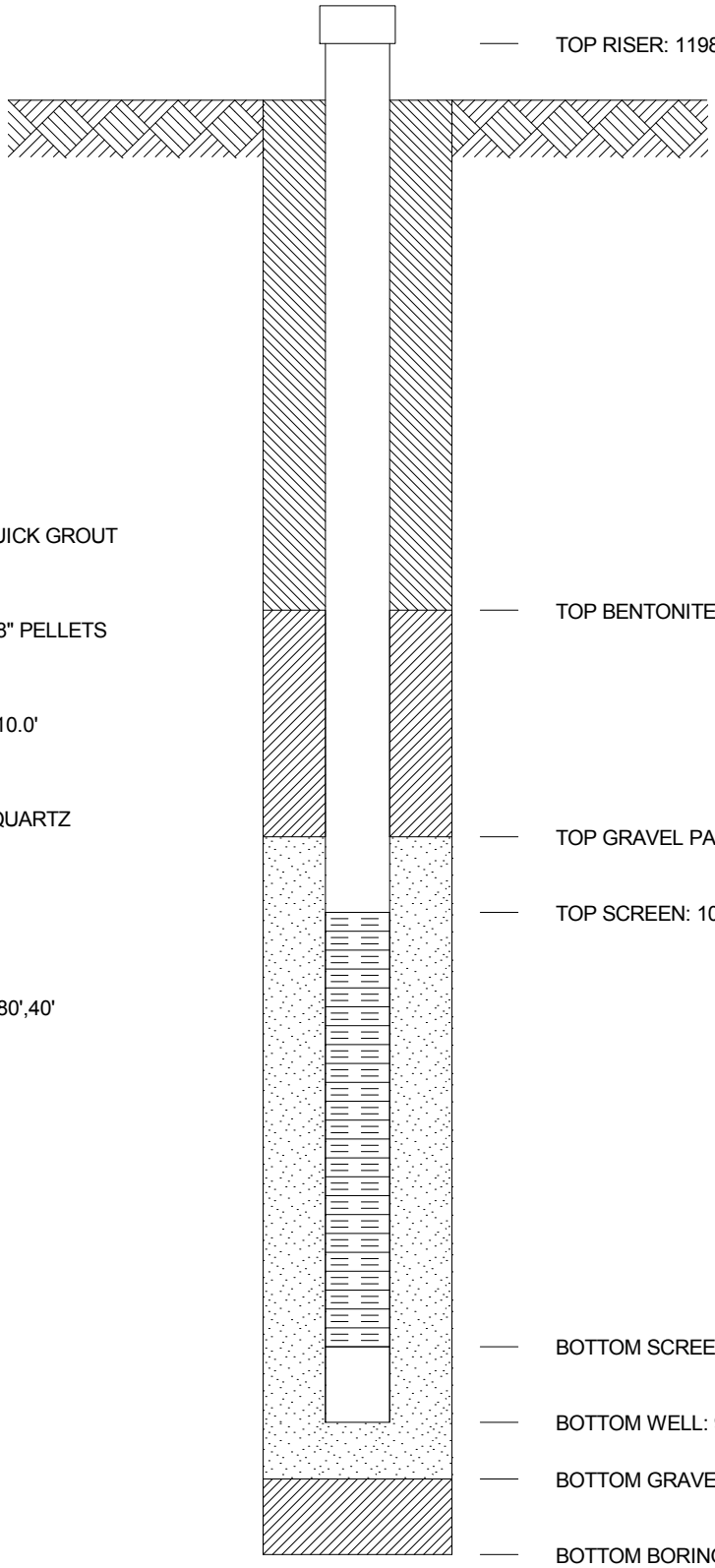
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-17** BORING No. **CA-0601** INSTALLED **6/12/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,612.2 E 2,512,715.1**

SYSTEM

GROUND ELEVATION 1195.63 FT.



GROUT SEAL: ~200 GALS QUICK GROUT

BENTONITE SEAL: 75 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 10.0'

GRAVEL PACK: 300 LBS #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 170',120',80',40'

NOTES:
-Decon 07/11/07
-Drilled w/6" Air Hammer
-SWL @ Install 193.4'
-Hydrated Pellets

-3' SS Pump Type
-Pump intake @ 199.5'

GEOMCNST CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

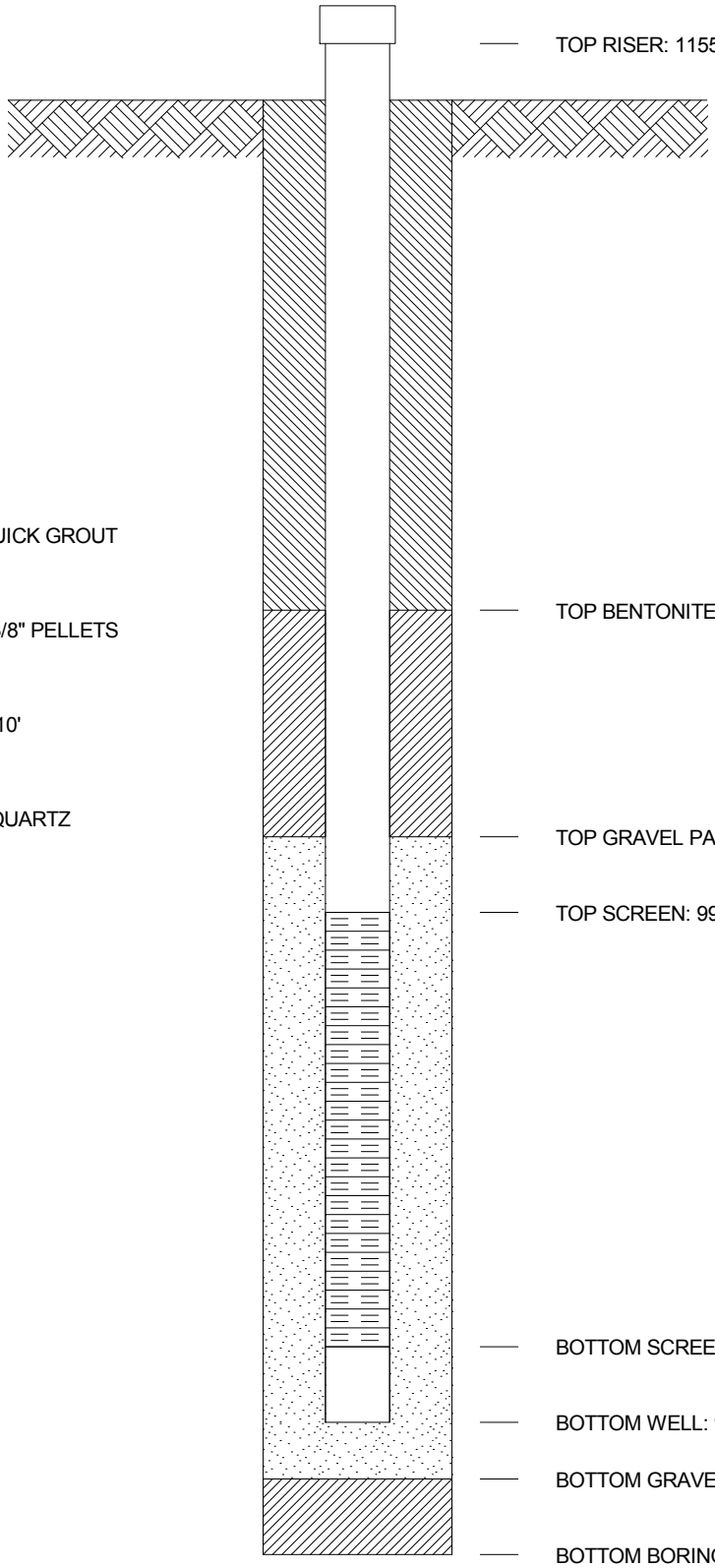
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-18** BORING No. **CA-0603** INSTALLED **8/22/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 832,194.6 E 2,513,596.2**

SYSTEM

GROUND ELEVATION 1153.26 FT.



GROUT SEAL: ~250 GALS QUICK GROUT

BENTONITE SEAL: 100 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 10'

GRAVEL PACK: 250 LBS #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 110', 30'

NOTES:
-Decon 07/09/07
-Drilled w/6" Air Hammer
-SWL @ Install 155.2'
-Hydrated Pellets

-3' SS Pump Type
-Pump intake @ 163'

GEOMCNST CD_FGD_LANDFILL.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

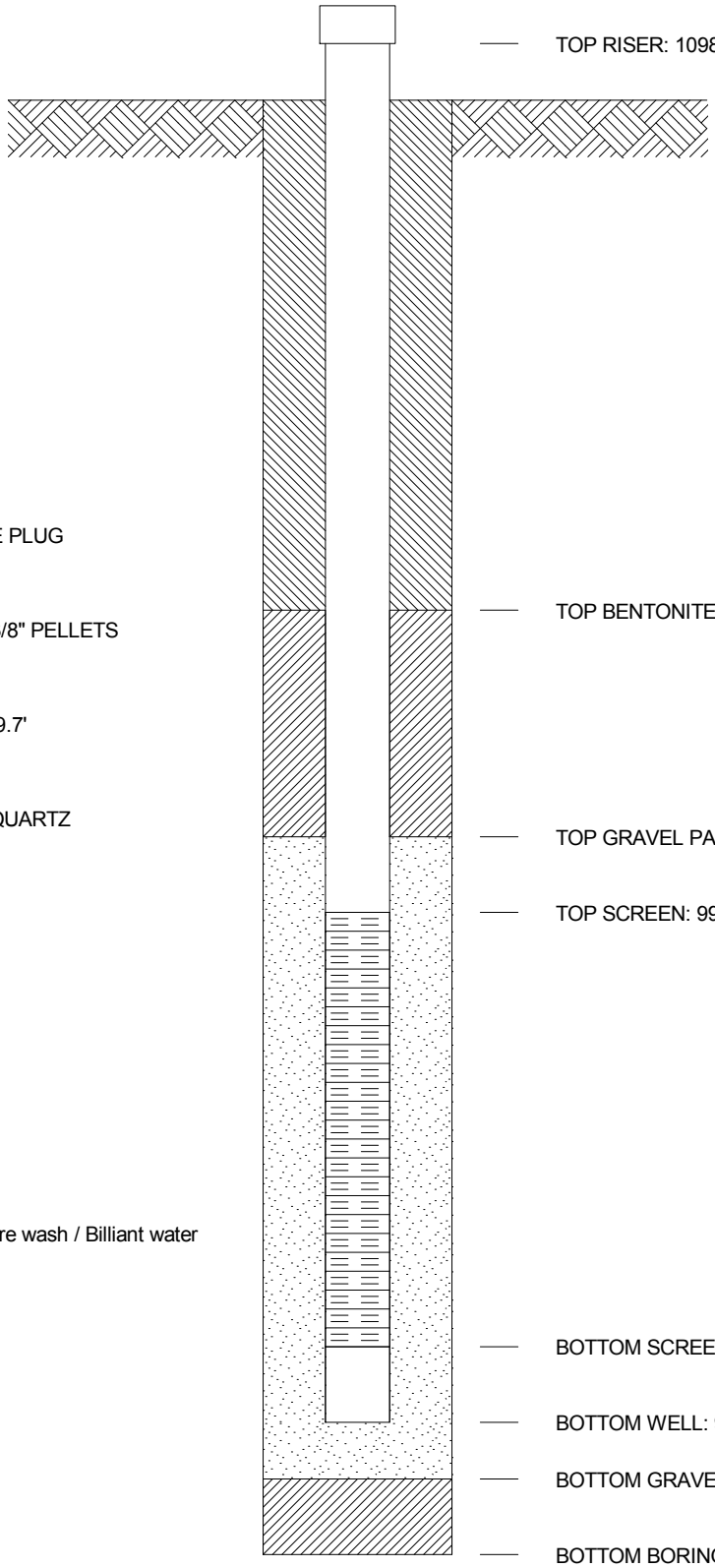
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-19A** BORING No. **CA-0606A** INSTALLED **7/28/11**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,793.8 E 2,514,074.6**

SYSTEM

GROUND ELEVATION 1095.98 FT.



GROUT SEAL: 750 LBS HOLE PLUG

BENTONITE SEAL: 200 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 9.7'

GRAVEL PACK: 600 LBS #4 QUARTZ

RISER PIPE: 2", dia.,

SPACERS, DEPTH: N/A

NOTES:
-Replacement well for S-19
-Decon 07/27/11 / High-pressure wash / Billiant water system
-Drilled w/6" air hammer
-SWL @ install 109.0'
-Hole would not grout up

GEOMCNST CD_FGD_LANDFILL.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

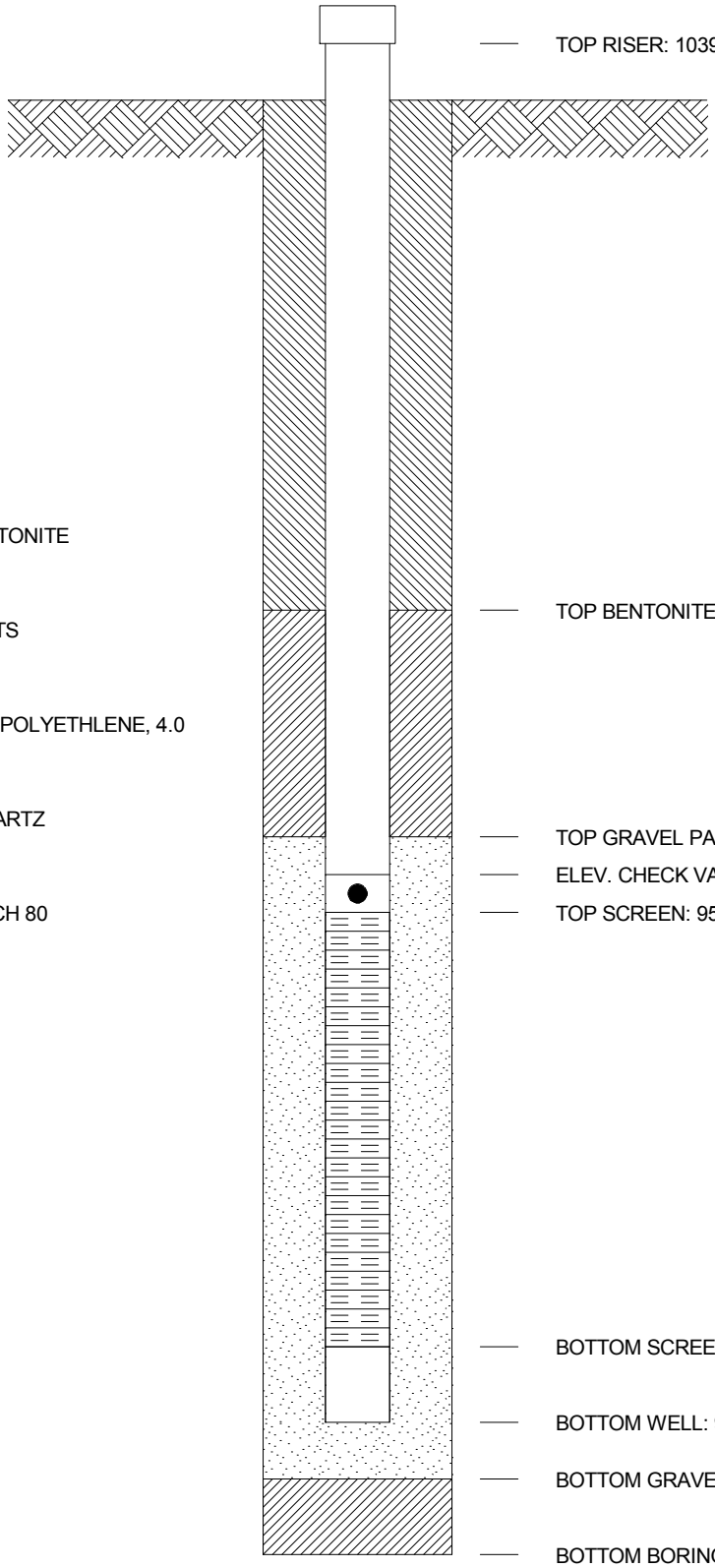
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-2** BORING No. **8503** INSTALLED **12/17/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,038.2 E 2,514,714.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1038.60 FT.



