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REPORT ON

CARDINAL POWER PLANT FACILITY RETROFIT BOTTOM ASH POND GROUNDWATER MONITORING SYSTEM UPDATE AND CERTIFICATION CARDINAL POWER PLANT BRILLIANT, OHIO

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Cardinal Operating Company
Brilliant, Ohio

File No. 210218
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1. Introduction

Haley & Aldrich, Inc. is pleased to present Cardinal Operating Company (Cardinal) with this Groundwater Monitoring System Update and Certification for the retrofitted Bottom Ash Pond (RBAP) (Site) for their power plant located in Brilliant, Ohio (Facility) (Figure 1). Cardinal is implementing the United States Environmental Protection Agency's (USEPA's) Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] §257.90-257.98) (CCR Rule) at the RBAP. The CCR Rule establishes requirements for the operations, maintenance, and closure of landfills and surface impoundments of CCR materials.

This report serves to provide Cardinal with recent data and information regarding the RBAP, in compliance with the federal CCR Rule under 40 CFR 257 Subpart D. According to Sargent & Lundy (2022), the RBAP received a Permit-to-Install (PTI) from the Ohio Environmental Protection Agency (Ohio EPA) in March 2021 to retrofit the southern portion of the pond with a CCR-compliant liner. This report will supersede previous groundwater monitoring systems outlined in reports by Geosyntec (2016a) and Cox-Colvin & Associates, Inc. (Cox-Colvin, 2022) for the RBAP.

It is important to note that within this report, the coordinate values for horizontal projections are based on the North American Datum of 1927 (NAD27) and elevations are based on the National Geodetic Vertical Datum of 1929 (NGVD 29).

2. Background Information

Cardinal operates a generating station consisting of three coal-fired units with a capacity of 1,800 megawatts. Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. Each unit is equipped with an electrostatic precipitator for removing fly ash particulate matter, a selective catalytic reduction (SCR) system for removing nitrogen oxide, and flue gas desulphurization (FGD) systems for removing sulfur dioxide (Geosyntec, 2016a).

Previously known as the South Pond of the Bottom Ash Complex (BAC), the RBAP is situated along the Ohio River, south of Cardinal Plant Unit 3, and it receives bottom ash sluicing discharge. Dredging of settled bottom ash from the pond for dewatering is performed by an excavator on an island of deposits in the center of the pond. The dewatered ash is transported to the FAR I Residual Solid Waste Landfill (RSW Landfill), a dry landfill north of the plant. A water circulation system is in place for bottom ash sluicing, and there are no discharge facilities from the Bottom Ash Pond (BAP), aside from the blowdown line of the Unit 3 FGD system, to maintain water quality and the water level in the pond (Sargent & Lundy, 2020b).

2.1 CONSTRUCTION AND OPERATIONAL HISTORY

The BAC was initially built as part of the construction of Generating Units 1 and 2, in the 1960s. In 1974, the pond underwent modifications, including the addition of a berm separating the pond. Two surface impoundments, known as the BAC, with miscellaneous non-CCR low-volume waste (LVW) streams and stormwater runoff, were used to manage the sluiced bottom ash. Collectively, the BAC consisted of a bottom ash pond, or North Pond, and a recirculation pond, or South Pond.

In 2008, the South Pond was divided into two areas by a polyvinyl chloride (PVC) sheet pile baffle wall. The water on the north side of the wall was recirculated back to the generating units for ash sluicing, while the area on the south side was used for settlement before discharge, when necessary.

2.2 RETROFIT OF THE BAP

The segmented portion of the BAP, known as the South Pond, was retrofitted in 2022, by digging out the deposited material and installing a CCR compliant liner and was renamed the "Retrofit Bottom Ash Pond" (RBAP). The RBAP was determined to have a sufficient size to cover the current loading of bottom ash and having the desired recirculation for water quality. The RBAP has an approximate area of 7 acres and a volume capacity of 74 acre-feet. The system consists of a geosynthetic clay layer over graded and compacted native soil in accordance with the CCR Rule permeability requirement, overlain by a 60-mil textured high-density polyethylene (HDPE) geomembrane. The liner system is protected by additional geotextile and gravel layers. The RBAP is shown on Figure 2.

2.3 HISTORICAL GROUNDWATER MONITORING

Prior to the retrofit of the BAP, the groundwater monitoring well network consisted of five wells: two upgradient monitoring wells (MW-BAP-4 and MW-BAP-5) and three downgradient monitoring wells (MW-BAP-1, MW-BAP-2, and MW-BAP-3) (Table 1). The monitoring wells were first installed to investigate the area's hydrogeologic conditions and quality of the uppermost aquifer. Of those initial five wells, only MW-BAP-3 continued to be used to collect groundwater samples. The other four wells are used for the collection of groundwater elevation measurements.

An initial eight baseline sample events were carried out from June 2016 to August 2017, followed by semiannual monitoring and statistical analyses to evaluate the potential impacts of CCR materials on groundwater quality. The results showed statistically significant increases (SSIs) in the concentrations relative to background values in the downgradient wells of the historical BAP. However, concentrations did not exceed statistically significant levels (SSLs) for groundwater protection standards (GWPS) of constituents that would require corrective action.

The BAC recently completed closure. As previously mentioned, the South Pond retrofit was completed in 2022, and the North Pond was closed by removal and re-purposed as a Low Volume Waste Pond in October 2024.

The previous groundwater monitoring system will no longer be necessary as groundwater concentrations remain below the GWPS levels after closure was completed.
The previous groundwater monitoring network for the RBAP was prepared and certified in 2022 by Cox-Colvin. The groundwater monitoring system for the RBAP is being updated as outlined in this report to include MW-BAP-5 as a well that is representative of background (outside of the influence of the RBAP) conditions.

3. Hydrogeologic Setting

3.1 CLIMATE

The weather station that best represents Brilliant, Ohio is located in New Cumberland, West Virginia (USC00466442). The weather station in Steubenville, Ohio is more proximate; however, the data is collected less consistently. The climate difference between these two locations does not affect the climatological impacts of this report. The monthly average temperature ranges from 37 degrees Fahrenheit (°F) (in January) to 73.6°F (in July), and annual precipitation of 37.56 inches was recorded in 2023, as shown on Table 2.

Additionally, there is no surface water entering the BAP from the surrounding area. The precipitation that falls onto the BAP is recirculated and used for bottom ash sluicing. The only discharge facility from the BAP is a blowdown line to the Unit 3 FGD system, which is used to manage and control water quality and level (Sargent & Lundy, 2020b).

3.2 GEOLOGIC SETTING

The RBAP is located along the western bank of the Ohio River within the river floodplain. Bedrock consists of a mixture of interbedded shale, sandstone, coal, and limestone from the Pennsylvanian Age Conemaugh Formation. The bedrock is overlain by unconsolidated deposits of sand and gravel resulting from the deglaciation process during the Wisconsin Glaciation, which ended roughly 12,000 years ago.

As shown in Appendices A and B, the sediments beneath the BAP are unconsolidated and can be broken down into three components: fill materials (10 to 20 feet thick), an alluvium unit composed of silt, clay, and sand (10 to 20 feet thick) deposited by Ohio River floodwaters, and a lower unit consisting of glacial outwash and alluvial deposits of sand and gravel (5 to 50 feet thick). The thickness of overburden materials is estimated to be about 50 to 75 feet in the vicinity of the BAP, thinning to the west near the topographic high and thickening east, approaching the Ohio River.

3.3 HYDROGEOLOGY

The uppermost aquifer at the Site consists of unconsolidated outwash sediments with hydraulic connections to overlying silts and clays. While the clay and silt layers are typically considered lowly permeable, there is no evidence to suggest the presence of a water-bearing formation or aquifer. Fill materials are predominantly located in the vadose zone above the water table, apart from a seasonal influence near MW-BAP-2 (Appendix A). Groundwater flow is typically from west to east below the RBAP toward the Ohio River. The exception to this flow pattern is during flood stage conditions, where flows could deflect, depending on the river stage.

3.3.1 Groundwater Use

The groundwater resource map prepared by the Ohio Department of Natural Resources (ODNR) (2024) indicates limited water capacity from shale, sandstone, and limestone bedrock units in the area, not exceeding 3 gallons per minute. However, the sediments near the RBAP, adjacent to the Ohio River, consisting of thick gravel and sand deposits, can yield more than 1,000 gallons per minute.

Water well records are maintained by the ODNR and are accessed by the online Water Well Database tool.[1] The nearest domestic water supply wells are located approximately 1 mile west of the Site. According to the *2023 Drinking Water Consumer Confidence Report* by the Jefferson County Water and Sewer District, the primary water supply for Brilliant, Ohio originates from three groundwater wells that are located approximately 2.5 miles northeast of the Site. Surface elevations of the domestic water supply wells are higher than those of the BAP, and there is no surface water intake suppling Brilliant, Ohio.

3.3.2 Surface Water Control

The primary surface water feature near the Site is the Ohio River. The river elevation is controlled by the Pike Island Dam, located 7 miles downstream. The normal reservoir elevation for the dam is approximately 644.0 feet (U.S. Army Corps of Engineers [USACE], 2024). The New Cumberland Lock and Dam is located at Ohio River Mile 54, near New Cumberland, Ohio, located approximately 23 river miles upstream of the Site at an elevation of 658.16 feet (National Weather Service [NWS], 2024). The Ohio River level responds to the seasonal variation of precipitation and generally shows the highest elevations during the spring and summer months.

Surface water drainages, including tributaries, such as Salt Run (0.6 miles), Riddles Run (1.4 miles), and Blackhouse Run (1.6 miles), flow into the Ohio River; however, they are isolated from the BAP and RBAP by pond embankments.

3.3.3 Hydraulic Conductivity and Effective Porosity

The estimated hydraulic conductivity within the vicinity of the RBAP ranges from 0.0001 centimeters per second (cm/sec; 0.27 feet per day [ft/day]) to 0.1 cm/sec (2,700 ft/day) (Geosyntec, 2016a). Groundwater velocity calculations are based on a hydraulic conductivity of 0.05 cm/sec and an effective porosity of 0.35.

In January 2021, monitoring wells MW-BAP-1001, MW-BAP-1002, and MW-BAP-1003 were installed. On 19 March 2021, a slug test was conducted for each well. The results of the slug testing show hydraulic conductivity values of 2.3×10^{-4} cm/s, 3.0×10^{-1} cm/s, and 2.8×10^{-1} cm/s for MW-BAP-1001, MW-BAP-1002, and MW-BAP-1003, respectively. Details of the data evaluation and calculations completed by Cox-Colvin can be found in Appendix C and are summarized in Table 3. Lower hydraulic conductivities are observed in the east, as evidenced by the low hydraulic conductivity calculated for MW-BAP-1001.

3.3.4 Groundwater Flow Characteristics

The groundwater flow pattern at the Site, as indicated by the 9 April 2024 potentiometric surface map, flows from the topographic high in the west toward the Ohio River in the east (Figure 2). The aquifer near the RBAP exhibits a strong connection with the river, Changes in groundwater elevation at monitoring wells ranged from 1.11 to 1.35 feet between 9 October 2023 and 9 April 2024. Calculations based on April 2024 measurements suggest a groundwater flow velocity of approximately 43.8 ft/yr at the RBAP.

[1] https://gis.ohiodnr.gov/MapViewer/?config=waterwells

4. Groundwater Monitoring System Evaluation

An “aquifer” is “a geologic formation, group of formations, or a portion of a formation capable of yielding usable quantities of groundwater to wells or springs.” The term of “uppermost aquifer” is defined by the CCR Rule (40 CFR §257.53) as “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.” Below the RBAP, the sand and gravel layer of outwash material forms the uppermost aquifer. The overlying silt and clay representing alluvial deposits are hydraulically connected with the outwash materials and are saturated; however, the alluvium is unable to produce usable quantities of groundwater. As a result, the alluvium silt and clay layer are not considered part of the uppermost aquifer.

The requirements that are needed for the groundwater monitoring system to meet the conditions specified in 40 CFR §257.91 are outlined below.

4.1 PERFORMANCE STANDARD

The performance standard that is specified by the CCR Rule §257.91(a) is:

The owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that:

(1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit […]; and

(2) Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.

The RBAP's previous monitoring system included four monitoring wells: MW-BAP-3, MW-BAP-1001, MW-BAP-1002, and MW-BAP-1003 (Cox-Colvin, 2022). To augment the monitoring network for the RBAP, an additional existing monitoring well, MW-BAP-5, will be added to the monitoring system. The well was installed on 25 November 2015. MW-BAP-5 is located approximately 580 feet north of MW-BAP-1001 and will represent background groundwater conditions unaffected by the RBAP.

Samples collected from MW-BAP-1001 and MW-BAP-5 will serve as representations of background groundwater concentrations. Monitoring wells MW-BAP-3, MW-BAP-1001, and MW-BAP-1003, located along the downgradient (eastern) portion of the RBAP near the Ohio River, will be used to assess groundwater conditions in the uppermost aquifer.

4.2 SITE-SPECIFIC TECHNICAL EVALUATION

The CCR Rule §257.91(b) specifies the following criteria for the Site technical evaluation:

The number, spacing, and depths of monitoring systems shall be determined based upon site-specific technical information that must include thorough characterization of:

(1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow; and

(2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities and effective porosities.

The uppermost aquifer is separated from the RBAP by fill materials and alluvial clay and silt with a minimum thickness of 5 feet, providing a barrier against contamination release. Any contamination would have to move vertically through the unsaturated zone before reaching the water table. The low permeability of these soils hinders this movement and acts as a barrier to the uppermost aquifer. Sand and gravel layers represent the uppermost aquifer below the RBAP, and monitoring well screens are positioned near the top of the aquifer, as depicted in Appendix A.

MW-BAP-1001 is screened in the same outwash materials as the compliance wells, despite variations in hydraulic conductivity. Monitoring well MW-BAP-5 is located north of the RBAP and is representative of background concentrations outside of the potential effects of the RBAP. Monitoring wells MW-BAP-3, MW-BAP-1002, and MW-BAP-1003 are positioned along the downgradient (eastern) boundary of the BAP and are designated as compliance wells to ensure the detection of groundwater contamination in the uppermost aquifer. Groundwater monitoring well locations are depicted on Figure 2.

4.3 NUMBER OF WELLS

The CCR Rule §257.91(c) specifies that:

The groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards specified in paragraph (a) of this section, based on the site-specific information specified in paragraph (b) of this section. The groundwater monitoring system must contain:

(1) A minimum of one upgradient and three downgradient monitoring wells; and

(2) Additional monitoring wells as necessary to accurately represent the quality of background groundwater not affected by leaking from the CCR unit and the quality of groundwater passing the waste boundary of the CCR unit.

The monitoring well network consists of five monitoring wells strategically positioned to cover the essential upgradient and downgradient locations of the Site. By meeting these criteria, the monitoring system aligns with the requirements set forth for CCR Rule compliance.

4.4 MULTIPLE CCR UNITS

CCR Rule §257.91(d) mentions that "a multiunit groundwater monitoring system instead of separate groundwater monitoring systems for each CCR unit." As the BAP and RBAP overlay the same uppermost aquifer and share the same area and there are no other CCR units nearby, this provision of the CCR Rule does not apply.

4.5 MONITORING WELL SYSTEM CONSTRUCTION

The CCR Rule §257.91(e) states that:

Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the groundwater.

(1) The owner or operator of the CCR unit must document and include in the operating record the design, installation, development, and decommissioning of any monitoring wells, piezometers and other measurement, sampling and analytical devices. The qualified professional engineer must be given access to this documentation when completing the groundwater monitoring system certification required under paragraph (f) of this section.

(2) The monitoring wells, piezometers, and other measurement, sampling, and analytical devices must be operated and maintained so that they perform the design specification throughout the life of the monitoring program.

4.5.1 Monitoring Well Construction

The logs for monitoring well construction are presented in Appendix D. Boring logs from well installation are presented in Appendix B. The monitoring wells are constructed with 2-inch-diameter PVC casings and screens. The annular spaces around the screen are filled with sand packs; above the sand pack is sealed with bentonite.

In August 2024, MW-BAP-1001 was damaged. Repairs were completed, and a resurvey of the entire monitoring well network was completed on 4 September 2024. Survey data presented in Table 1 reflects this update.

4.5.2 Groundwater Monitoring Program

Groundwater sampling will occur semiannually in accordance with the CCR Rule. The flow direction and velocities at the RBAP and BAP show that the groundwater residence times at the monitoring wells range from less than one week to less than six months. Therefore, the sampling frequency ensures that samples are physically independent. Groundwater elevations will be measured immediately before purging the monitoring wells to collect the groundwater samples. To minimize the effects of temporal variation and accurately determine groundwater flow rate and direction, water levels at the groundwater monitoring wells in the RBAP groundwater monitoring system will be measured on the same day within the shortest practical time frame, even if sampling spans multiple days.

The groundwater monitoring wells will be sampled utilizing low-flow sampling techniques in compliance with Chapter 10 of the Ohio EPA's Technical Guidance Manual (TGM) for Hydrogeologic Investigations and Ground Water Monitoring (Ohio EPA, 2020) and the Facility Groundwater Monitoring Program Plan, approved by the Ohio EPA Division of Materials & Waste Management (Cardinal, 2020). A submersible pump will be used to purge the groundwater monitoring wells through disposable polyethylene tubing. Down-hole equipment will be decontaminated prior to moving between sampling locations.

Groundwater will be pumped through an enclosed flow-through cell fitted with a multi-parameter groundwater meter, and measurements of temperature, pH, specific conductance, turbidity, dissolved oxygen (DO), and oxidation-reduction potential (ORP) will be periodically taken during purging. Groundwater will be purged until three consecutive readings fall within the specified limits for at least three stabilization parameters:

- Turbidity has stabilized to less than 10 nephelometric turbidity units (NTUs) or ±10 percent if greater than 10 NTUs;
- Temperature has stabilized to ±0.5 degrees Celsius (°C);
- ORP has stabilized to ±20 millivolts (mV);
- DO has stabilized to 10 percent or ±0.2 milligrams per liter (mg/L);
- pH has stabilized to ±0.2 standard units (SU); and
- Specific conductance has stabilized to ±3 percent (Cox-Colvin, 2023).

Groundwater levels will be monitored during purging to ensure minimal drawdown. Samples will be collected once field parameters stabilize. If stabilization is not achieved after purging three well volumes, the field crew may collect a sample at their discretion. Efforts will be made to avoid purging to dryness, and samples will be collected as soon as there is enough water to best represent groundwater quality (Cox-Colvin, 2022).

Groundwater samples will be collected unfiltered in pre-preserved containers provided by the laboratory. To verify that analytical data accurately represents Site conditions according to the Facility Groundwater Monitoring Program Plan, quality control blanks and field duplicates will be collected (Cardinal, 2020). Samples will be transported to a qualified laboratory in an ice-cooled chest under a chain of custody protocols. Laboratory analysis will follow the specifications outlined in 40 CFR §257.93, utilizing analytical methods that accurately measure hazardous constituents listed in Appendix III or IV of 40 CFR §257, as detailed in the Statistical Analysis Plan (Geosyntec, 2020). The statistical evaluation of groundwater analytical results will be conducted in accordance with the Site's 2020 Statistical Analysis Plan (Geosyntec, 2020) or subsequent revisions.

5. Professional Engineer Certification

The undersigned Professional Engineer registered in the state of Ohio is familiar with the requirements of 40 CFR Part 257, Subpart D and has visited and examined the Site. The undersigned Registered Professional Engineer attests that the RBAP Groundwater Monitoring System has been prepared in accordance with good engineering practice, including the design and construction to meet the requirements of 40 CFR §257.91, for the Site to the best of his knowledge. The minimum number of wells specified in 40 CFR §257.91(c)(1) has been met and documented in Section 4 of this report.

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

Steven Putrich, P.E. (#PE63729)

14 October 2024
Date

HALEY ALDRICH

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TABLES

TABLE 1
MONITORING WELL SURVEY DATA
RBAP
CARDINAL POWER PLANT
BRILLIANT, OHIO

Monitoring Well ID	Position X	Position Y	Elevation (ft)
MW-BAP-1001	2513096.25	819474.75	673.35
MW-BAP-1002	2513611.75	819468.13	672.90
MW-BAP-1003	2513400.75	818691.63	672.68
MW-BAP-3	2513517.00	819114.94	673.13
MW-BAP-5	2513275.25	820055.19	672.18

Notes:

1. Elevation measurements resurveyed on 4 September 2024.

2. Survey coordinates are NAD83 Ohio South CRS.

TABLE 2
2023 NOAA CLIMATOLOGICAL SUMMARY
RBAP
CARDINAL POWER PLANT
BRILLIANT, OHIO

Month	Average Temperature (degrees F)	Precipitation (Inches)
January	37.0	4.06
February	37.0	1.54
March	39.3	3.37
April	52.1	3.72
May	57.7	2.18
June	65.3	3.45
July	73.6	3.80
August	70.6	6.60
September	66.1	0.61
October	56.4	3.30
November	41.2	2.12
December	40.4	2.81
Annual	53.1	37.56

Notes:

Data collected from NOAA Station USC00466442, located in Cumberland, West Virginia

degrees F = degrees Fahrenheit

TABLE 3
HYDRAULIC CONDUCTIVITY OF RBAP
RBAP
CARDINAL POWER PLANT
BRILLIANT, OHIO

Monitoring point	Hydraulic Conductivity		Remark
	ft/day	cm/s	
MW-BAP-1001	0.661	2.3E-04	Slug test
MW-BAP-1002	836.400	3.0E-01	Slug test
MW-BAP-1003	797.600	2.8E-01	Slug test
MW-BAP-3	817.000	2.9E-01	Average of MW-BAP-1002 and MW-BAP-1003
MW-BAP-5	622.512	2.2E-01	Estimation based on interpolation of known values