GROUT SEAL: CEMENT\BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., POROUS POLYETHLENE, 4.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

4' GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

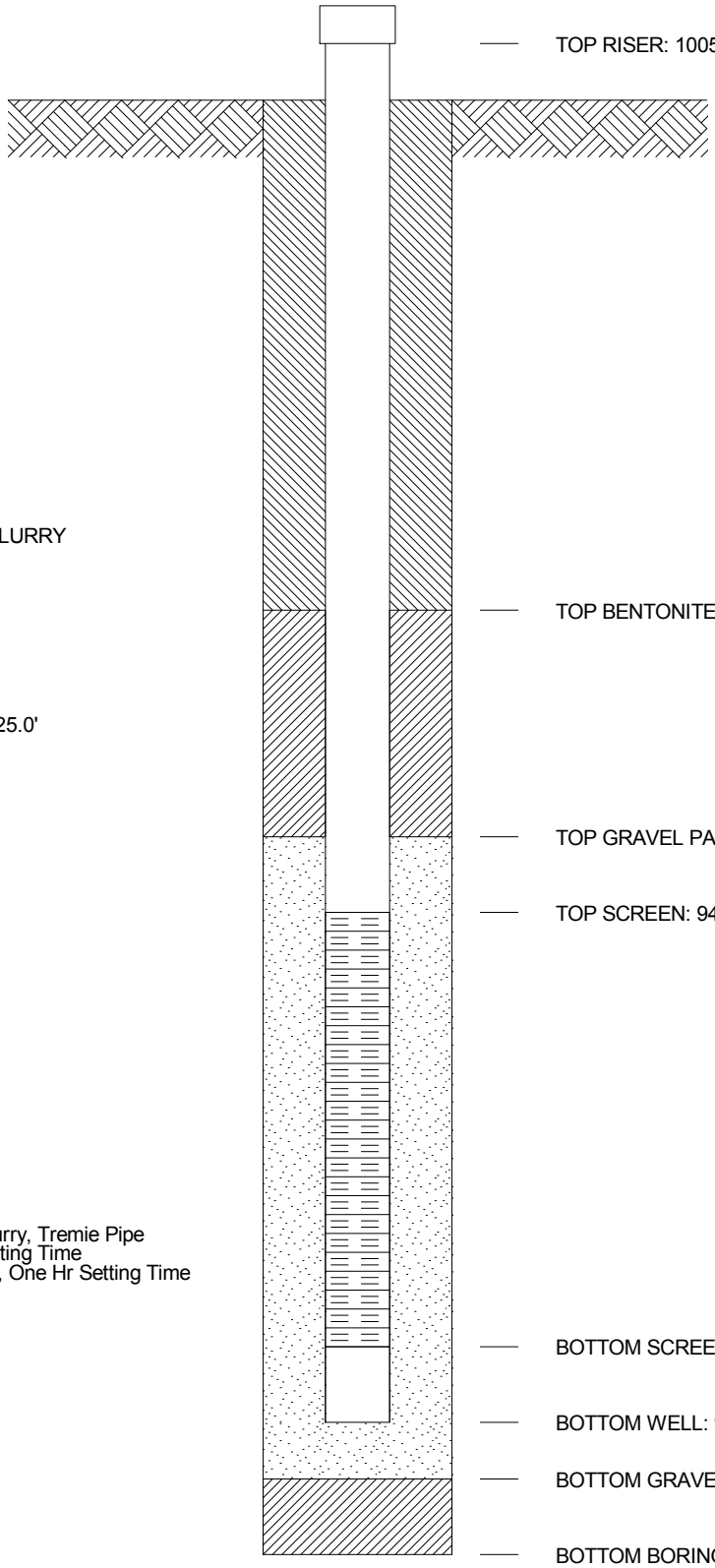
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-20** BORING No. **CA-0619** INSTALLED **8/24/06**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,850.2 E 2,515,582.3**

SYSTEM

GROUND ELEVATION 1003.43 FT.



GROUT SEAL: BENTONITE SLURRY

BENTONITE SEAL: PELLETS

SCREEN: 1" dia., .020 SLOT, 25.0'

GRAVEL PACK: FILTER PRO

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH:

NOTES:
-Surface Seal: Cement
-Annular Sealant: Bentonite Slurry, Tremie Pipe Installation, Overnight Setting Time
-Bentonite Seal: Poured Slowly, One Hr Setting Time
-Sand Pack: Poured Slowly

-3' PVC Pump Type
-Pump intake @ 84.5'

GEOMCNST CD_FGD_LANDFILL.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

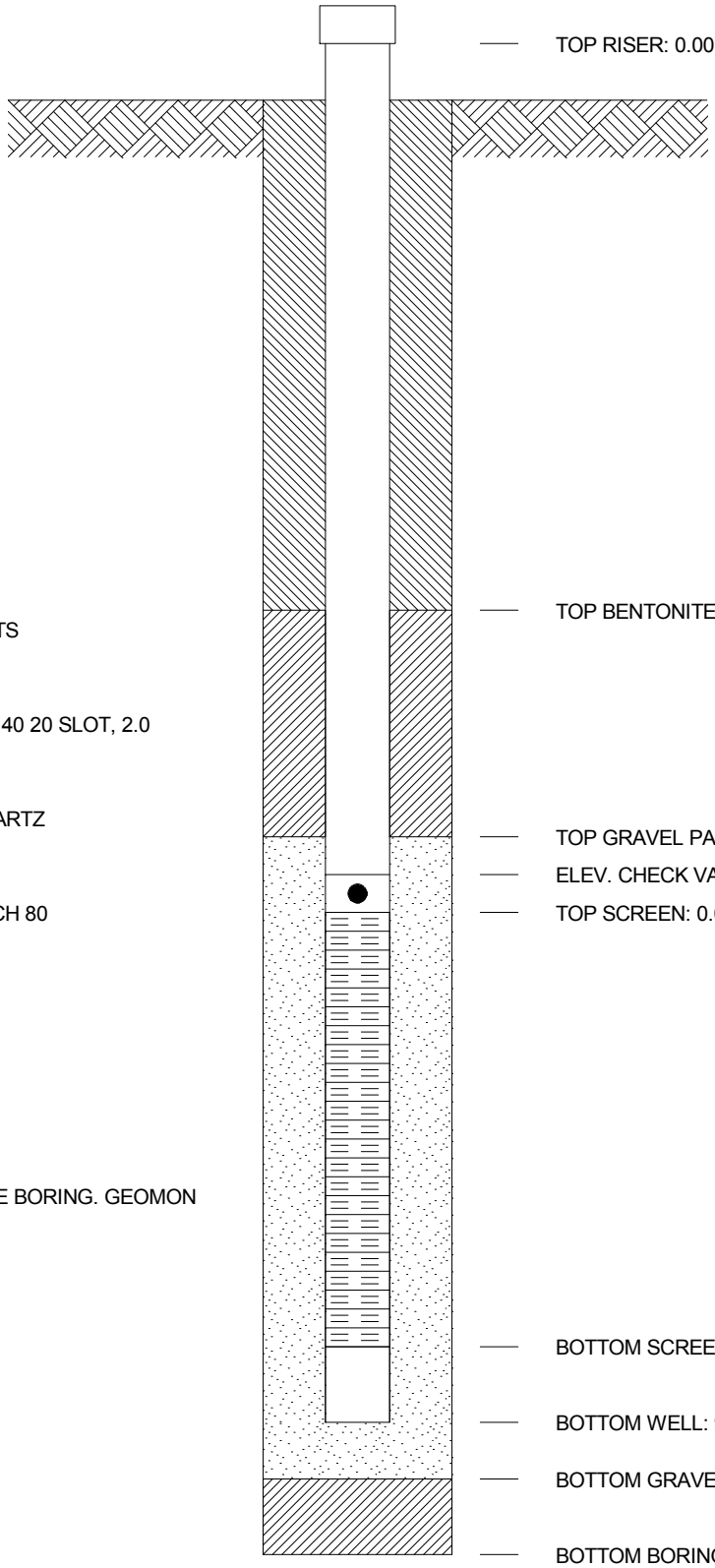
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-4** BORING No. **88-5-6** INSTALLED **8/16/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,352.3 E 2,513,052.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1010.90 FT.



GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELLS S-4 AND M-2 IN SAME BORING. GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

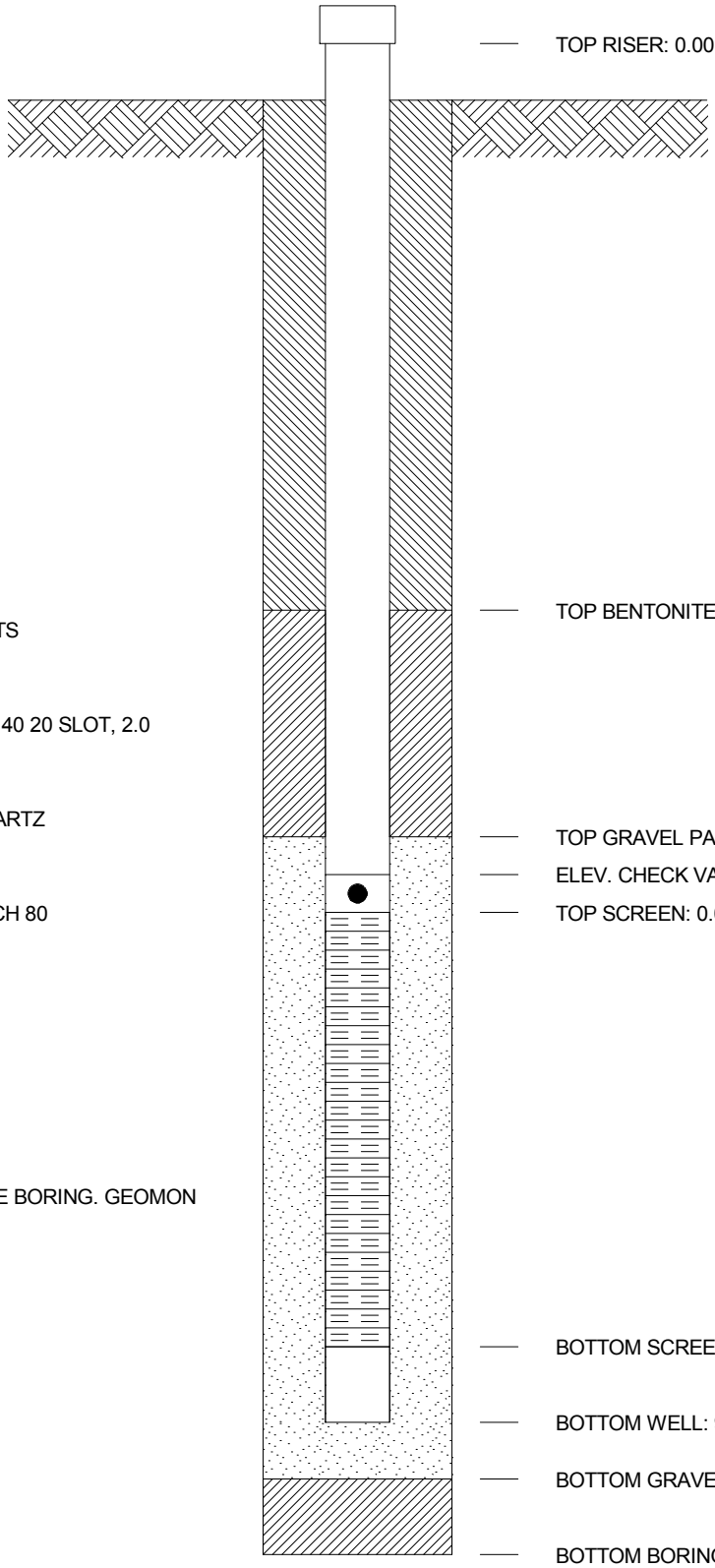
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-5** BORING No. **88-7-8** INSTALLED **8/10/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,917.6 E 2,513,916.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1000.20 FT.



GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELLS S-5 AND M-3 IN SAME BORING. GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

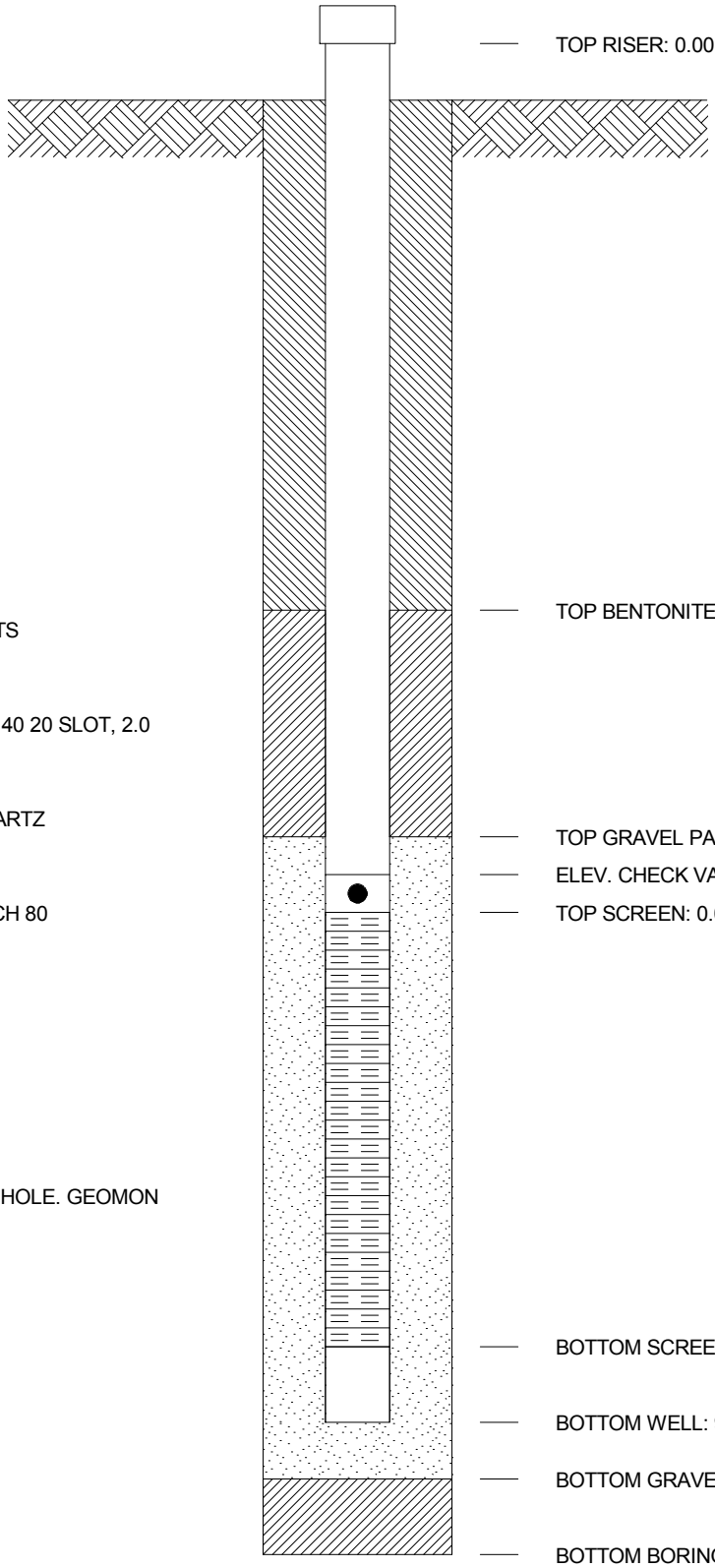
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-6** BORING No. **88-9-10** INSTALLED **8/4/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,577.4 E 2,513,679.4**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1010.90 FT.



GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELL S-6 AND M-4 IN SAME HOLE. GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

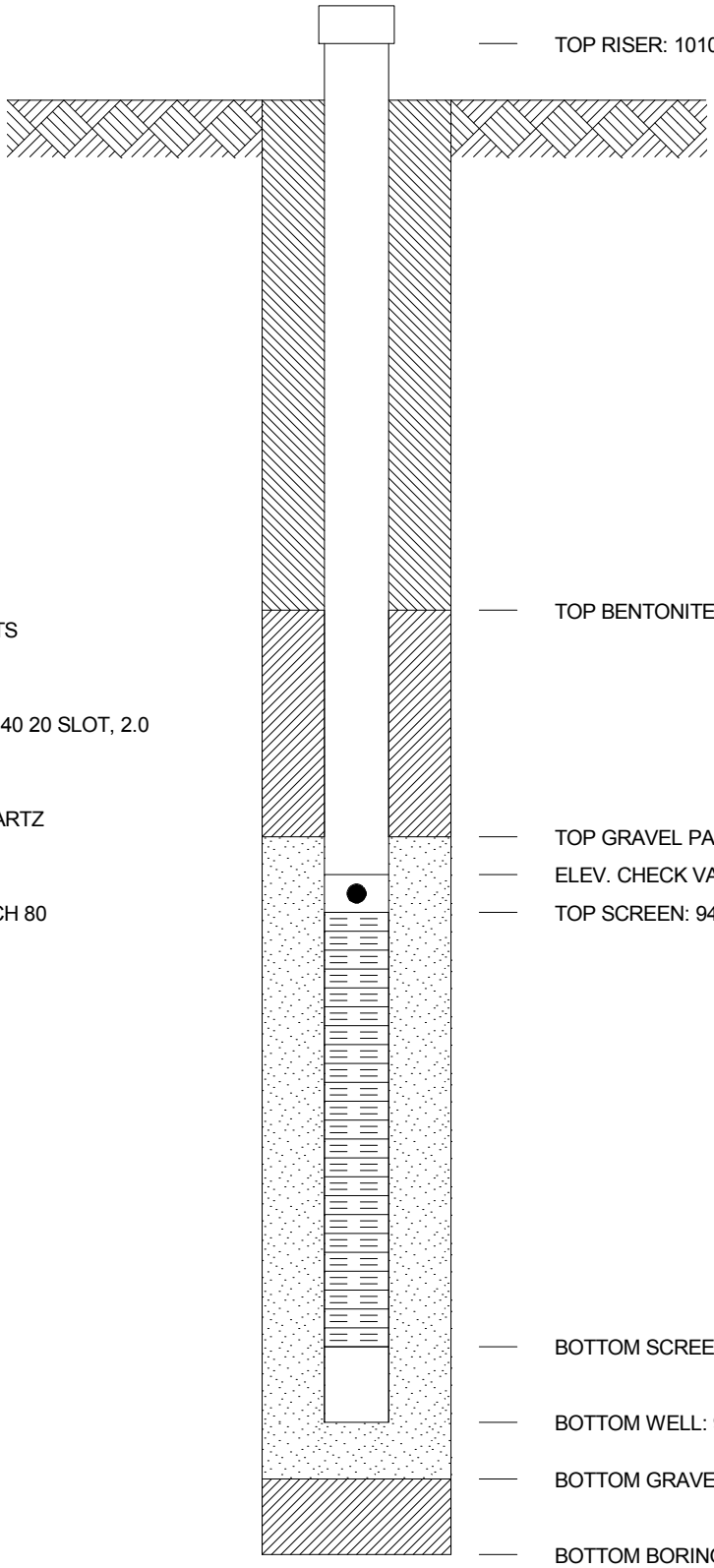
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-7** BORING No. **90CA22-S** INSTALLED **8/14/90**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,920.2 E 2,516,676.4**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1008.52 FT.



GROUT SEAL: BENSEAL

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 1.0, dia., PVC SCH 80

SPACERS, DEPTH:

GEOMON

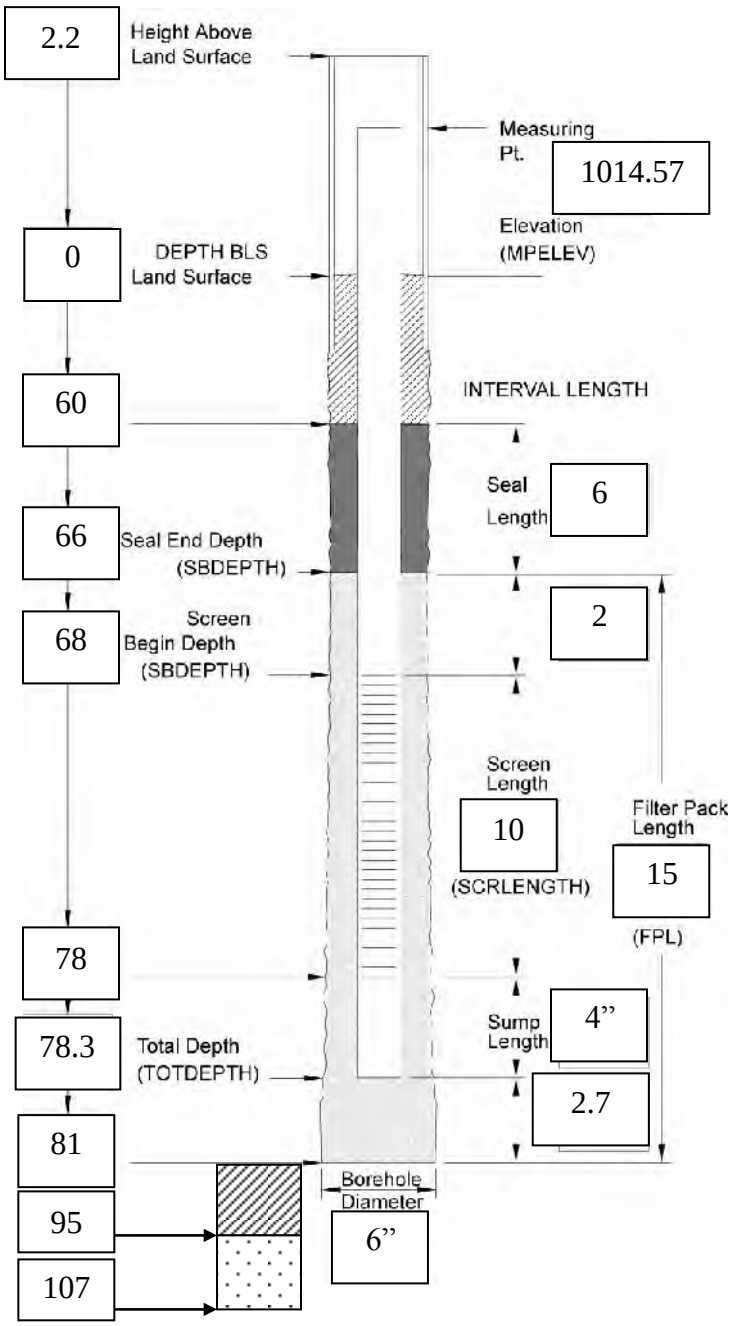
GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-1
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature: _____

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA
Casing Installation Date (INSDATE): 4/12/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE): _____



Well Completion
2 Guard Posts (Y / N) Date: _____
Surface Pad Size: 2 ft x 2 ft x 6"
Protective Casing or Cover
Diameter/Type: 4" locking flip-top
Depth BGS: 2.5 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O; 15 x 50 lb bags
Placement Method: pressure tremie

Seal Date: 4/12/16
Type: 3/8" coated bentonite pellets; 2 x 5 gal buckets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 filter sand
Source: Flat Rock Bagging, Sparta, MI
Amount Used: 30 x 50 lb bags
Placement Method: Poured gravity
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN): _____
Sump or Bottom Cap ((Y) N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y (N)
Material: 3/8" med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time: _____

Comments
Total drilled depth = 107'; backfilled to 81' with sand and chips.

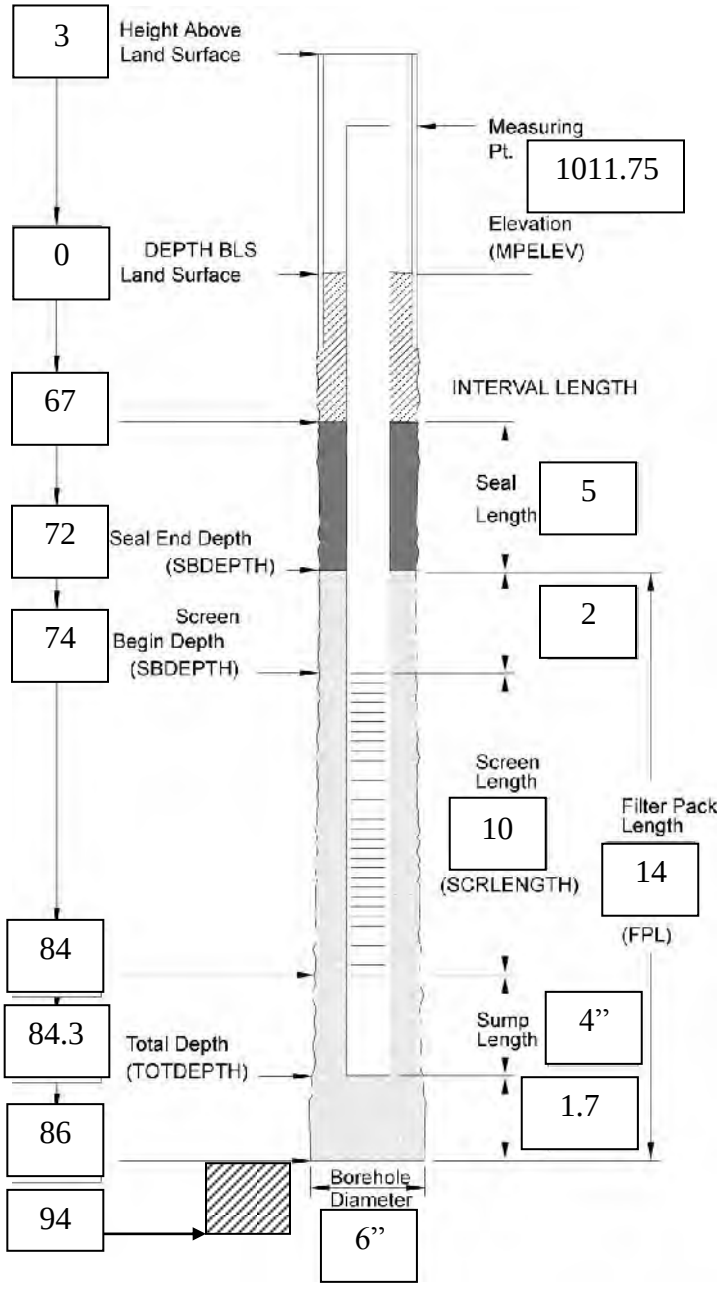
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-2
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature: _____

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA
Casing Installation Date (INSDATE): 4/12/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE): _____



Well Completion
2 Guard Posts (Y / N) Date: _____
Surface Pad Size: 2 ft x 2 ft x 6"
Protective Casing or Cover
Diameter/Type: 4" locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite
Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/12/16
Type: 3/8" coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 filter pack sand
Source: Flat Rock Bagging, Sparta, MI
Amount Used: 10 x 50 lb bags
Placement Method: poured gravity
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN): _____
Sump or Bottom Cap (Y) N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y) N)
Material: 3/8" coated bentonite pellets
Placement Method: poured gravity
Set-up/Hydration Time: 45 mins

Comments
Total boring depth = 94 ft; backfilled with chips to 86'.