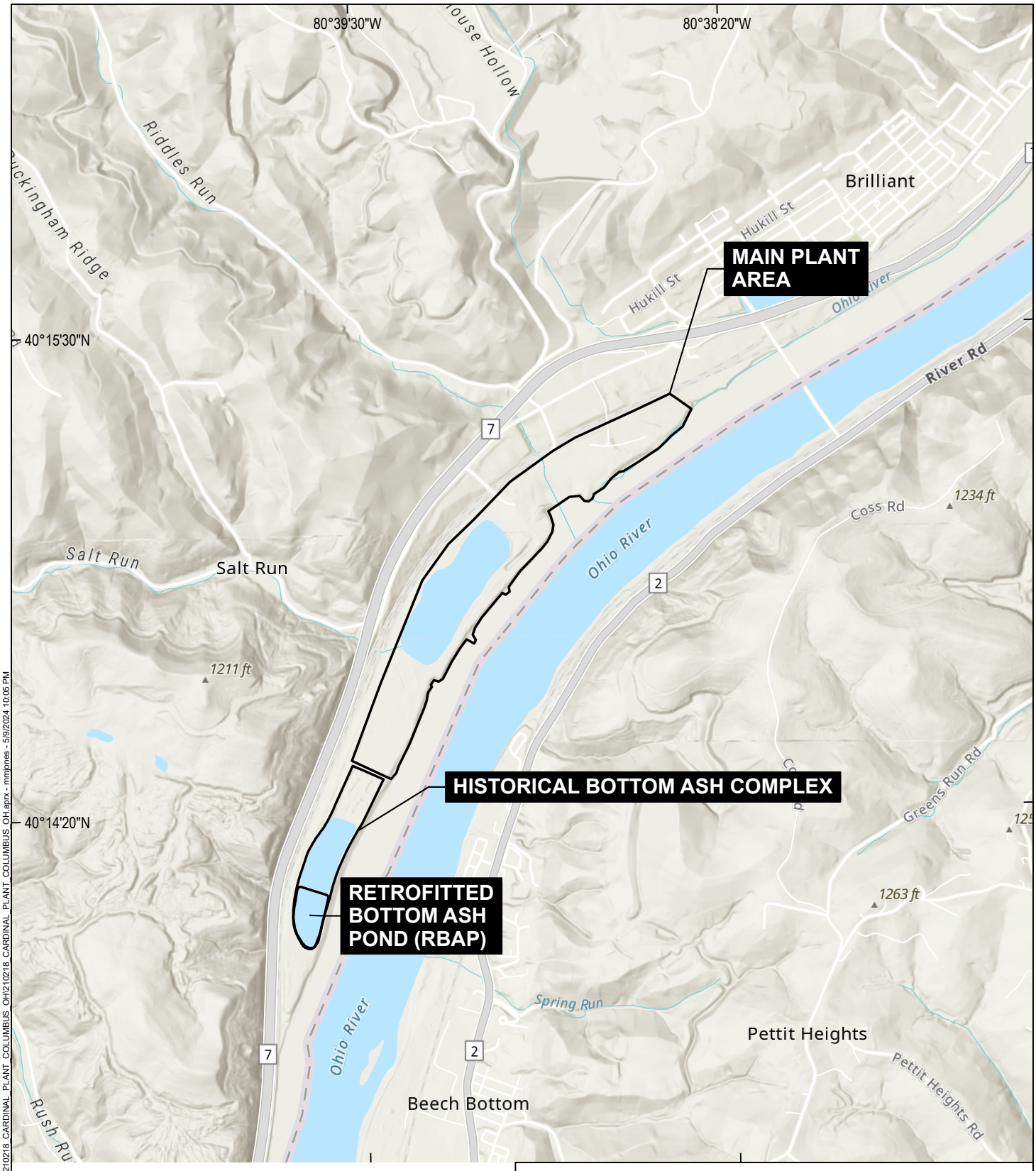
Notes:

cm/s = centimeters per second

Details of the data evaluation and calculations completed by Cox-Colvin can be found in Appendix C.

ft/day = feet per day

FIGURES



MAP SOURCE: ESRI
SITE COORDINATES: 40°14'55"N, 80°39'05"W

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CARDINAL PLANT
BRILLIANT, OHIO

PROJECT LOCUS

APPROXIMATE SCALE: 1 IN = 2000 FT
OCTOBER 2024

FIGURE 1

GIS: \\haleyaldrich\share\CF\Projects\02102218\GIS\210218_CARDINAL_PLANT_COLUMBUS_OH\210218_CARDINAL_PLANT_COLUMBUS_OH.aprx - mmiones - 5/9/2024 10:05 PM

LEGEND

- RBAP MONITORING WELL WITH **GROUNDWATER ELEVATION** IN FEET
- BAP MONITORING WELL WITH **GROUNDWATER ELEVATION** IN FEET
- GROUNDWATER ELEVATION CONTOUR, 0.05-FT INTERVAL (NGVD29)
- RAILROAD
- RETROFITTED BOTTOM ASH POND (RBAP)
- HISTORIC BOTTOM ASH POND (BAP)

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. DEFINITIONS:
   FT = FOOT
   NGVD29 = NATIONAL GEODETIC VERITCAL DATUM 1929
3. GROUNDWATER ELEVATIONS MEASURED 9 APRIL 2024.
4. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (FT MSL).
5. AERIAL IMAGERY SOURCE: NEARMAP, 14 MAY 2023

N

0 150 300
SCALE IN FEET

HALEY ALDRICH

CARDINAL PLANT
BRILLIANT, OHIO

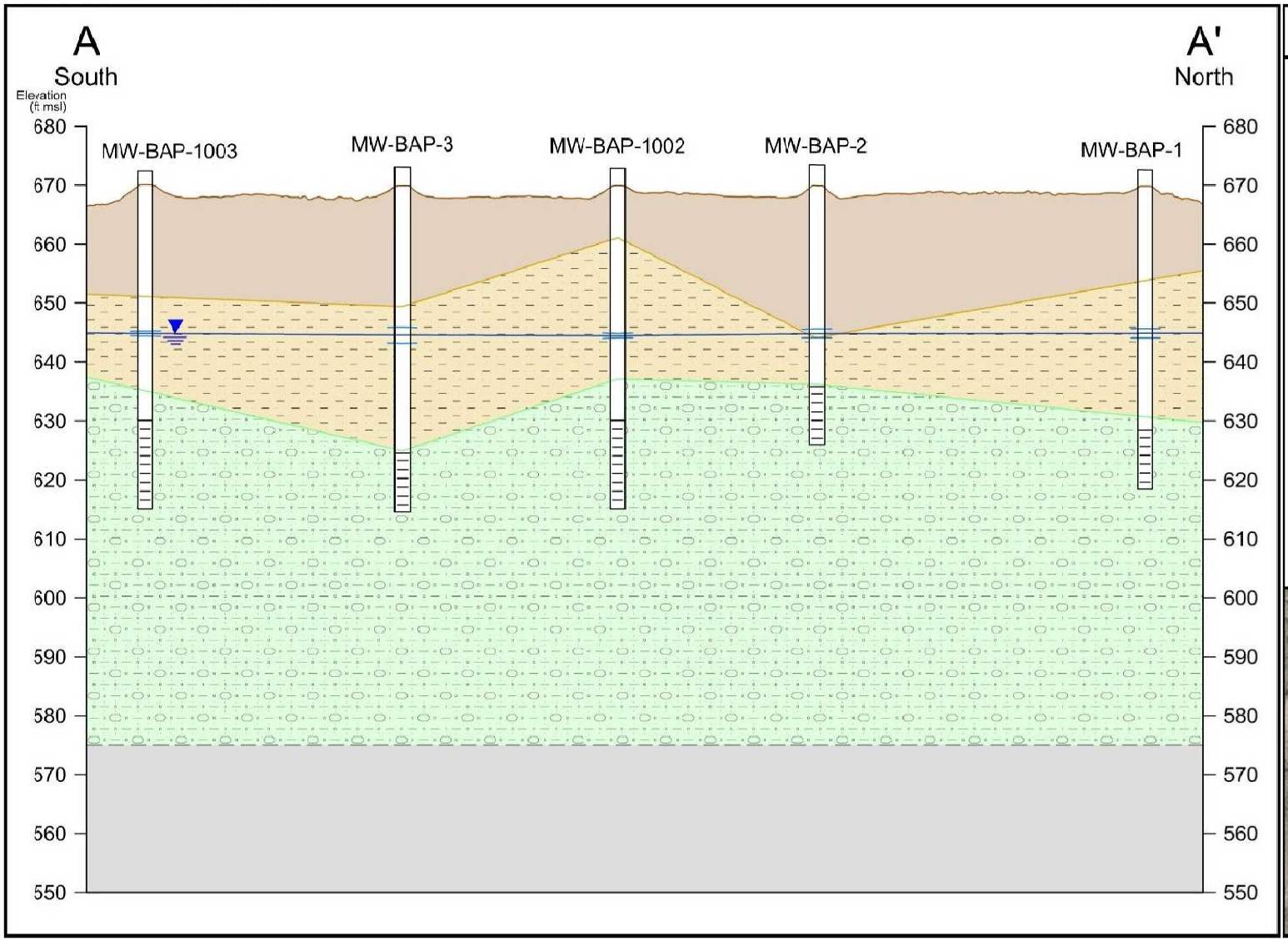
POTENTIOMETRIC SURFACE RETROFITTED BOTTOM ASH POND (RBAP) UPPERMOST AQUIFER 9 APRIL 2024

OCTOBER 2024

FIGURE 2

GIS FILE PATH: \\haleyaldrich.com\share\CP\Projects\021021\GIS\210218_CARDINAL_PLANT_COLUMBUS_OH\210218_CARDINAL_PLANT_COLUMBUS_OH.aprx - USER: mtoner - LAST SAVED: 8/1/2024 3:40 PM

APPENDIX A
Geologic Cross-Sections



Legend

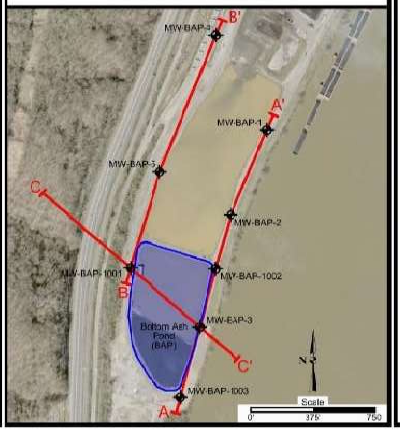
- Fill
- Alluvium (Silt/Clay)
- Glacial Outwash
- Bedrock
- Monitor Well
- Typical Groundwater Leve
- Range of Observed Groundwater Elevations
- A — A' Line of Geologic Cross Section

Source of Aerial Photography: CGRIP, 2020.