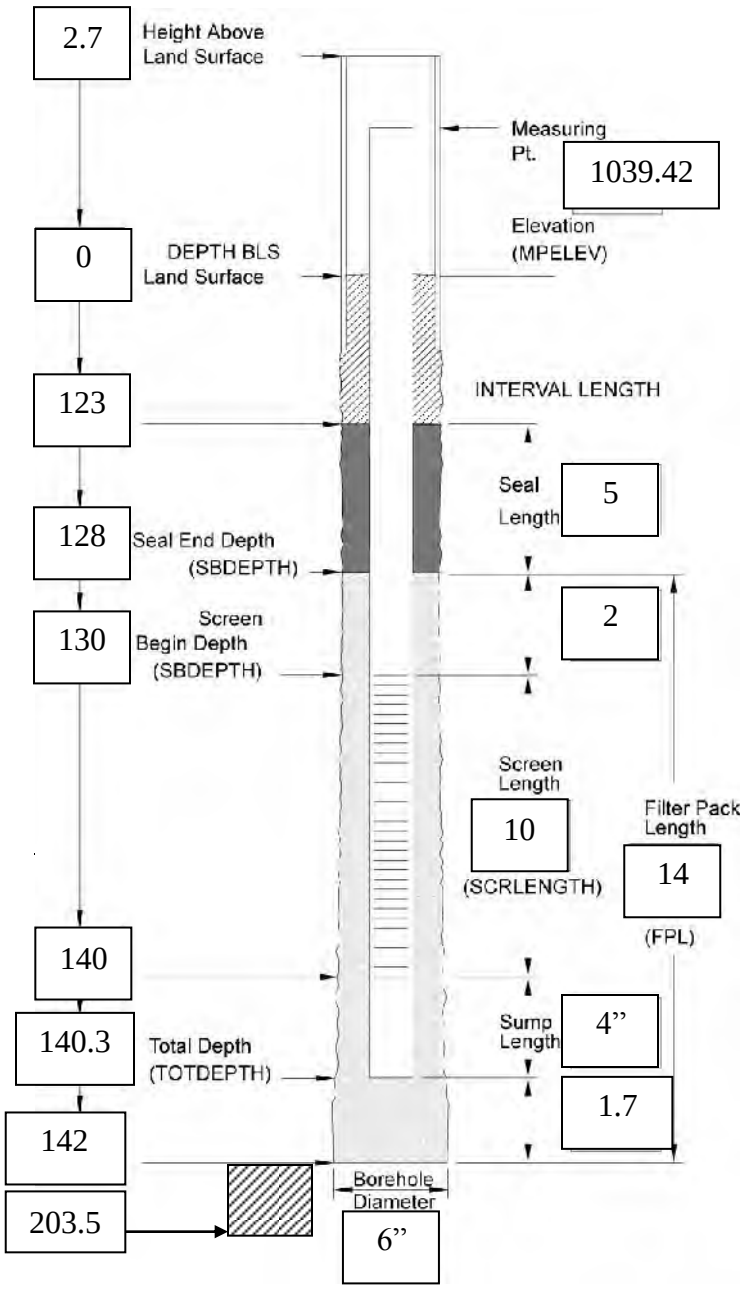
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-3
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: J. Bannantine
Signature: _____

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA/Rotary
Casing Installation Date (INSDATE): 4/5/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE): _____



Well Completion
2 Guard Posts (Y / N) Date: _____
Surface Pad Size: 2 ft x 2 ft x 6"
Protective Casing or Cover
Diameter/Type: 4" locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/5/16
Type: 3/8" coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 8 x 50 lb bags
Placement Method: poured gravity

Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN): _____
Sump or Bottom Cap (Y / N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8" med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time: _____
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 5/3/2016

Comments
Total drilled depth = 203.5'; backfilled with chips to 142'.

Appendix B

Potentiometric Maps

CA-0623
1088.05

S-GS-3

S-5
996.94

S-6
1000.77

S-4

S-17
1001.56

S-GS-1

0AE 2005,10C
1012.49

Former Fly Ash Reservoir I /
Residual Waste Landfill

S-GS-2

S-18
995.72

S-10
968.19

Fly Ash Reservoir II

S-7
963.56

S-1
991.57

S-2
999.02

S-19A
997.75

S-20
969.25

Ohio River

1010
1000
990
980
970

N

Legend

- Existing Monitoring Well Network (Shallow Aquifer)
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Aerial imagery courtesy of ESRI.
- All locations are approximate.
- Groundwater levels measured on 15 September 2014.
- Groundwater contours based on Shallow Water Table Map (AEP, 2014).
- Only wells within the shallow aquifer and with static water level measurements during this event are shown.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Aquifer
Former FAR I RSW Landfill

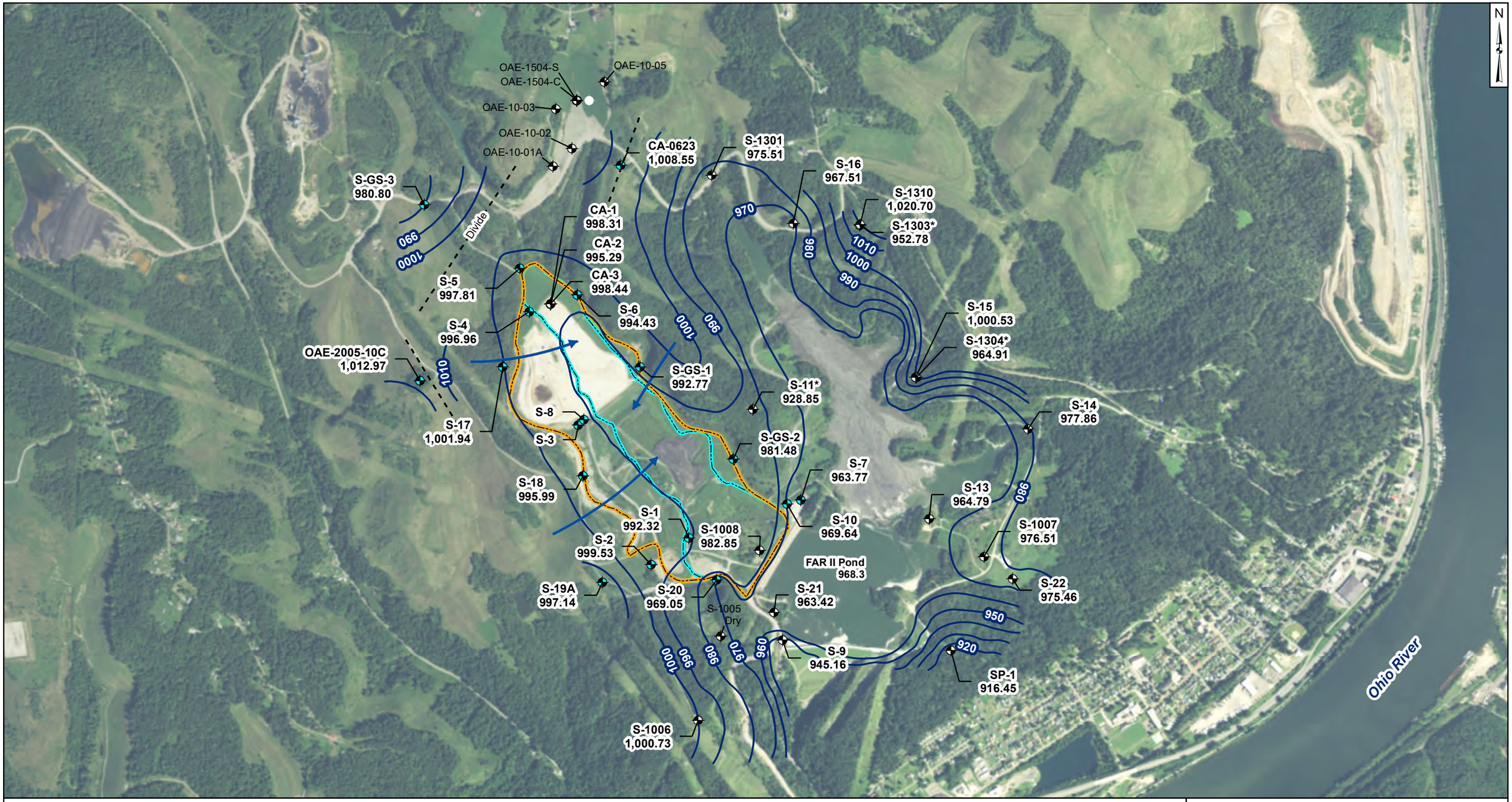
Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Chicago, IL | July 2016

Figure
3-1

P:\GIS\PROJECTS\AEP\Cardinal\Figures\GW Contours\Shallow F201.4 Rev. 7-2016.mxd; Milwaukee - DZ; 01-August-2016;CH2E8126A\01/1.3/1810



Legend

- base_layer_point
- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between June 21 and June 22, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
June 2016

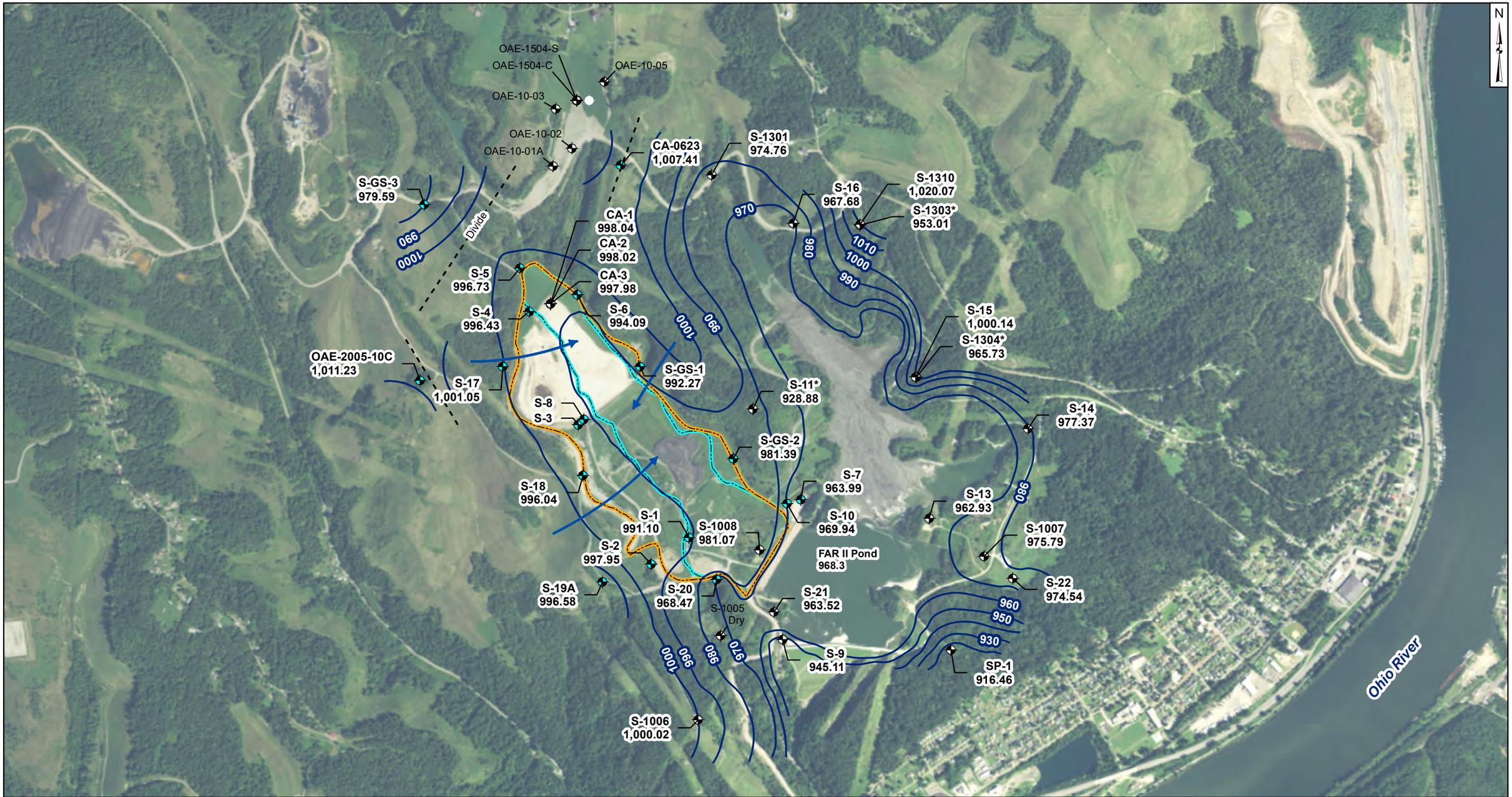
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **1**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2016-06_June.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between August 1 and August 2, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
August 2016

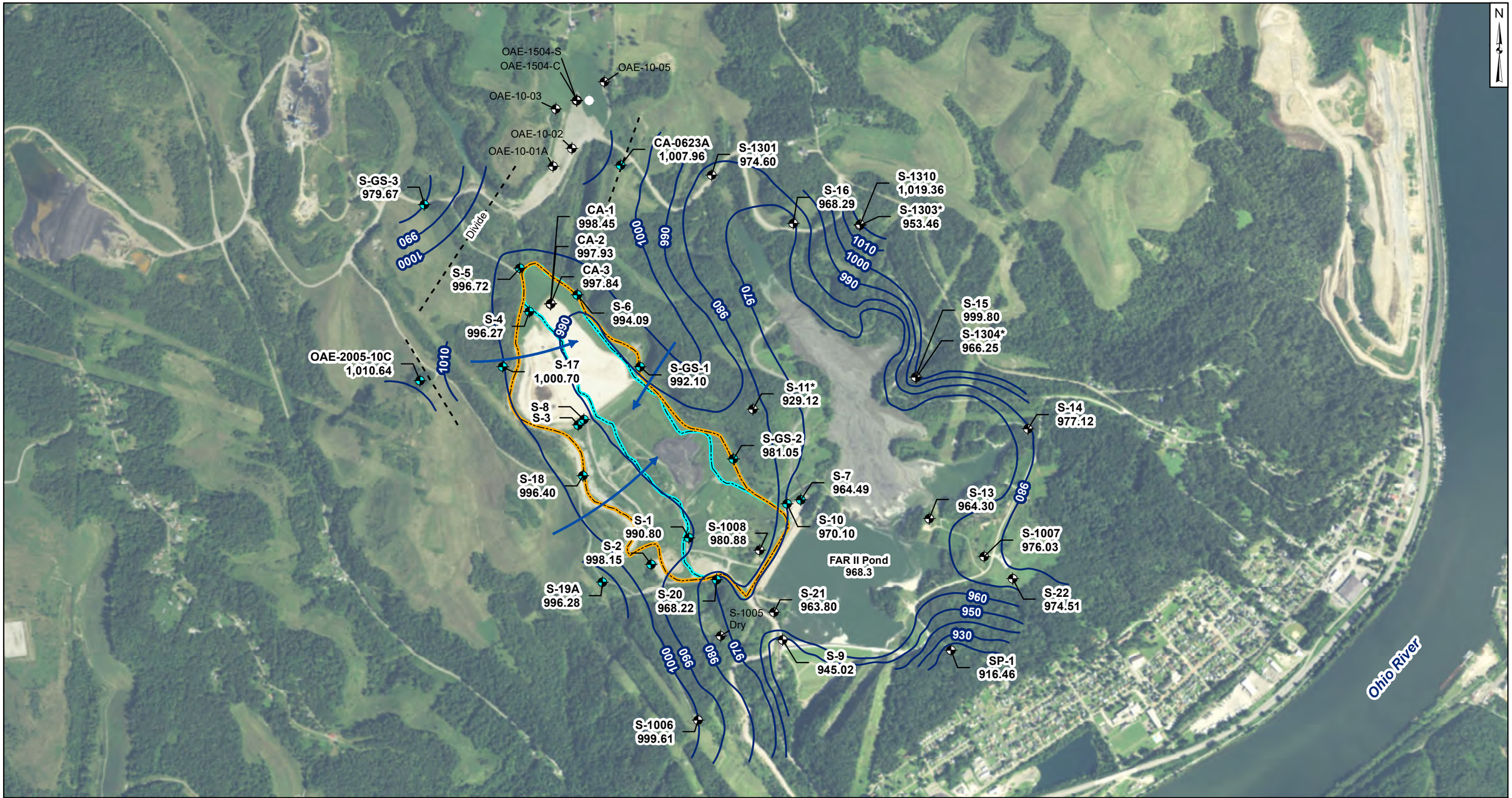
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/18

Figure **2**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2016-08_August.mxd. MMuenich. 8/18/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between October 3 and October 4, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- CA-0623 was replaced by CA-0623A on 8/16/2016

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
October 2016

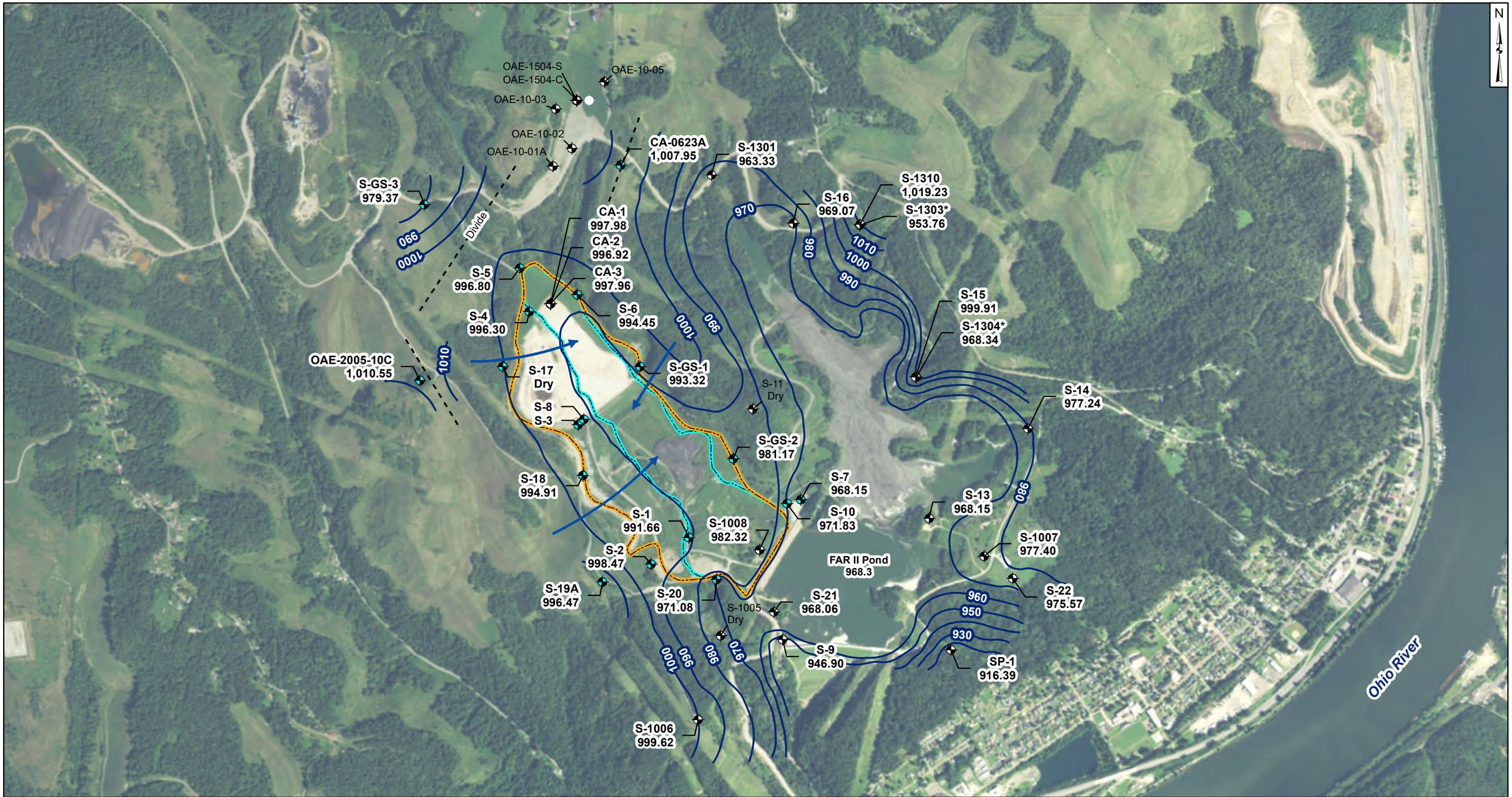
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **3**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2016-10_October.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on November 14, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
November 2016

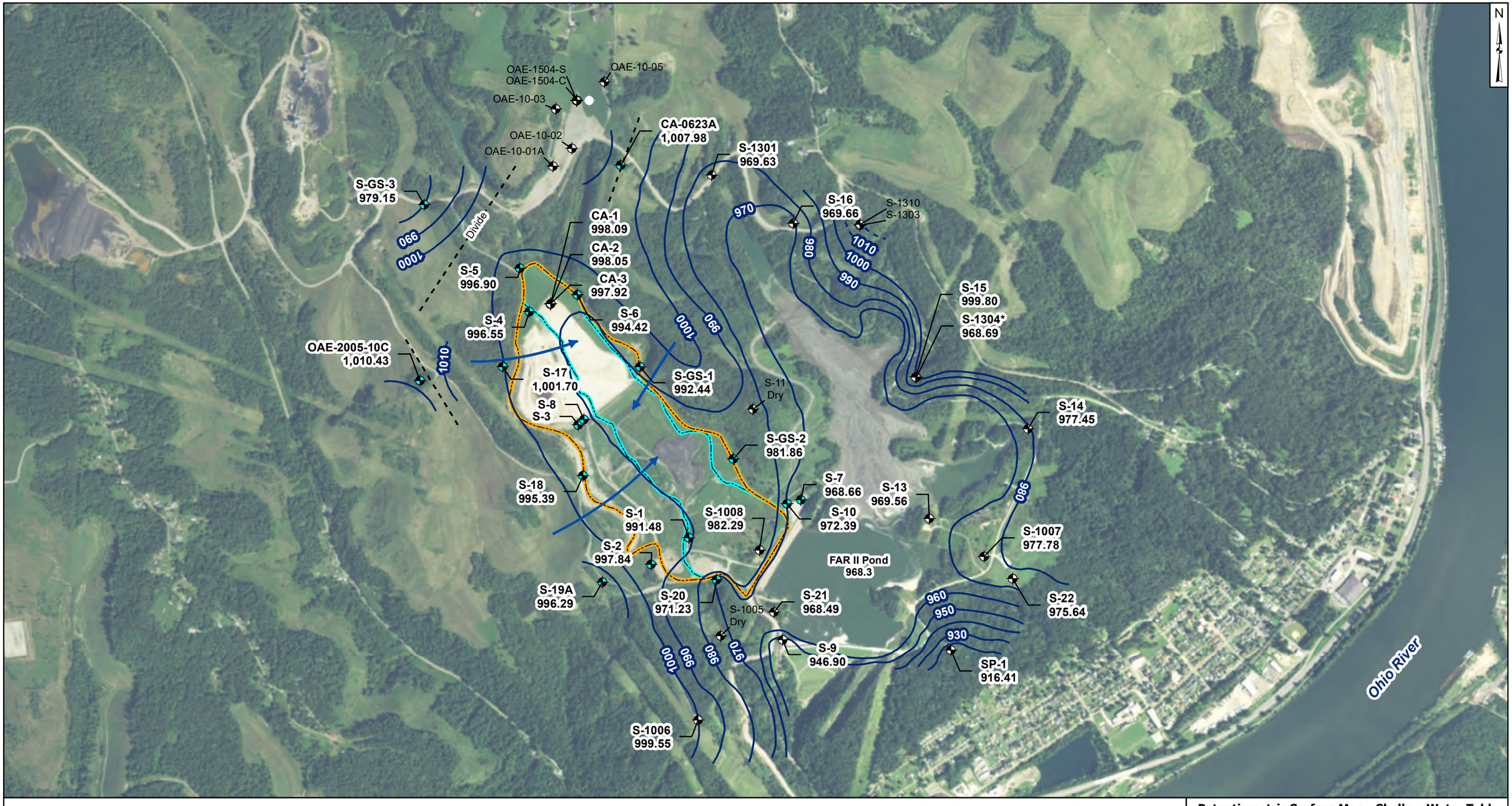
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **4**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2016-11_November.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on December 12, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- S-1310 not measured; contours inferred from previous events.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
December 2016

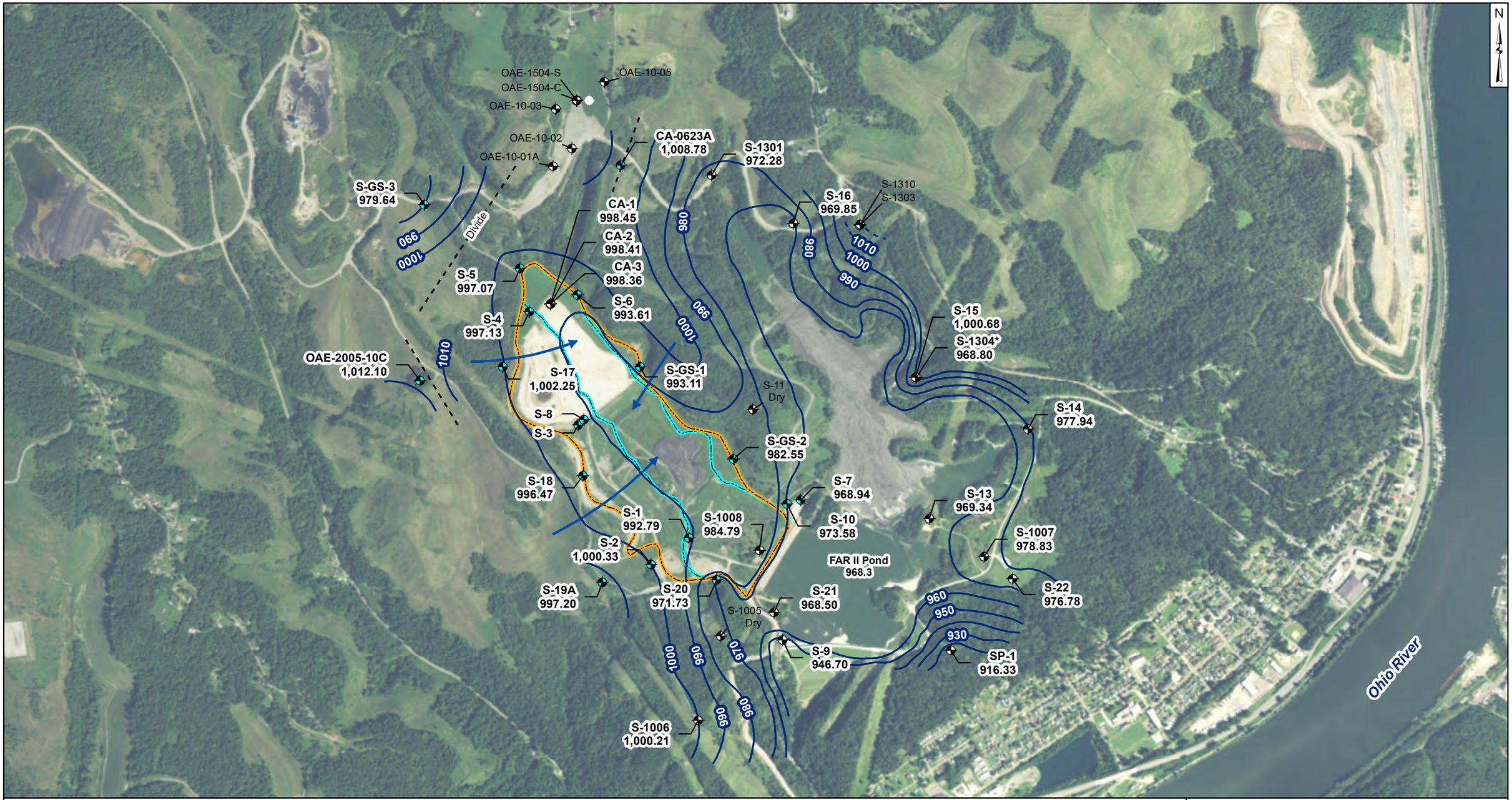
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **5**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2016-12_December.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on January 9, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- S-1310 not measured; contours inferred from previous events.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
January 2017