Horizontal Scale

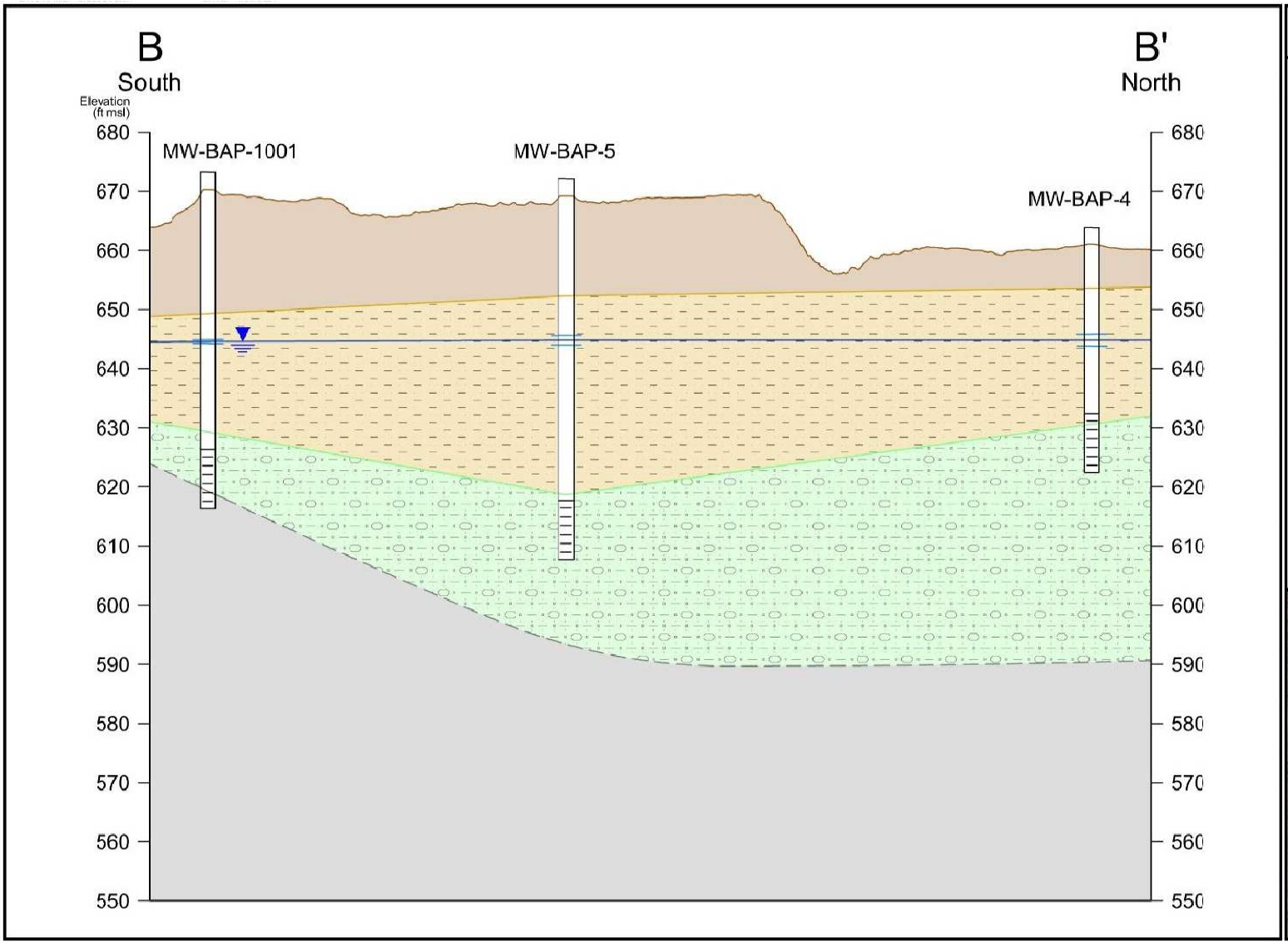
0' 87.5' 175' 350'

Vertical Exaggeration: 10x



Geologic Cross-Section A - A'

Cox-Colvin (2022)



Legend

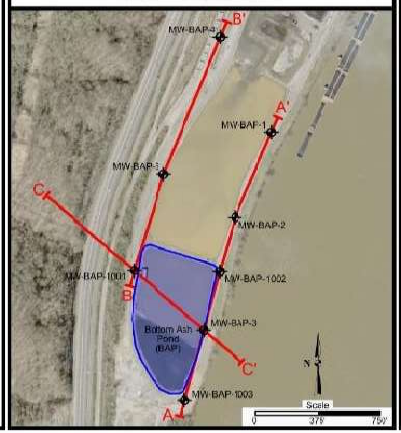
- Fill
- Alluvium (Silt/Clay)
- Glacial Outwash
- Bedrock
- Monitor Well
- Typical Groundwater Leve
- Range of Observed Groundwater Elevations

B B' Line of Geologic Cross Section

Source of Aerial Photography: OGRIP, 2020.

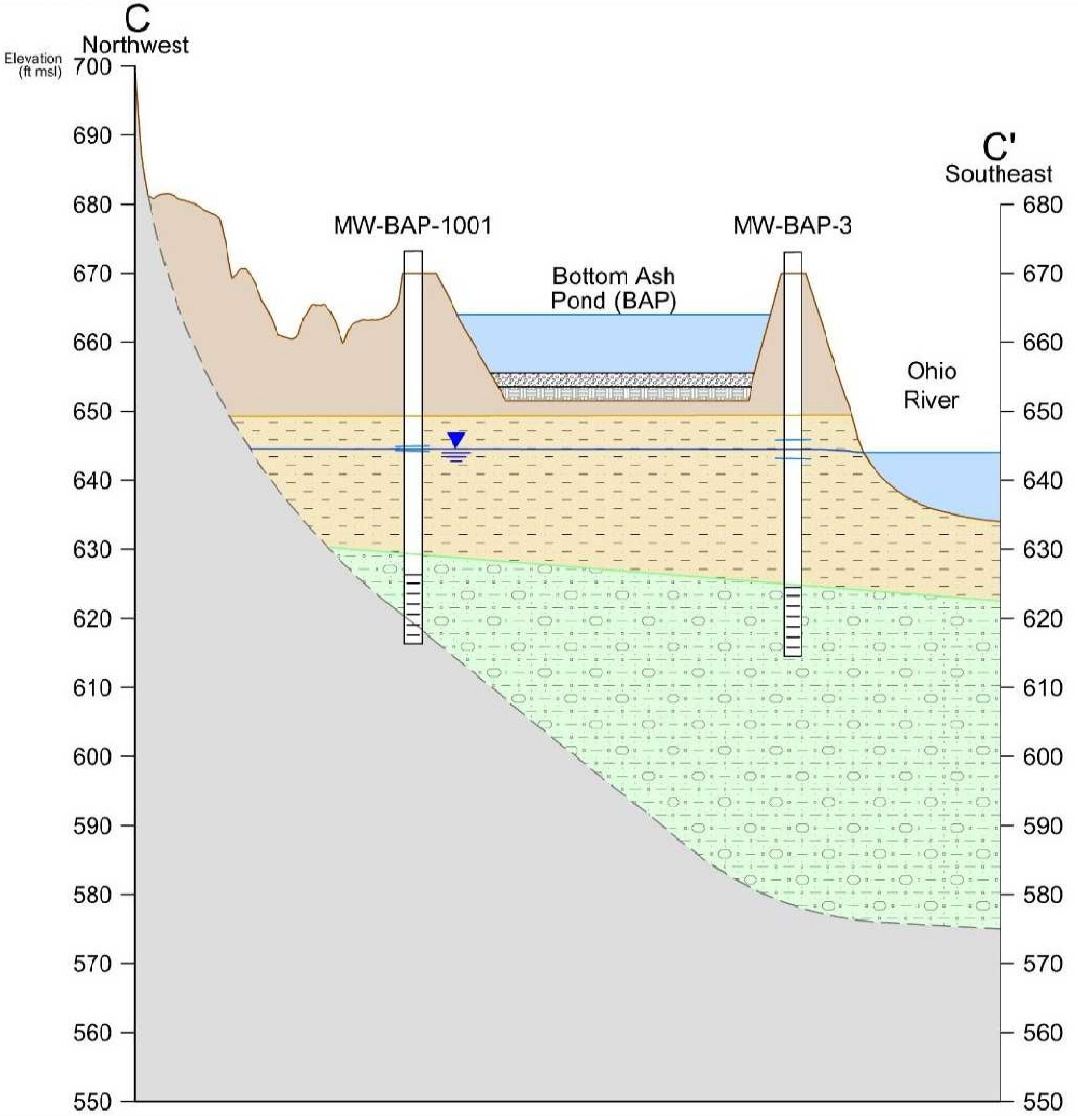
Horizontal Scale
0' 87.5' 175' 350'

Vertical Exaggeration: 10x



Geologic Cross-Section B - B'

Cox-Colvin (2022)



Legend

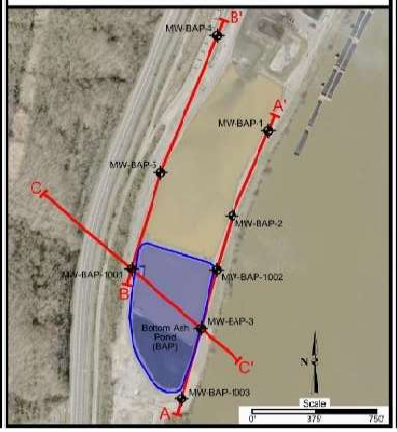
- Fill
- Alluvium (Sil/Clay)
- Glacial Outwash
- Bedrock
- Monitor Well
- Typical Groundwater Leve
- Range of Observed Groundwater Elevations
- Line of Geologic Cross Section

Source of Aerial Photography: OGRIP, 2020.

Horizontal Scale

0' 90' 180' 360'

Vertical Exaggeration: 10x



Geologic Cross-Section C - C'

Cox-Colvin (2022)

APPENDIX B
Boring Core Logs

EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

SAMPLING DATA

 - Blocked-in "SAMPLES" column indicates sample was attempted and recovered within this depth interval.

 - Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches. Addition of one of the following symbols indicates the use of a split-barrel other than the 2" O.D. sampler:

2S - 2½"O.D. split-barrel sampler

3S - 3" O.D. split-barrel sampler

P - Shelby tube sampler, 3" O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2" - Number of blows (50) to drive a split-barrel sampler a certain number of inches (2), other than the normal 6-inch increment.

S/D - Split-barrel sampler (S) advanced by weight of drill rods (D),

S/H - Split-barrel sampler (S) advanced by combined weight of rods and drive hammer (H).

SOIL DESCRIPTIONS

All soils have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor components as follows:

Adjective	Percent by Weight
trace	1 to 10
little	11 to 20
some	21 to 35
"and"	36 to 50

The following terms are used to describe density and consistency of soils:

Term (Granular Soils)	Blows per foot
Very-loose	Less than 5
Loose	5 to 10
Medium-dense	11 to 30
Dense	31 to 50
Very-dense	Over 50

Term (Cohesive Soils)	Qu (tsf)
Very-soft	Less than 0.25
Soft	0.25 to 0.5
Medium-stiff	0.5 to 1.0
Stiff	1.0 to 2.0
Very-stiff	2.0 to 4.0
Hard	Over 4.0

LOG OF BORING NO. MW-BAP-3
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 819,111, E. 2,513,519 ELEVATION: 669.9 DATE: 11/11/15 - 11/12/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 55.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N 60	SAMPLE REC.-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT — LIQUID LIMIT)	TEST RESULTS
	0						AGGREGATE - 12 INCHES	10 20 30 40	
668.9		1		20/12/10	28	87	FILL: Medium-dense to dense gray and brown fine to coarse gravel, some to "and" fine to coarse sand, little to some silt or silty clay (variers), contains pockets of fine to coarse sand, dry.		H=3.5
		2		10/13/18	39	80			H=4.0
	5	3		10/14/20	43	67			
		4		3/22/13	44	100			
661.4		5		9/11/9	25	67			
659.9		6		3/10/13	29	100	FILL: Hard gray and brown silty clay, some fine to coarse and, little fine to coarse gravel, damp.		H=4.5+
	10	7		11/27/30	71	67	FILL: Very-dense fine to coarse black and gray sand, some fine to coarse gravel, damp.		
658.4		8		6/6/9	19	100	FILL: Very-stiff brown silty clay, some to "and" fine to coarse sand, some fine to coarse gravel, damp.		H=3.5
655.4		9		6/14/14	35	87			H=3.5-4.0
	15	10		4/5/6	14	80	FILL: Loose to medium-dense brown fine to coarse gravel, some to "and" fine to coarse sand, some silty clay, damp to moist.		
		11		6/6/5	14	80	- Contains zones of hard silty clay at 16.0'.		H=4.5
		12		2/4/6	13	93			
649.4	20	13		1/4/2	8	67			
		14		2/3/4	9	53	Medium-stiff to stiff brown clayey silt, "and" fine to coarse sand, some fine to coarse gravel, wet.		H=1.0-2.0
647.3		15A		2/2/3	6	100			H=0.5
		15B					Loose gray fine to medium sand, trace coarse sand, trace fine gravel, little silt, wet.		
		16		1/3/1	5	100			
644.4	25								
		17		1/1/SH	0	100	Very-loose gray silt, little fine to medium sand, wet.		
641.9									
		18		1/2/	8	100	Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine		H=1.0-1.5
	30								

WATER LEVEL: 28.2
WATER NOTE: Inside Well
DATE: 12/11/15

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. (See Separate Curves)
E - Penetrometer (tsf), W - Unit Dry Wt (pcf), D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME
ATV 550-2

JOB: 7217-15-007B

-CONTINUED-

PLATE 7

2010 NEW DEFAULT BORING LOG-W/ N60

LOG OF BORING NO. MW-BAP-3
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 819,111, E. 2,513,519 ELEVATION: 669.9 DATE: 11/11/15 - 11/12/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 55.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC.-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT — LIQUID LIMIT; 10 20 30 40)	TEST RESULTS
	30						sand seams and roots, wet.		
		19		1 / 2 / 2	5	100	Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine sand seams and roots, wet.		
		20		SH / 2 / 1	4	100			
634.4	35								
		21		SH / 2 / 1	4	100	Soft to medium-stiff dark-brown mottled with gray slightly organic to organic clayey silt, some to "and" fine to medium sand, wet.		
		22		SH / 1 / 2	4	100			
629.4	40								
		23		SH / 2 / 1	4	100	Soft to medium-stiff gray mottled with brown silty clay, trace to some fine to coarse sand, slightly organic, contains fine sand seams, wet.		
		24		SH / 4 / 7	14	100			
624.9	45						Medium-dense to very-dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.		
		25		6 / 11 / 17	35	80	- Contains zones of fine to coarse sand at 49.0'.		
		26		22 / 35 / 25	75	53			G
	50								
		27		21 / 8 / 8	20	33			
614.9	55						- Encountered seepage at 16.0'. - Encountered water at 20.5'. - Borehole converted to monitoring well upon completion - See separate well completion diagram. - Datum: Ohio State Plane South. NAD		
	60								

WATER LEVEL: ▽ 28.2 ▼
WATER NOTE: Inside Well
DATE: 12/11/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. (See Separate Curves)

H - Penetrometer (tsf), W - Unit Dry Wt (pcf), D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME ATV 550-2

JOB: 7217-15-007B

-CONTINUED-

PLATE 8

2010 NEW DEFAULT BORING LOG-W/ N60

LOG OF BORING NO. MW-BAP-3
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 819,111, E. 2,513,519 ELEVATION: 669.9 DATE: 11/11/15 - 11/12/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 55.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT — LIQUID LIMIT)	TEST RESULTS
	60						27/NAVD 29 (Plant Grid).	10 20 30 40	
	65								
	70								
	75								
	80								
	85								
	90								

WATER LEVEL: ▽ 28.2 ▼

WATER NOTE: Inside Well

DATE: 12/11/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. } See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME
ATV 550-2

JOB: 7217-15-007B

PLATE 9

2010 NEW DEFAULT BORING LOG-W N60

LOG OF BORING NO. MW-BAP-5
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 820,052, E. 2,513,277 ELEVATION: 669.2 DATE: 11/24/15 - 11/25/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 62.5'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						AGGREGATE - 12 INCHES	
668.2		1		6/8/11	24	60	FILL: Medium-dense brown fine to coarse sand, some fine to coarse gravel, some to "and" silty clay, dry.	
		2		16/5/5	13	60		
663.7	5	3		4/4/6	13	73		G
		4		5/9/32	51	87	FILL: Hard gray and brown silty clay, "and" fine to coarse sand, little to some fine to coarse gravel, damp.	H=4.5
660.7		5		16/15/16	39	80		H=4.5
659.2	10	6		10/13/11	30	87	FILL: Medium-dense brown and gray fine to coarse sand, little fine to coarse gravel, some silty clay, damp.	
				P			FILL: Hard brown silty clay, some fine to coarse sand, some fine to coarse gravel (shale fragments), damp.	H=4.5
655.7		7		3/5/10	19	80		H=4.5
		8		10/11/25	45	80	FILL: Medium-dense to dense brown fine to coarse gravel, some fine to coarse sand, some silty clay becoming trace silt at bottom of stratum, damp.	H=3.0
	15	9		11/7/6	16			
652.3		10A		4/6/10	20	100	Medium-stiff to stiff gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, few silt seams, slightly organic, moist.	
		10B		P				
	20	11		SH/1/3	5	100		G=0.5-1.25
646.2								
		12		2/2/4	8	100	Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp.	H=3.5
	25			P				
				P				
	30							

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

WATER LEVEL: 27.1
WATER NOTE: Inside Well
DATE: 12/15/15

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation, C - Uncon Comp, T - Triax Comp, C - Consol. (See Separate Curves)
H - Penetrometer (tsf), W - Unit Dry Wt (pcf), D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME
ATV 550-2

JOB: 7217-15-007B

-CONTINUED-

PLATE 12

2010 NEW DEFAULT BORING LOG-W/ N60

LOG OF BORING NO. MW-BAP-5
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 820,052, E. 2,513,277 ELEVATION: 669.2 DATE: 11/24/15 - 11/25/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 62.5'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT (PLASTIC LIMIT / LIQUID LIMIT) 10 20 30 40	TEST RESULTS
	30						Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp.		
		13		2 / 4 / 6	13	100			H=2.0-3.5
		14		3 / 4 / 5	11	100			H=2.5-3.0
	35								
		15		2 / 5 / 6	14	100			H=2.5
		16		2 / 3 / 5	10	100			H=2.5
	40								
		17		SH / 2 / 3	6	100			H=1.25
		18		SH / SH / SH	0	100			H=1.25
623.7	45						Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp.		
		19		SH / SH / 1	0	100			H=0.75
621.2							Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp.		
		20		SH / SH / SH	0	100			H=0.75-1.25
618.7	50						Medium-dense to dense fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.		
		21		6 / 9 / 9	23	87			G
		22		8 / 21 / 34	69	87			
613.8	55						Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.		
		23		14 / 20 / 14	43	80			
		24		7 / 12 /	35	60			G
	60								

WATER LEVEL: 27.1
WATER NOTE: Inside Well
DATE: 12/15/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. (See Separate Curves)

H - Penetrometer (tsf), W - Unit Dry Wt (pcf), D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME ATV 550-2

JOB: 7217-15-007B

-CONTINUED-

PLATE 13

2010 NEW DEFAULT BORING LOG-W/ N60

LOG OF BORING NO. MW-BAP-5
BOTTOM ASH POND MONITORING WELL INSTALLATION
CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: N. 820,052, E. 2,513,277 ELEVATION: 669.2 DATE: 11/24/15 - 11/25/15

DRILLING METHOD: 4-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 62.5'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT — LIQUID LIMIT)	TEST RESULTS
	60							10 20 30 40	
606.7		25	■	8 / 4 / 16 / 5	11	60	Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.		
	65						- Encountered water at 17.0'. - Borehole converted to monitoring well upon completion. See separate well completion diagram. - Boring location and elevation surveyed by AEP. - Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid).		
	70								
	75								
	80								
	85								
	90								

2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ 27.1 ▼
WATER NOTE: Inside Well
DATE: 12/15/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. } See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME ATV 550-2

JOB: 7217-15-007B

PLATE 14

TEST BORING LOG

PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

BORING	**MW-BAP-1001**
G.S. ELEV.	670.31
FILE	415532
SHEET	1 OF 2

GROUNDWATER DATA			
FIRST ENCOUNTERED NR			
DEPTH	HOUR	DATE	ELAPSED TIME

METHOD OF ADVANCING BOREHOLE				
d	FROM	0.0 '	TO	52.3 '

DRILLER	HAD
HELPER	
INSPECTOR	K. FOWLER
DATE STARTED	01/06/2021
DATE COMPLETED	01/06/2021

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
5	S-1	2 2 4 6		***Sandy Fill**, hydroexcavated from 0-5 feet*		
				7.0 663.3		
	S-2	4 8 6 6				
10	S-3	3 9 9 6		***Light brown, brown and gray Silty Clay**, stiff to very stiff, dry*		
	S-4	7 4 5 7				
15	S-5	2 4 6 4		15.0 655.3		
	S-6	2 3 3 3		***Brown and gray Sand and Rock Fragments**, loose to medium dense, wet*		
	S-7	40 22 8 6				
20	S-8	4 7 4 3		21.0 649.3		
	S-9	3 3 5 8				
25	S-10	2 6 4 6				
	S-11	2 6 4 6		***Brown and light brown Clayey Silt**, some rock fragments, soft to stiff, damp to moist*		
	S-12	1 2 2 5			23.6	mottled from 29 feet to 31 feet with some black organics
30	S-13	1 2 2 2				
	SH-14			33.0 637.3	23.8	
35	S-15	1 2 2 4		***Black and greenish gray Lean Clay**, soft to medium stiff, dry, (CL)*		

DRN.	SAP
CKD.	SDM

NEW PROJECTS TEST BORING LOG 415532_CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT.GDT 3/8/21

TEST BORING LOG

BORING	**MW-BAP-1001**
G.S. ELEV.	670.31
FILE	415532
SHEET	2 OF 2

PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
	SH-16			***Black and greenish gray Lean Clay, soft to medium stiff, dry, (CL)***	28	some gravel from 37 feet to 39 feet
	S-17	2 3 3 4			27.1	
40	SH-18			41.0 629.3		
	S-19	1 1 2 2		***Gray Silty Sand, with clay, some organics, very soft to soft (SM)***		some organics from 43 feet to 45 feet
45	S-20	WH WH 1 3		45.0 625.3		
	S-21	WH WH WH 2		***Greenish gray Silty Sandy Clay, organics, very soft to medium stiff, dry***		
	S-22	2 2 3 3				
50	S-23	1 3 2 1		51.0 619.3		
	S-24	16 25 50/0.3		***Sandstone*** 52.3 618.0		Monitoring well installed at boring completion; see monitoring well installation log
				END OF BORING AT 52.3'		
55						
60						
65						
70						
75						

NEW PROJECTS TEST BORING LOG 415532_CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT GCT 3/8/21