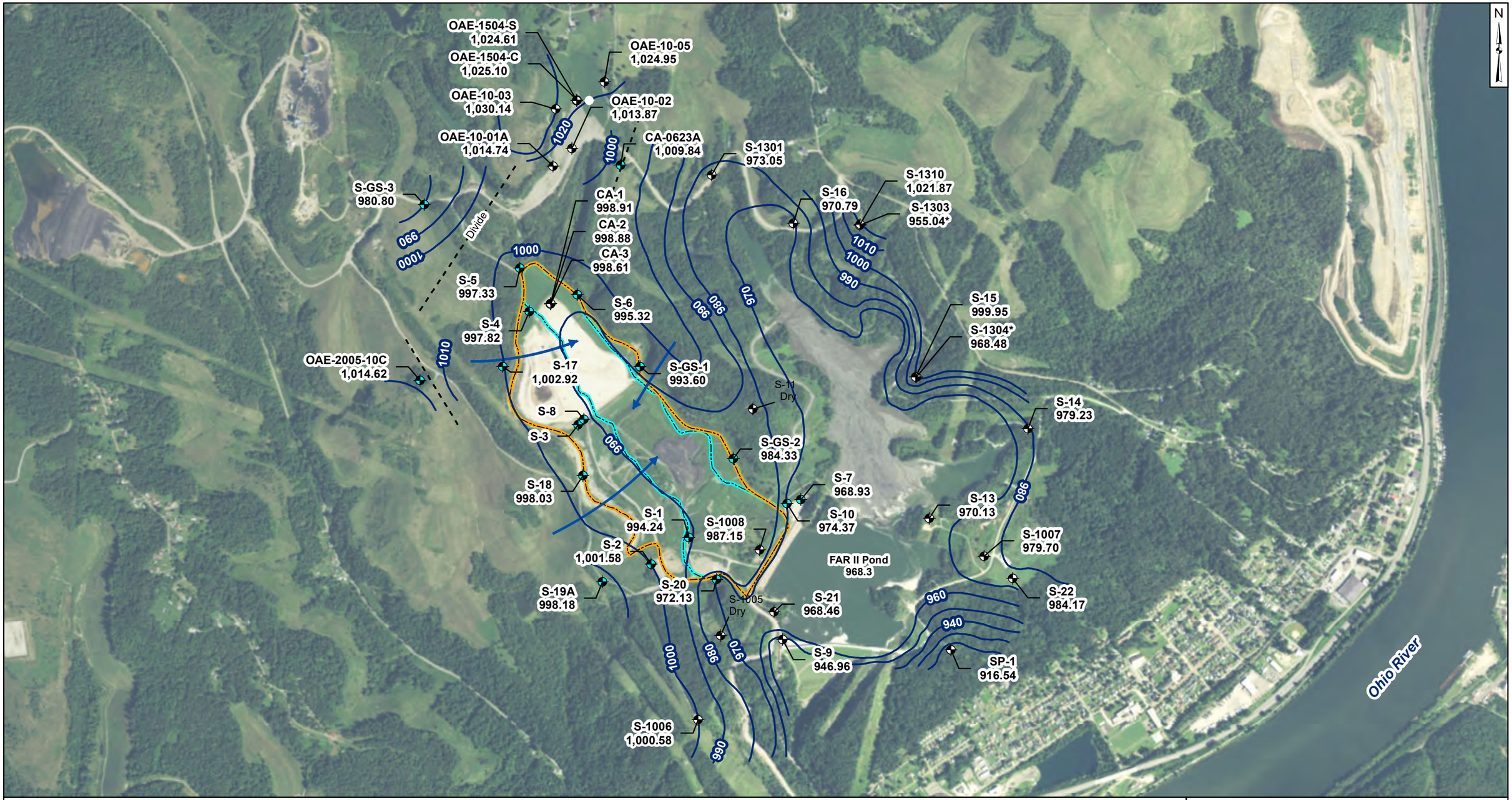
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **6**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-01_January.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on April 10, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
April 2017

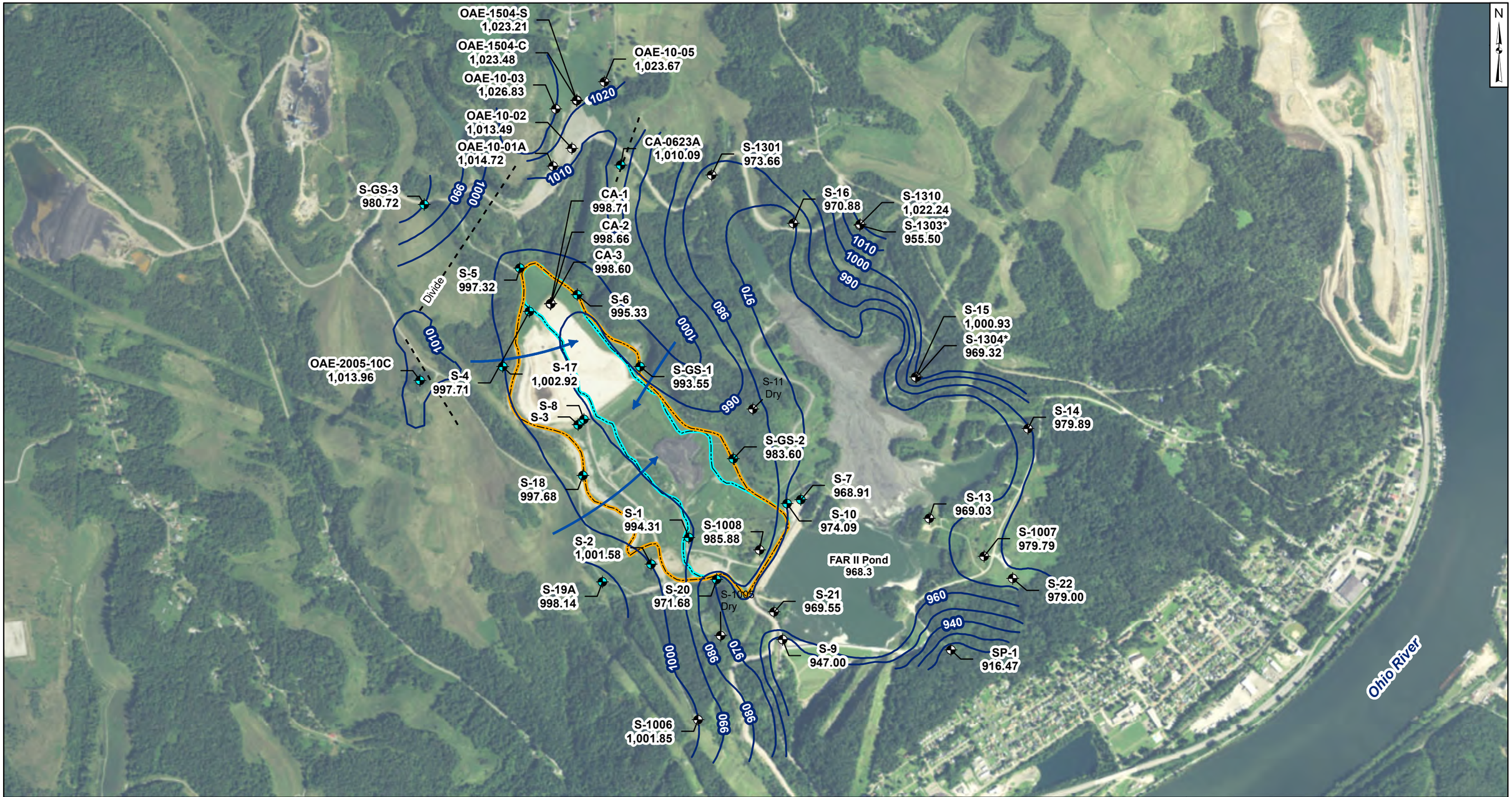
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **7**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-04_April.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on May 23, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
May 2017

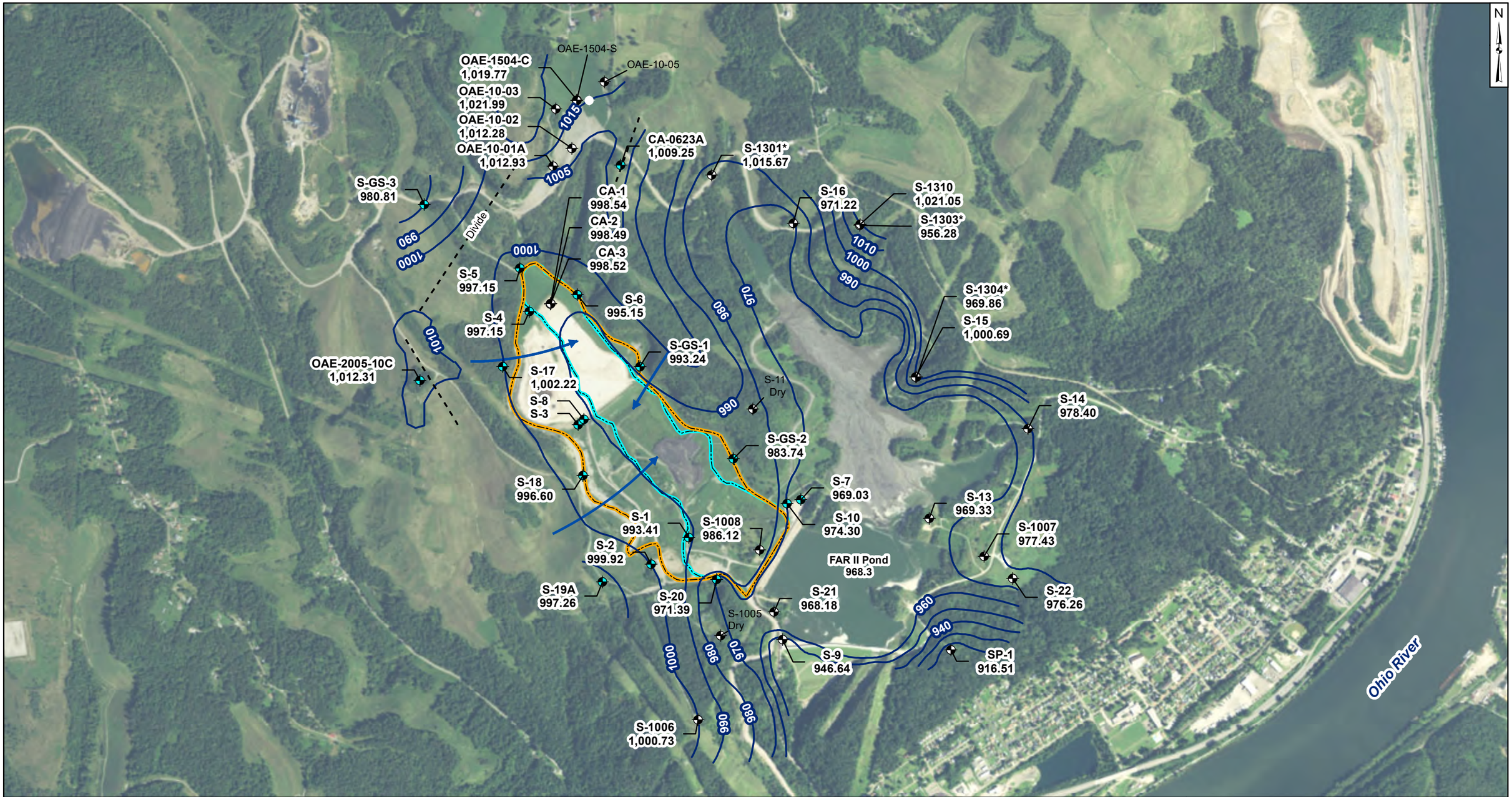
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **8**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-05_May.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on June 19, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
June 2017

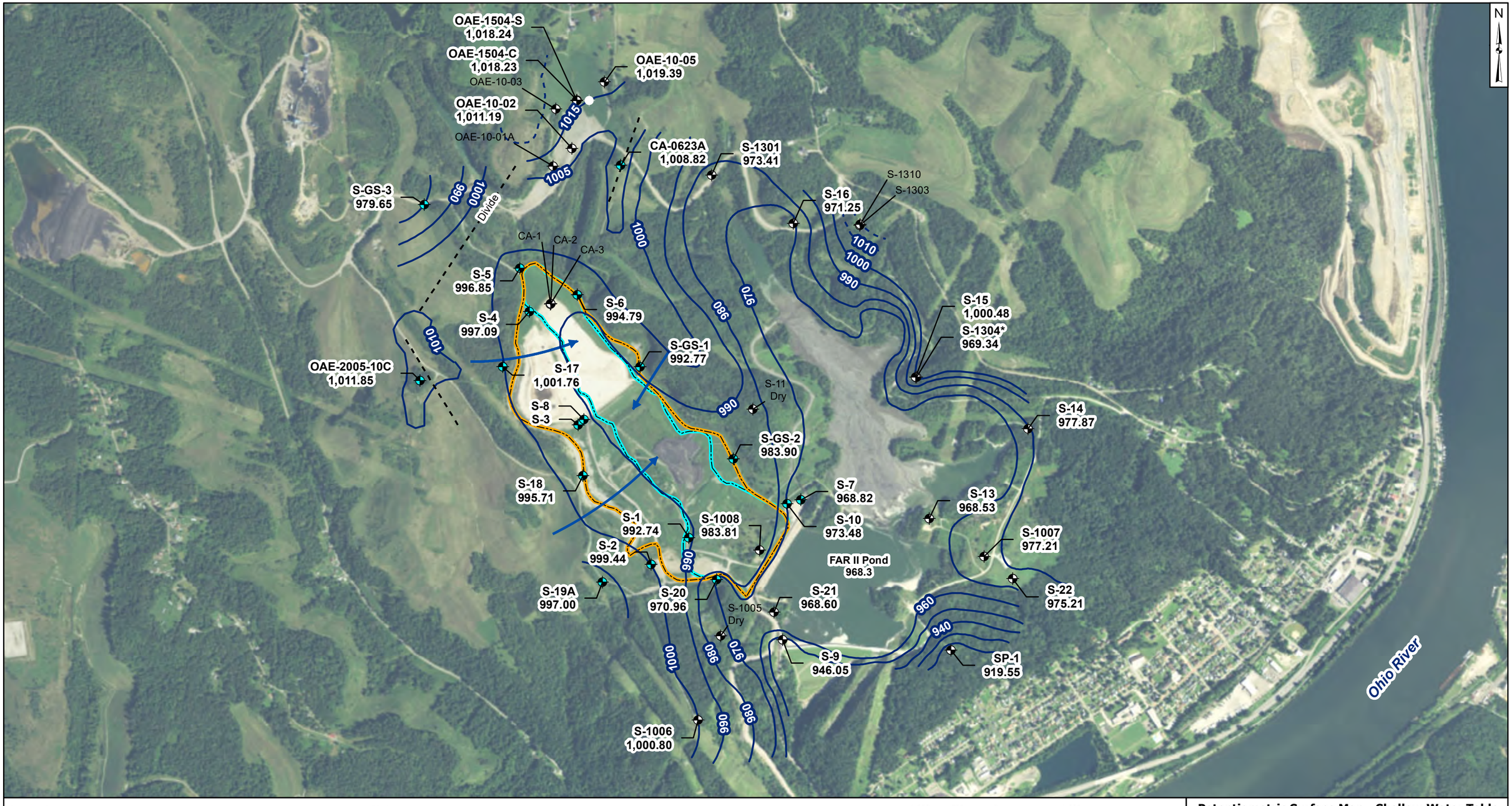
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **9**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-06_June.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on July 25, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- S-1310 and OAE-10-3 not measured; contours inferred from previous events.