TEST BORING LOG

PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

BORING	**MW-BAP-1002**
G.S. ELEV.	670.06
FILE	415532
SHEET	1 OF 2

GROUNDWATER DATA			
FIRST ENCOUNTERED NR			
DEPTH	HOUR	DATE	ELAPSED TIME

METHOD OF ADVANCING BOREHOLE				
d	FROM	0,0 '	TO	54,0 '

DRILLER	HAD
HELPER	
INSPECTOR	K. FOWLER
DATE STARTED	01/05/2021
DATE COMPLETED	01/06/2021

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
				Sandy Fill, hydroexcavated from 0-5 feet		
5				5.0 / 665.1		
	S-1	2 7 11 11		***Brown and gray Sand, with clay and gravel, medium dense, dry (FILL)***		
	S-2	4 7 7 9		9.0 / 661.1		
10	S-3	5 20 14 9				
	S-4	6 9 9 13				
15	S-5	9 9 8 9				orange mottling from 15 feet to 19 feet
	S-6	5 3 3 4				
	S-7	1 1 3 3				organics present from 19 feet to 21 feet. slight odor from 19 feet to 21 feet.
20	S-8	1 1 3 1		***Orange Clayey Silt, some rock fragments, very soft to very stiff, dry to wet (ML)***		
	S-9	2 2 2 2			27.5	
25	SH-10					
	S-11	1 1 2 3			26.3	
	SH-12					
30	S-13	1 1 1 1			42.5	
	SH-14			33.0 / 637.1		
35	S-15	WH WH WH WH		***Gray and brown Sand very loose to dense, moist to wet (SW)***		

DRN.	SAP
CKD.	SDM

NEW PROJECTS TEST BORING LOG 415532_CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT GCT 3/8/21

TEST BORING LOG

PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

BORING	**MW-BAP-1002**
G.S. ELEV.	670.06
FILE	415532
SHEET	2 OF 2

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
	S-16	1 1 1 1				
	S-17	1 3 5 5				
40	S-18	1 2 1 2				
	S-19	5 8 11 13				
45				***Gray and brown Sand very loose to dense, moist to wet (SW)***		
50	S-20	2 5 8 10				Coarse gravel from 49.5 feet to 50 feet
	S-21	11 9 10 8				Monitoring well installed at boring completion; see monitoring well installation log
	S-22	7 12 10 9				
55				55.0 615.1 ***END OF BORING AT 55'***		
60						
65						
70						
75						

NEW PROJECTS TEST BORING LOG 415532 CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT.GDT 3/8/21

TEST BORING LOG

PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

BORING	**MW-BAP-1003**
G.S. ELEV.	670.08
FILE	415532
SHEET	1 OF 2

GROUNDWATER DATA			
FIRST ENCOUNTERED NR			
DEPTH	HOUR	DATE	ELAPSED TIME

METHOD OF ADVANCING BOREHOLE				
d	FROM	0.0 '	TO	55.0 '

DRILLER	HAD
HELPER	
INSPECTOR	K. FOWLER
DATE STARTED	01/04/2021
DATE COMPLETED	01/05/2021

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
				Sandy Fill, hydroexcavated from 0-5 feet		
5				5.0		
	S-1	4 3 2 4		***Brown Clay, and rock fragments, medium stiff (FILL)*** 7.0		
	S-2	2 2 3 5		***Brown and gray Clayey Silt, medium stiff to very stiff, dry***		
10	S-3	7 6 8 11		11.0		
	S-4	8 50/0.5		***Brown Shale Rock Fragments with clay, stiff to hard, dry***		
15	S-5	7 7 5 6		15.0		
	S-6	1 1 5 5		***Gray and brown Silty Clay, medium stiff to stiff, dry***		
	S-7	1 3 3 4		19.0		wood organics from 19 feet to 21 feet
20	S-8	1 2 2 5				
	SH-9				25.1	
25	S-10	1 4 4 7		***Dark gray Silt, with wood organics, low plasticity, soft to stiff, dry to moist (ML/OL)***	28.9	
	SH-11				30.9	
	S-12	3 4 5 6				
30	SH-13			31.0	43.6	
	S-14	WH WH WH WH		***Gray and light brown Lean Clay, very soft, damp to moist***		
35	S-15	WH WH WH WH		35.0		

DRN.	SAP
CKD.	SDM

NEW PROJECTS TEST BORING LOG 415532_CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT GDT 3/8/21

TEST BORING LOG

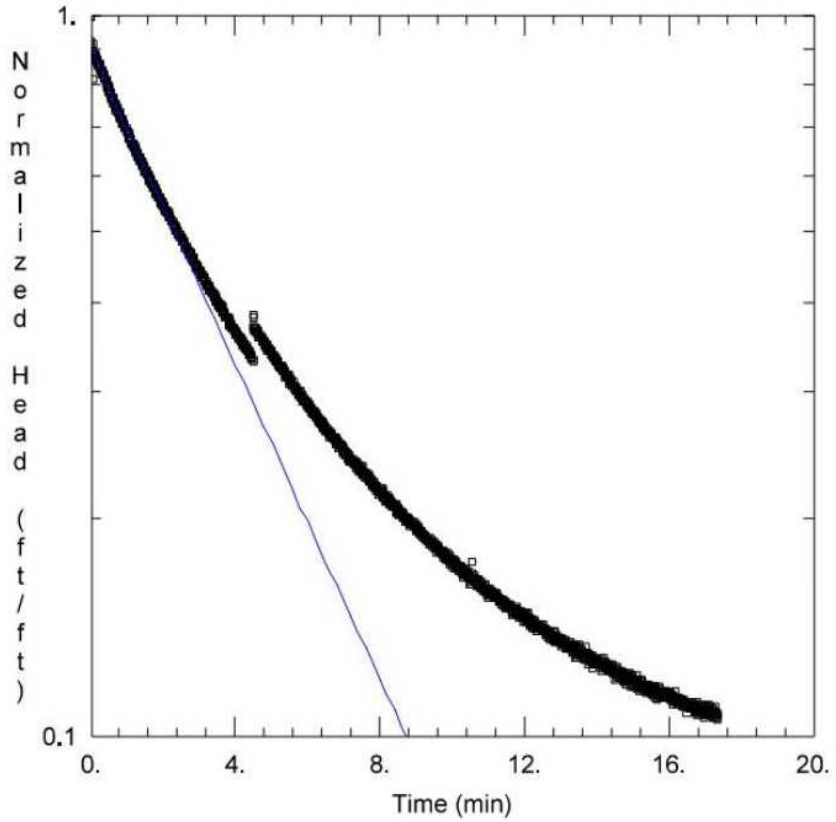
PROJECT: CARDINAL BOTTOM ASH POND WELL INSTALLATION
LOCATION: BRILLIANT, OH

BORING	**MW-BAP-1003**
G.S. ELEV.	670.08
FILE	415532
SHEET	2 OF 2

DEPTH	A	B	C	DESCRIPTION	Wn	REMARKS
	S-16	1 2 2 4				
	S-17	9 12 8 9				
40	S-18	10 17 16 20				
	S-19	10 15 12 20				
45	S-20	8 12 15 16		***Light brown Sand, fine to coarse grained, loose to dense, moist to wet***		
	S-21					
	S-22	10 11 13 10				
50	S-23	10 16 19 20				
	S-24	10 16 15 20				Monitoring well installed at boring completion; see monitoring well installation log
55	S-25	9 14 16 16		55.0		
				END OF BORING AT 55'		
60						
65						
70						
75						

NEW PROJECTS TEST BORING LOG 415532_CARDINAL BOTTOM ASH POND WELL INSTALLATION.GPJ SITE BLAUVELT GDT 3/8/21

APPENDIX C
Slug Test Results



WELL TEST ANALYSIS

Data Set: C:\...\MW-BAP-1001 (ft-day).aqt
Date: 04/09/21 Time: 15:41:07

PROJECT INFORMATION

Company: Hull
Test Well: MW-BAP-1001
Test Date: 3-19-2021

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

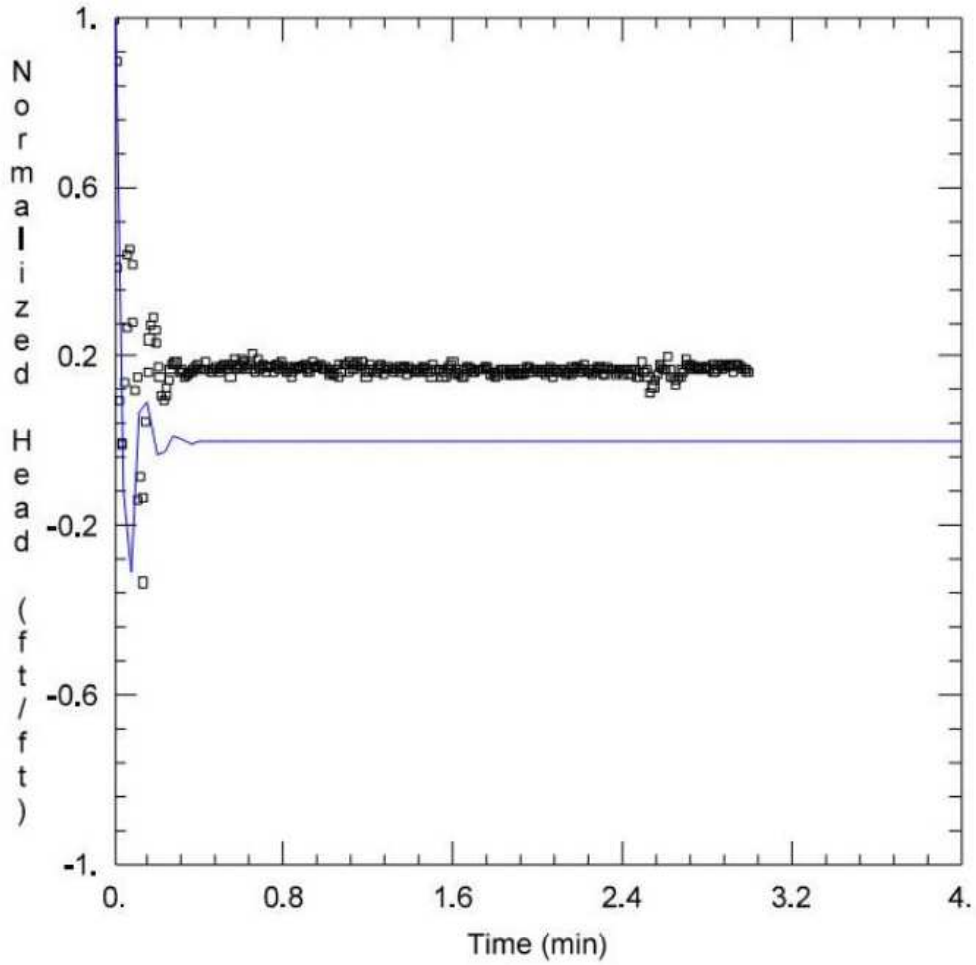
WELL DATA (MW-BAP-1001)

Initial Displacement: 2.898 ft
Total Well Penetration Depth: 54. ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.65 ft
Screen Length: 10. ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 0.6606 ft/day y0 = 2.597 ft



WELL TEST ANALYSIS

Data Set: C:\...\MW-BAP-1002 (ft-day).aqt
Date: 04/09/21 Time: 15:42:13

PROJECT INFORMATION

Company: Hull
Test Well: MW-BAP-1001
Test Date: 3-19-2021

AQUIFER DATA

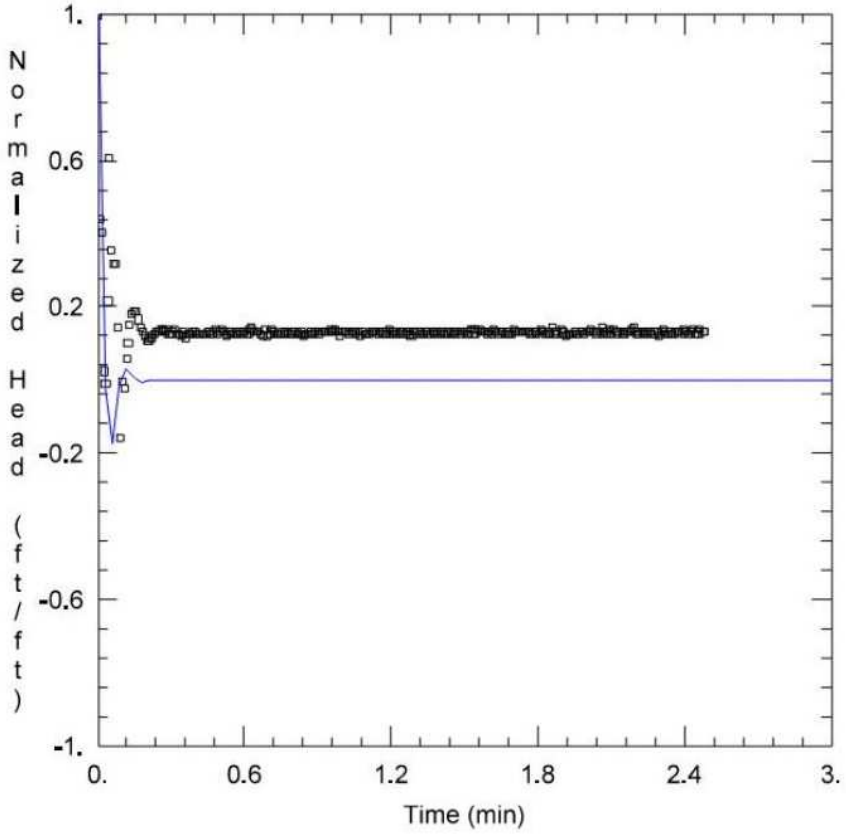
Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-BAP-1002)

Initial Displacement: 0.503 ft
Total Well Penetration Depth: 55. ft
Casing Radius: 0.08 ft
Static Water Column Height: 25.2 ft
Screen Length: 15. ft
Well Radius: 0.08 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Butler
K = 836.4 ft/day
Le = 8.523 ft



WELL TEST ANALYSIS

Data Set: C:\...\MW-BAP-1003 (ft-day).aqt
Date: 04/09/21 Time: 15:41:25

PROJECT INFORMATION

Company: Hull
Test Well: MW-BAP-1001
Test Date: 3-19-2021

AQUIFER DATA

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

WELL DATA (MW-BAP-1003)

Initial Displacement: 0.618 ft
Total Well Penetration Depth: 55. ft
Casing Radius: 0.08 ft
Static Water Column Height: 24.94 ft
Screen Length: 15. ft
Well Radius: 0.08 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Butler
K = 797.6 ft/day
Le = 4.319 ft

APPENDIX D
Monitoring Well Construction Data

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
673.26	-3.33	Top of Cover
672.84	-2.91	Top of PVC
669.93	0.0	Ground Surface
667.4	2.5	Top of Grout
632.5	37.4	Top of Bentonite
626.5	43.4	Top of Filter Pack
624.5	45.4	Top of Screen Openings
614.5	55.4	Bottom of Screen Openings
613.9	56.0	Bottom of Well
613.9	56.0	Bottom of Boring

(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

8 " 0.0 to 56.0

" to

" to

Grout: Portland & Quick Gel

Bentonite Seal: 3 - 5 gallon buckets (15 gal) bentonite pellets

10 - Slot Screen

Filter Pack: 5 - 50 lb. bags (250 lb.) #5 quartz sand

Depth to Static Water:	28.2	28.0	28.2		
Static Water Elevation:	638.8	639.1	638.8		
Date:	11/29/15	12/8/15	12/11/15		

Well Development:

11/17 - Bailed 62.5 gallons of water (approx. 15 well volumes) out of well via submersible pump, water level stayed steady.
-Water level measurement on 12/8 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

Cumulative Gallons	NTU	C	ms/cm	PH	ORPmV
62.5	4.7	18.09	0.7	6.92	50

Location: N, 819,112.0' E, 2,513,519.4'
Datum: NAD27/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

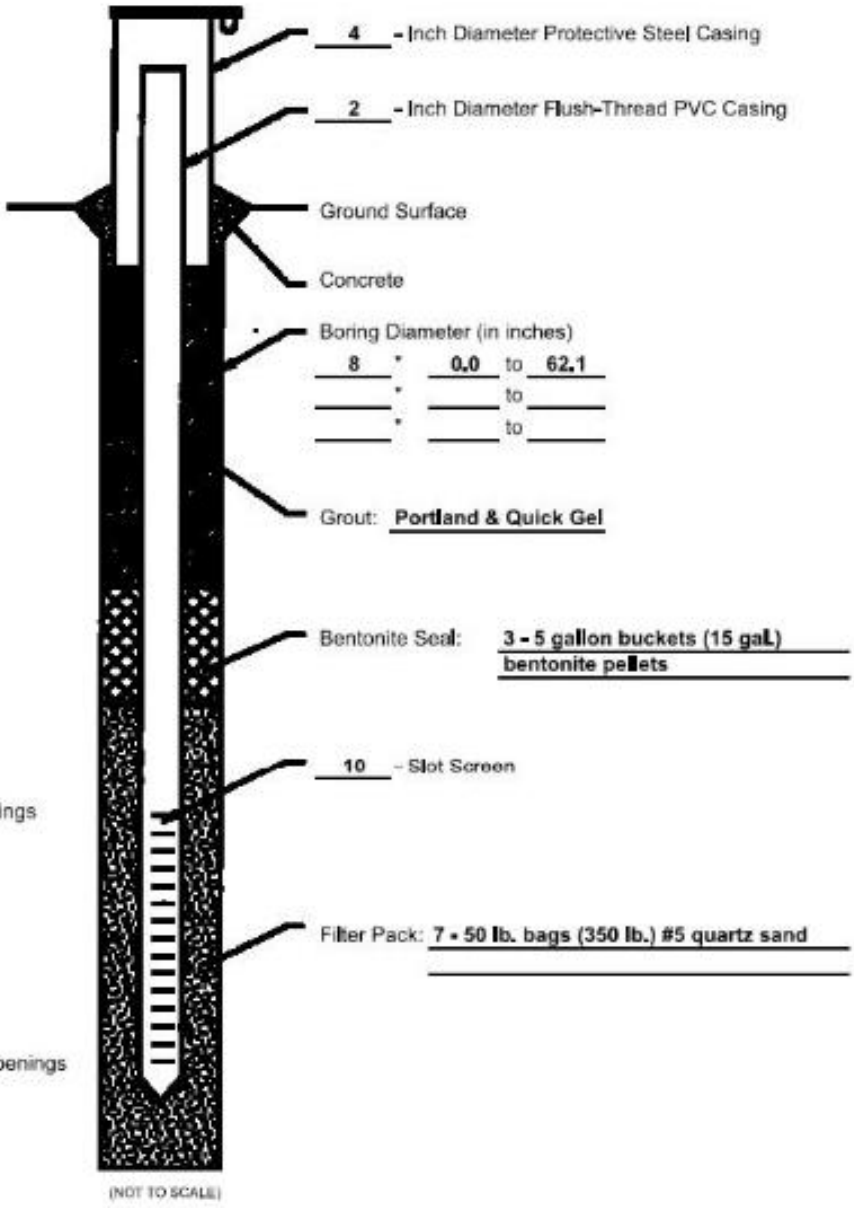
Project Number:
7217-15-007A

Boring Number:
MW-BAP-3

Date Well Installed:
11/13/2015

S&ME

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
672.28	-3.10	Top of Cover
672.00	-2.82	Top of PVC
669.18	0.0	Ground Surface
662.6	6.6	Top of Grout
625.0	44.2	Top of Bentonite
619.5	49.7	Top of Filter Pack
617.5	51.7	Top of Screen Openings
607.7	61.5	Bottom of Screen Openings
607.1	62.1	Bottom of Well
606.7	62.5	Bottom of Boring



Depth to Static Water:	27.3	27.6	27.2	27.1	
Static Water Elevation:	639.1	638.8	639.2	639.2	
Date:	**11/29/15**	**12/7/15**	**12/11/15**	**12/15/15**	

Well Development:

12/10 - Bailed 61.5 gallons of water (approx. 13 well volumes) out of well via submersible pump, water level stayed steady.
-Measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

Cumulative Gallons	NTU	C	ms/cm	PH	ORPmV
61.5	24.3	15.08	1.46	6.86	-56

Location: N, 820,052.1' E, 2,513,277.5'
Datum: NAD27/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