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
July 2017

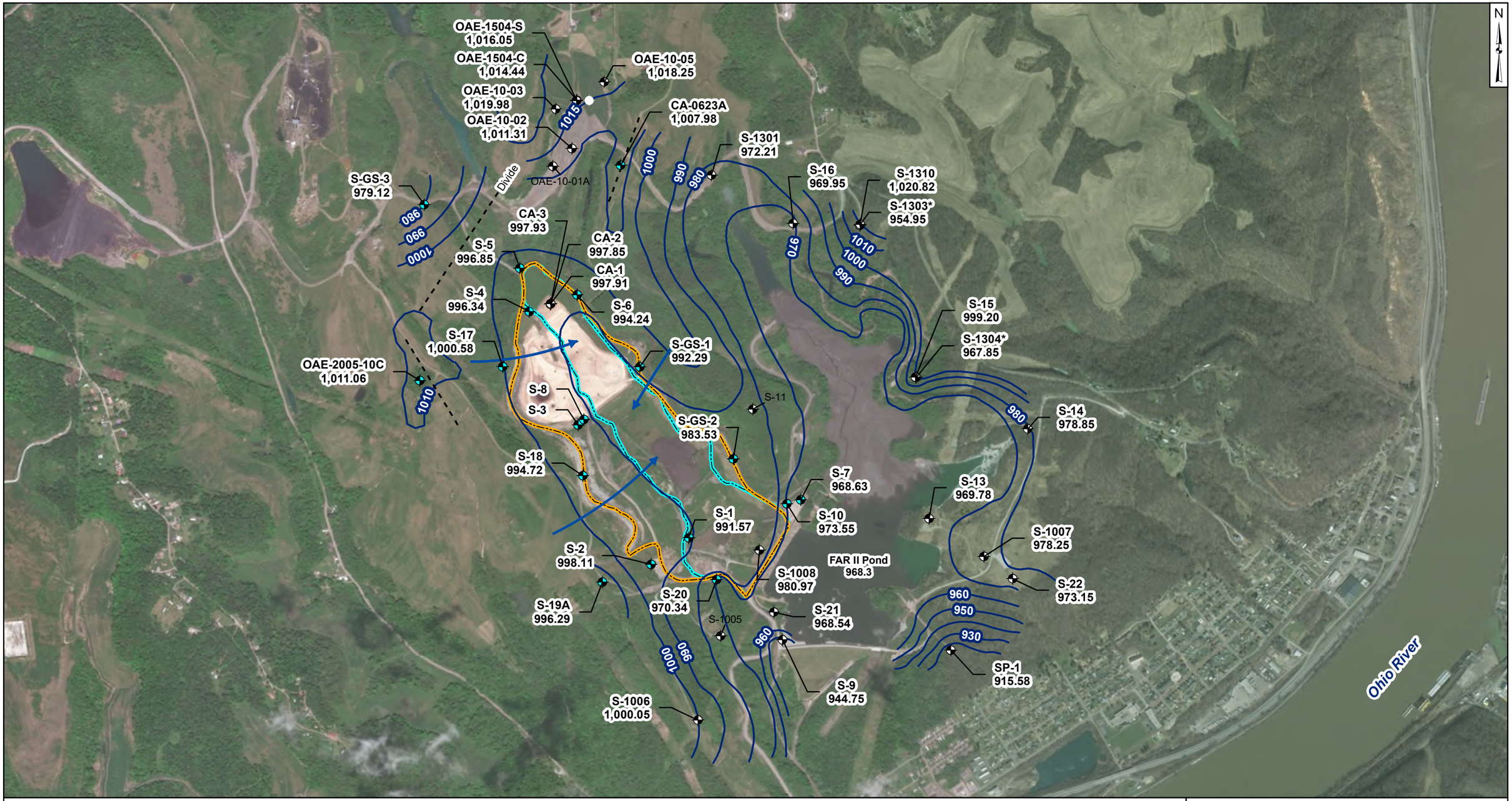
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure **10**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-07_July.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on October 1, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Wells not used for contouring due to inconsistent/anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
October 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2018/01/29

Figure **11**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-10_Oct.mxd. MMuenich. 1/29/2018. CHA8423/01/08.

Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected May 14, 2018) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former Fly Ash Reservoir I RSW Landfill
May 2018

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/01/10

Figure **3**

P:\Projects\Buckeye Power\GIS\MXDs\Buckeye-Cardinal_FAR_I_GW_2018-05.mxd. ARevezzo. 1/10/2019. CHA8423/01/08.

Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected October 8-16, 2018) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former Fly Ash Reservoir I RSW Landfill
October 2018

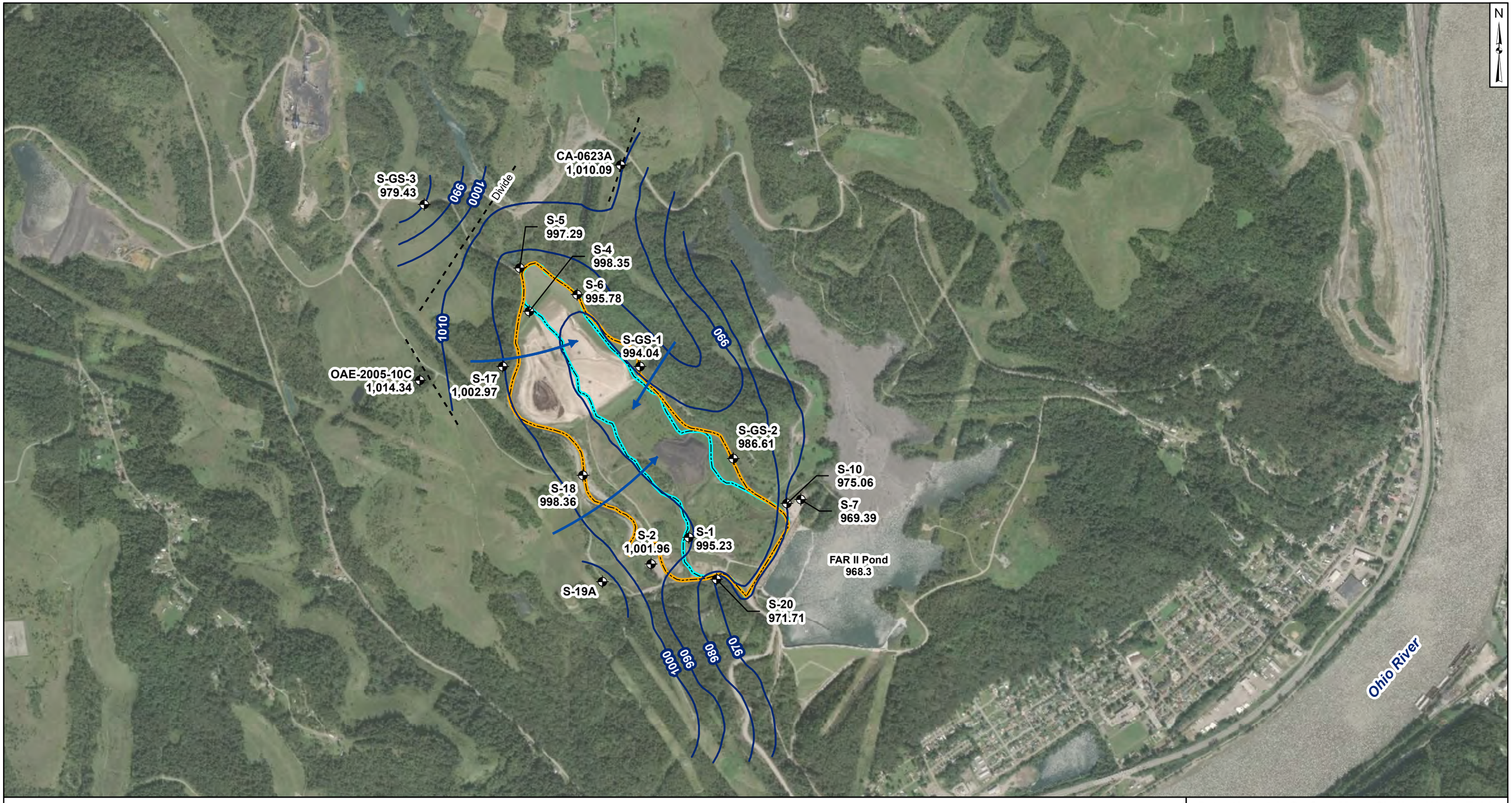
Buckeye Power, Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2018/12/24

Figure **4**

P:\Projects\Buckeye Power\GIS\MXDs\Buckeye-Cardinal_FAR_I_GW_2018-10.mxd. ARevezzo. 12/24/2018. CHA8423/01/08.



Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on March 21, 2019) provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- MW-19A was not gauged during March 2019.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
March 2019

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/08

Figure **3**

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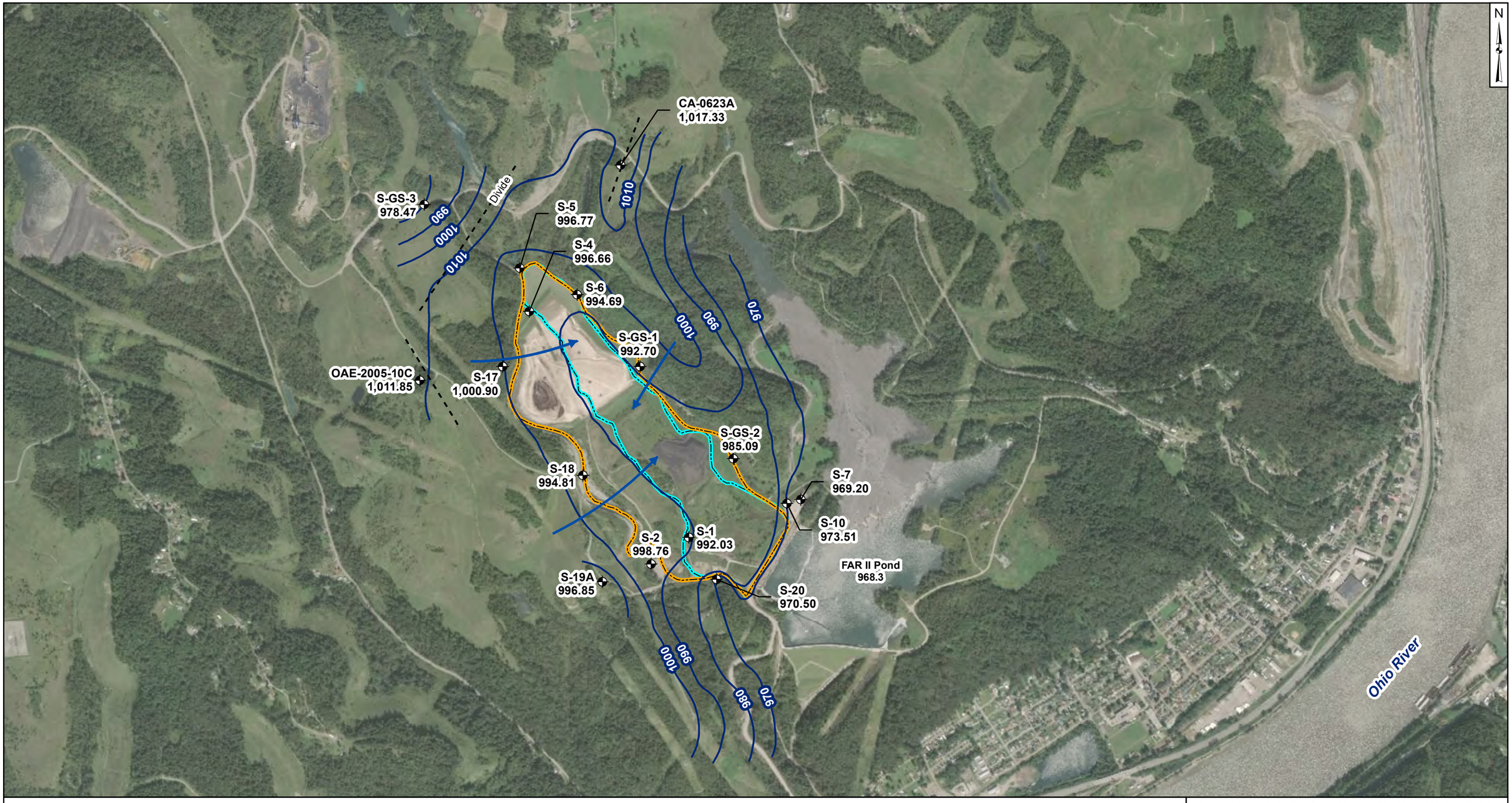

Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on October 26 , 2019) provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
October 2019

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/08

Figure **4**

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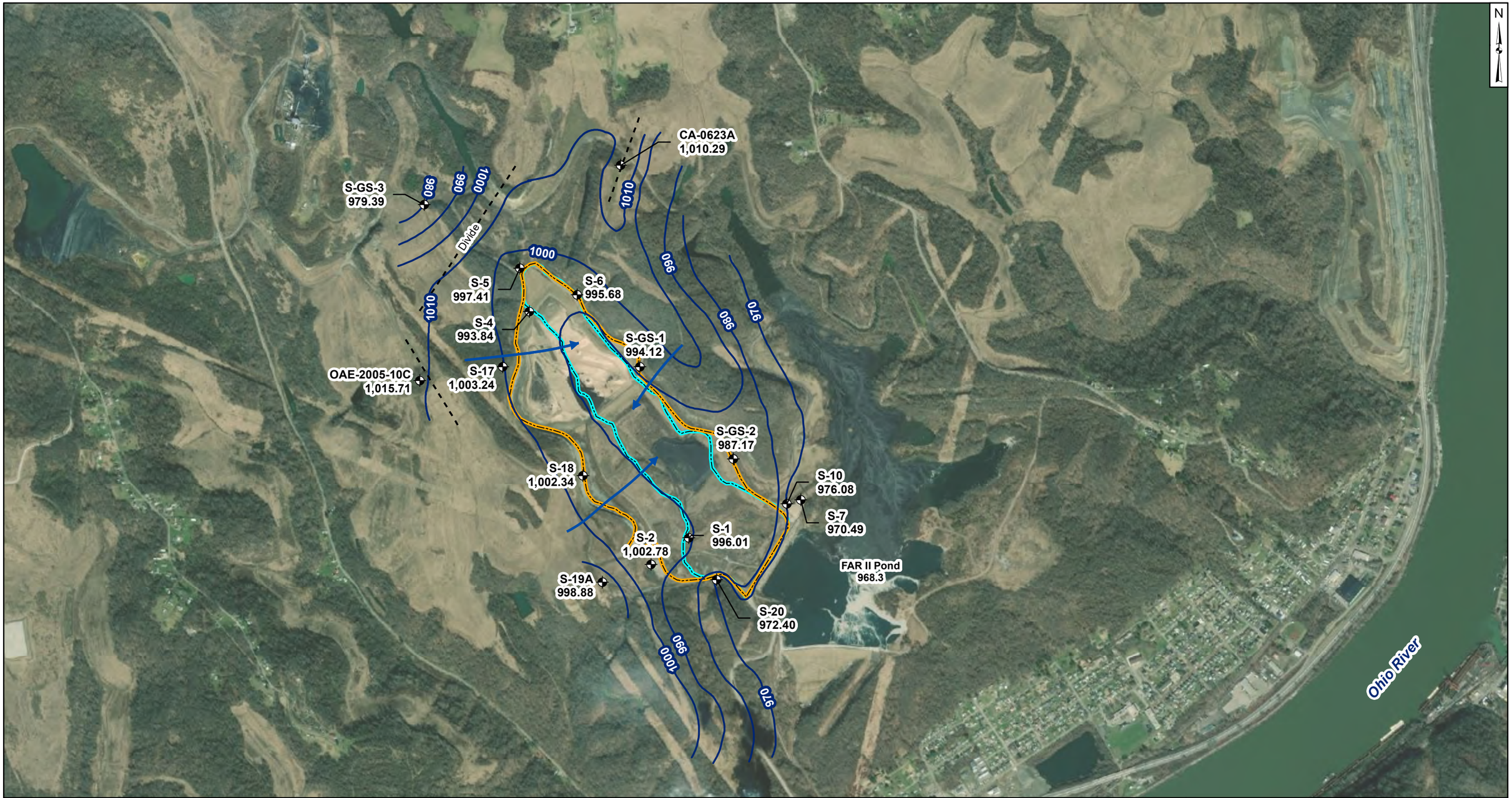


Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on April 6 - 7, 2020) provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
RSW Landfill
April 2020

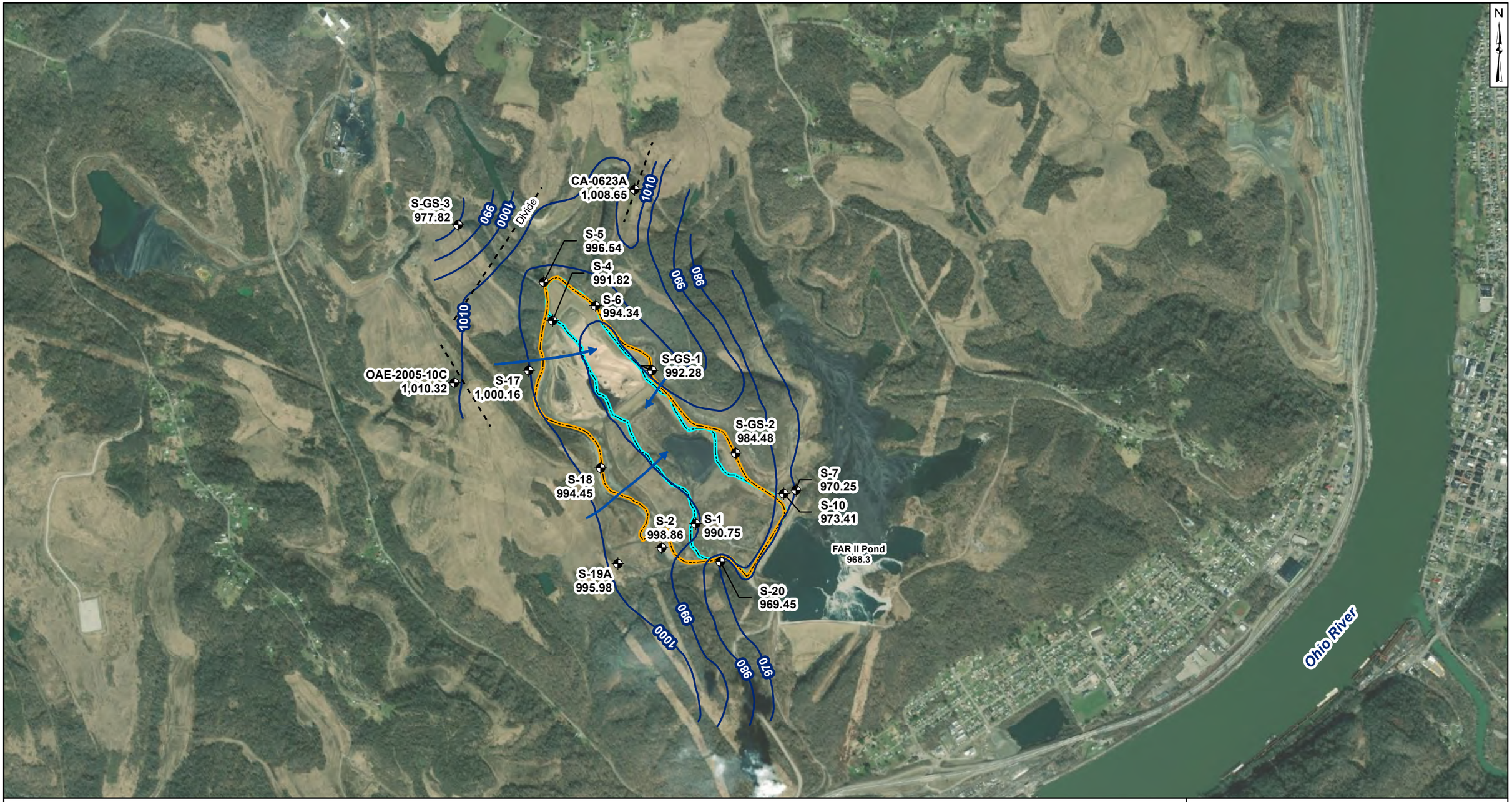
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2021/01/08

Figure **3**

P:\Projects\Buckeye Power\GIS\MXDs\FAR I\Buckeye-Cardinal_FAR I_GW_2020-04.mxd. ARevezzo. 12/15/2020. CHA8423/01/08.



Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I
- Watershed Divide

Notes

- Monitoring well coordinates and water level data (collected on October 1, 2020) provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016).
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
RSW Landfill
October 2020

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/12/22

Figure **4**

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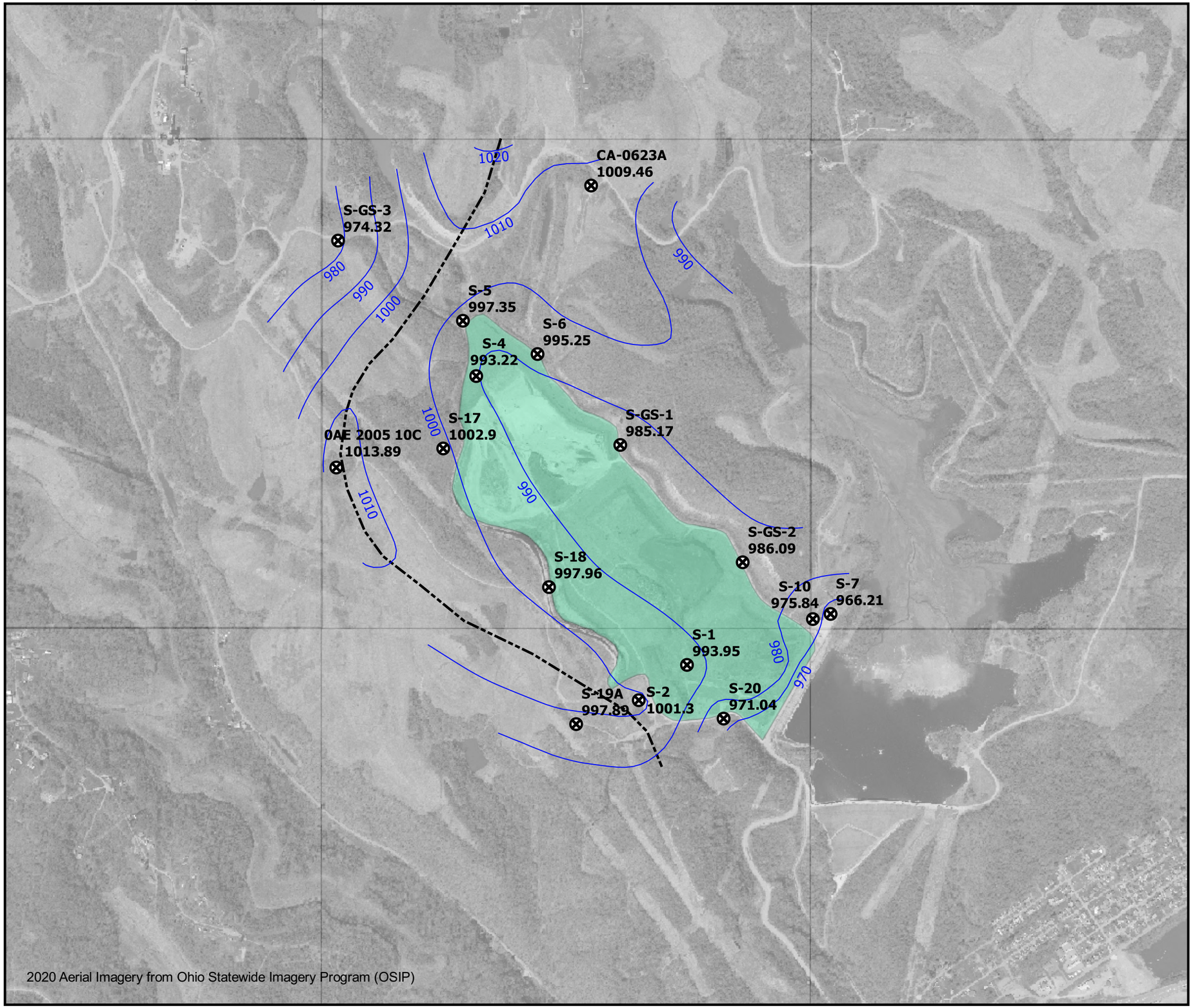

Legend

- FAR I Network Monitoring Well and Groundwater Elevation
- Groundwater Elevation Contour
- FAR I RSW Landfill
- Approximate Location of Groundwater Divide

N

0 1,000 2,000 3,000 ft

Cox-Colvin & ASSOCIATES, INC.
ENVIRONMENTAL SERVICES

Figure

4-1

Potentiometric Surface Map - Shallow Aquifer
FAR I RSW Landfill - April 5, 2021
Cardinal Plant
Brilliant, Ohio

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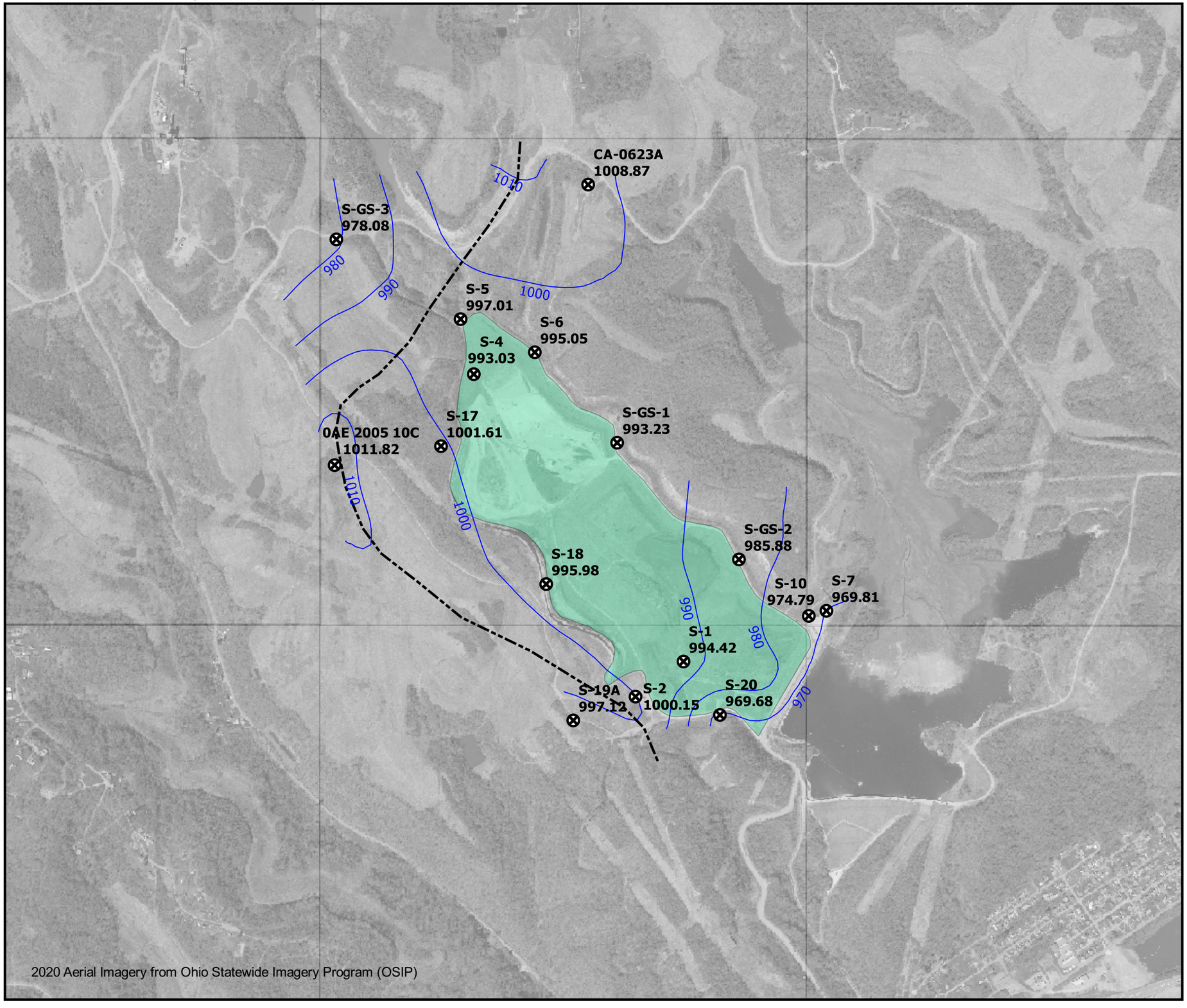

Legend

- FAR I Network Monitoring Well and Groundwater Elevation
- Groundwater Elevation Contour
- FAR I RSW Landfill
- Approximate Location of Groundwater Divide

N

0 1,000 2,000 3,000 ft

Cox-Colvin & ASSOCIATES, INC.
ENVIRONMENTAL SERVICES

Figure

4-2

Potentiometric Surface Map - Shallow Aquifer
FAR I RSW Landfill - October 11, 2021
Cardinal Plant
Brilliant, Ohio