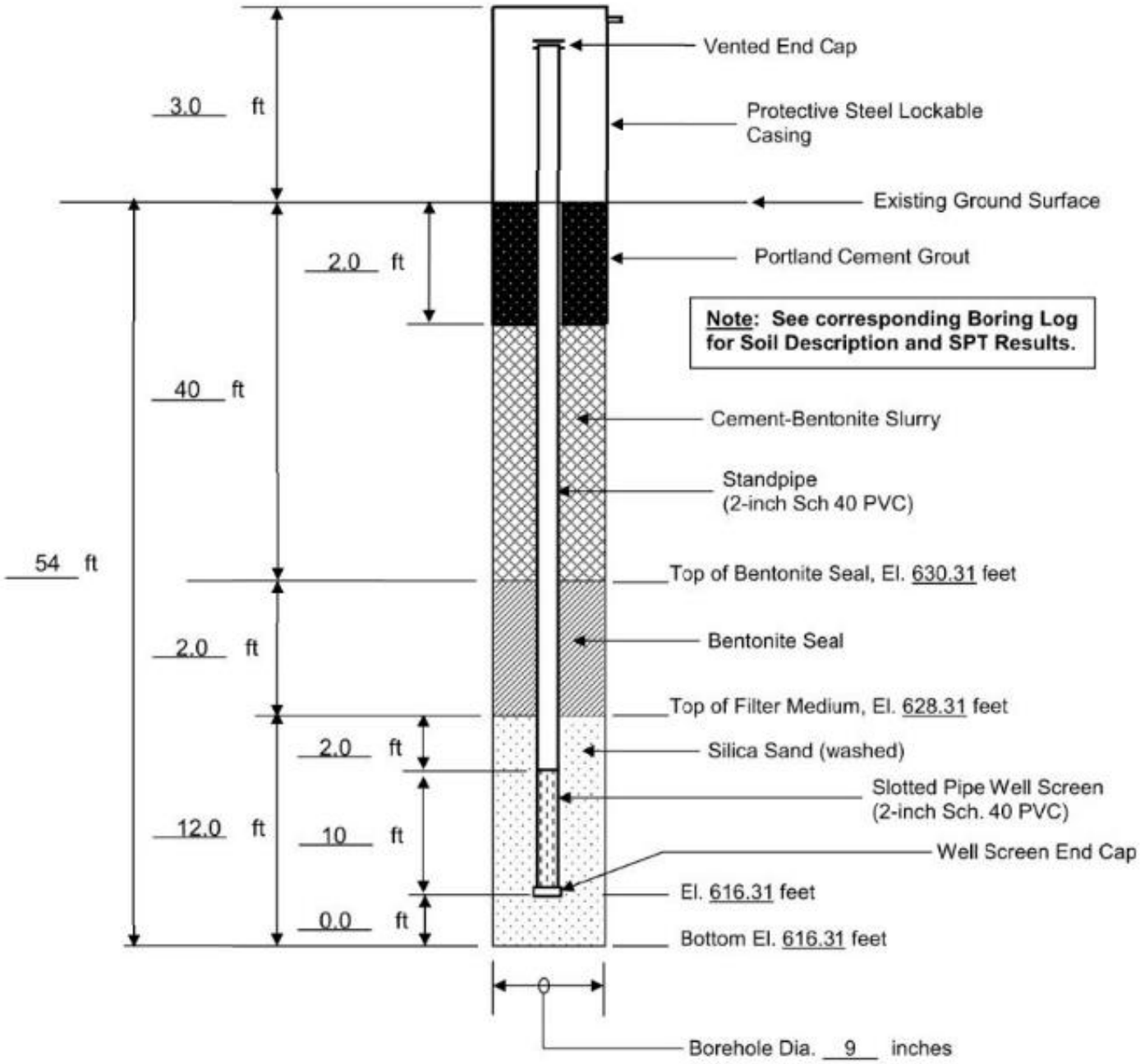
Boring Number:
MW-BAP-5

Date Well Installed:
11/25/2015

MONITORING WELL INSTALLATION LOG

Date Started: 1/6/2021	Date Completed: 1/6/2021
Coordinate: 819474.75 / 2513096.16	TOC Elev: 673.34
Driller: HAD	Field Inspector: Kenton Fowler

Well Number	MW-BAP-1001
G.S Elev	670.31
Sheet 1	of 1



Remarks: 10 ft long screen used due to location of clay organic layer.

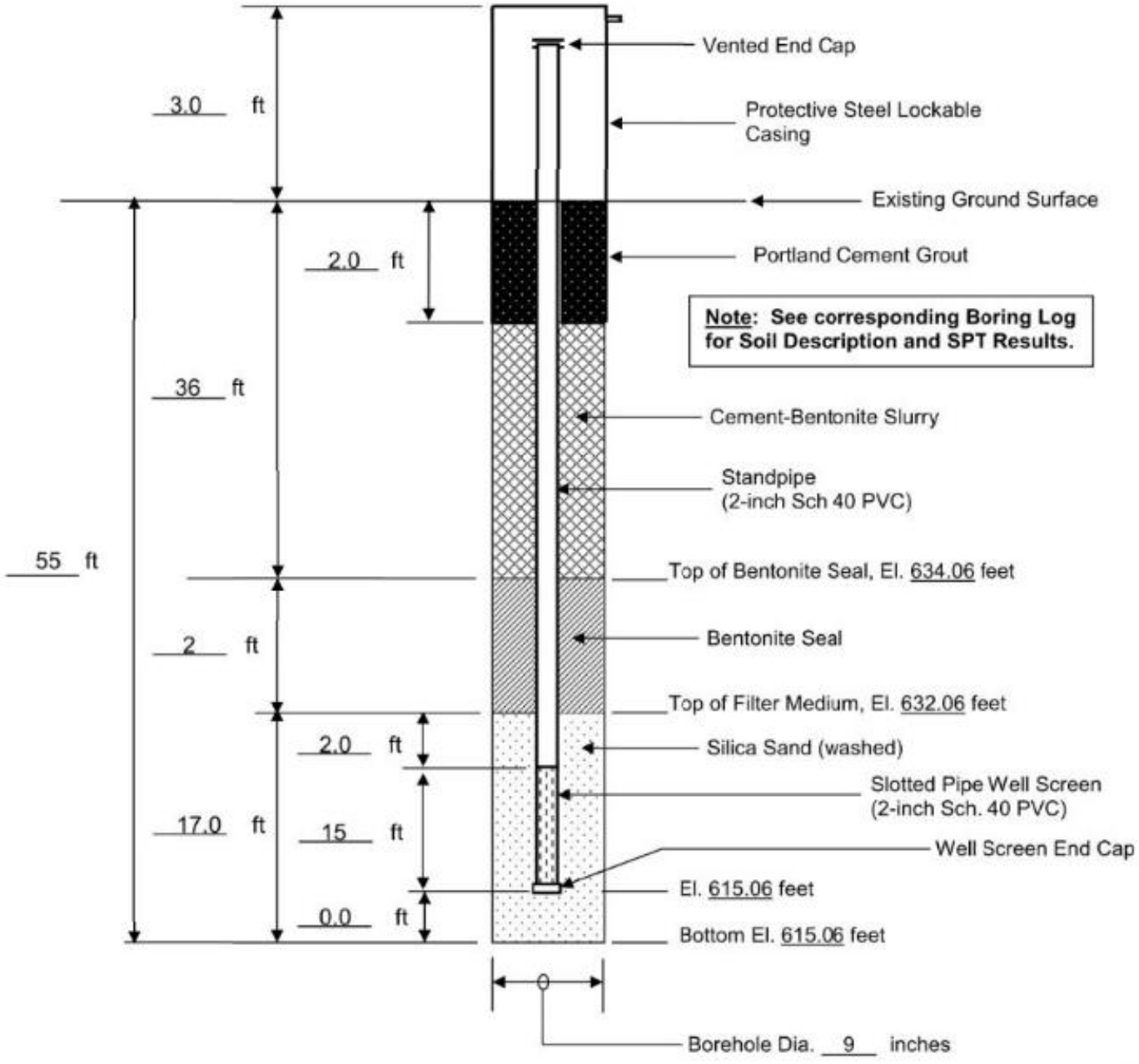
Horizontal Datum: NAD 27 Ohio State Plane (South Zone)

Vertical Datum: NGVD 29

Buckeye Power Inc.
Cardinal BAP Monitoring Well Install
Brilliant, Ohio
Drawing Not to Scale

MONITORING WELL INSTALLATION LOG

Date Started: 1/5/2021 Date Completed: 1/6/2021	Well Number MW-BAP-1002
Coordinate: 819468.12 / 2513611.82 TOC Elev: 673.15	G.S Elev 670.06
Driller: HAD Field Inspector: Kenton Fowler	Sheet 1 of 1



Remarks:

Horizontal Datum: NAD 27 Ohio State Plane (South Zone)

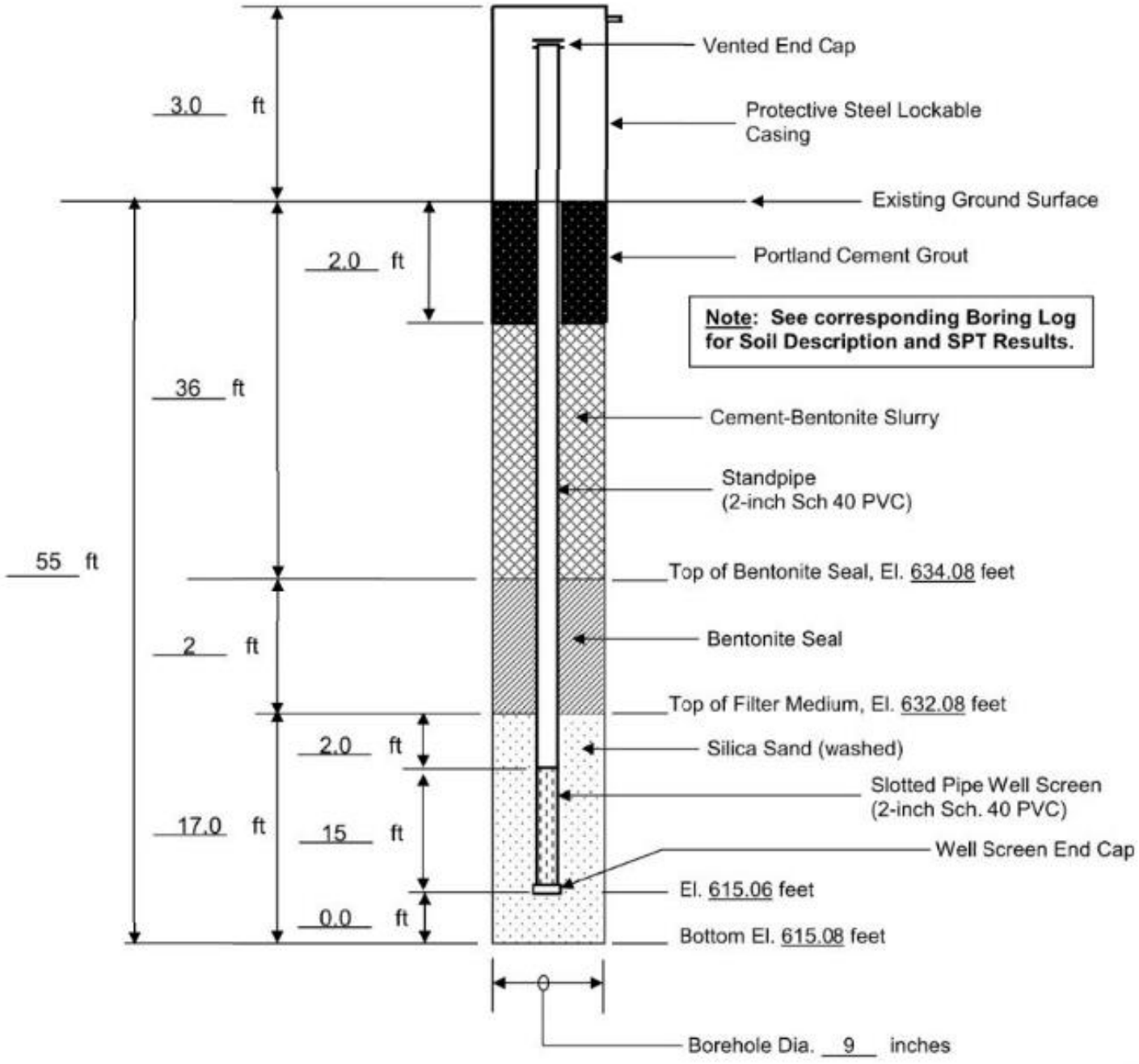
Vertical Datum: NGVD 29

Buckeye Power Inc.
Cardinal BAP Monitoring Well Install
Brilliant, Ohio
Drawing Not to Scale

MONITORING WELL INSTALLATION LOG

Date Started: 1/4/2021	Date Completed: 1/5/2021
Coordinate: 818691.63 / 2513400.83	TOC Elev: 672.87
Driller: HAD	Field Inspector: Kenton Fowler

Well Number	MW-BAP-1003
G.S Elev	670.08
Sheet	1 of 1



Remarks:

Horizontal Datum: NAD 27 Ohio State Plane (South Zone)

Vertical Datum: NGVD 29

Buckeye Power Inc.
Cardinal BAP Monitoring Well Install
Brilliant, Ohio
Drawing Not to Scale