2021 Annual Groundwater Monitoring Report for Bottom Ash Pond (BAP) -Rev.1 Cardinal Operating Company – Cardinal Plant 306 County Road 7E Brilliant, Ohio

January 27, 2022

Revised March 3, 2022

Submitted to:

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Cox-Colvin
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March 3, 2022

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio 43913

Subject: Bottom Ash Pond CCR 2021 Annual Groundwater Report – Revision 1

The original 2021 Annual Groundwater Report for the Bottom Ash Pond was uploaded to the Operating Record on January 31st, 2022 and uploaded to the publicly available CCR Compliance Data and Information Site on March 1st, 2022.

The Groundwater Protection Standards in Table 4 - 5 incorrectly identified the GWPS for Fluoride as 6.6 mg/l, when the actual limit is 4 mg/l. Table 4-5 has been revised in this report to reflect the 4 mg/l limit.

Any additional questions, please contact CCRQuestions@ohioec.org

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Executive Summary

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2021 Annual Groundwater Monitoring Report (Report) for the Bottom Ash Pond (BAP), an existing coal combustion residual (CCR) unit at the Cardinal Plant in Brilliant, Ohio. This report has been prepared in accordance with §257.90(e) of the Federal Coal Combustion Residuals Rules ("CCR Rules", 40 CFR Subpart D), which requires owners and/or operators of existing CCR landfills and surface impoundments to prepare a groundwater monitoring and corrective action report no later than January 31, annually. This report summarizes groundwater monitoring activities conducted pursuant to the CCR Rules from January 1, 2021, through December 31, 2021.

During 2021 groundwater monitoring, statistically significant increases (SSIs) above background concentrations were observed for the following constituents and wells:

- Boron: MW-BAP-1, MW-BAP-2, MW-BAP-3
- Chloride: MW-BAP-1, MW-BAP-2, MW-BAP-3
- Fluoride: MW-BAP-1, MW-BAP-2
- pH: MW-BAP-1, MW-BAP-2
- Sulfate: MW-BAP-1, MW-BAP-3
- TDS: MW-BAP-3

Additionally, a statistically significant decrease (SSD) of pH below background levels was observed at MW-BAP-3.

In accordance with §257.95 of the CCR Rules, assessment monitoring at the BAP was initiated in May 2018 after an SSI over groundwater background levels was first detected. The BAP was operating under the assessment monitoring program (§257.95 of the CCR Rules) at the start of the 2021 annual reporting period and remained in the assessment monitoring program throughout the 2021 annual reporting period.

Statistical evaluations of two assessment monitoring events were completed during this annual reporting period – the second semiannual event of 2020 (October 2020)[1] and the first semiannual event of 2021 (April 2021). These evaluations identified no statistically significant levels (SSLs) above groundwater protection standards (GWPSs). As such, no corrective actions are necessary.

[1] Although samples were collected in October 2020, evaluation of the laboratory results was performed in 2021 and discussion of the evaluation is, therefore, included in this annual report. The October 2020 sampling results were included in the 2020 Annual Groundwater Monitoring Report.

1.0 Introduction

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2021 Annual Groundwater Monitoring Report for the Bottom Ash Pond (BAP) at the Cardinal Plant in Brilliant, Ohio (Figure 1-1, Site). This report has been prepared in accordance with §257.90(e) of the Federal Coal Combustion Residuals Rule ("CCR Rules", 40 CFR Subpart D), which requires owners and/or operators of existing CCR landfills and surface impoundments to prepare a groundwater monitoring and corrective action report no later than January 31, annually. This report summarizes groundwater monitoring activities conducted pursuant to the CCR Rule from January 1, 2021, through December 31, 2021.

1.1 Site Summary

The Site is located one mile south of Brilliant, Ohio in Jefferson County and is operated by Cardinal Operating Company (Cardinal). Located along the Ohio River, the generating station consists of three coal-powered units with an 1,800-megawatt (MW) capacity. Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. Each generating unit is equipped with an electrostatic precipitator (ESP) for removal of fly ash particulate matter, a selective catalytic reduction (SCR) system for removal of nitrogen oxide, and flue gas desulfurization (FGD) systems for removal of sulfur dioxide (Geosyntec 2016).

1.2 CCR Unit Description

The BAP is situated along the Ohio River south of Cardinal Plant Unit 3. The BAP perimeter dikes enclosing the facility are approximately 6,500 feet (ft) in length with a 20-foot average height. The dikes were originally constructed in the 1960s, with major reconstruction in 1974 as part of the Unit 3 addition. The BAP received bottom ash, pyrite, and other wastes from the coal burning process in addition to stormwater drainage and wastewater flows from the property (Geosyntec 2016). Historically, bottom ash transport water (BATW) was recirculated to Fly Ash Reservoir II. However, Fly Ash Reservoir II has initiated closure, and surface water from the BAP is currently discharged through a permitted NPDES Outfall. Additionally, the southern portion of the Bottom Ash Pond is currently being retrofitted.

The BAP and associated monitoring wells are shown in Figure 1-2.

I.3 Regional Physiographic Setting

The BAP is located immediately west of the Ohio River. Regional geology is dominated by sedimentary bedrock units overlain by unconsolidated deposits (typically sand and gravel) associated with the Ohio River Valley in an area of Ohio which was unglaciated during the most recent ice age. Bedrock consists of interbedded shale, sandstone, coal, and limestone of the Pennsylvanian Age Conemaugh Formation.

The uppermost aquifer at the BAP consists of fine to coarse sand and gravel below a silty clay, interbedded organic clay, and silt. Groundwater in the uppermost aquifer generally flows southeast towards the Ohio River (to which it is hydraulically connected) with hydraulic conductivity ranging from 1×10^{-1} to 1×10^{-4} centimeters per second (cm/s) (Geosyntec 2016).

2.0 Groundwater Monitoring System

The BAP's groundwater monitoring network was designed to comply with §257.91 of the CCR Rules. The groundwater monitoring network utilizes monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation and is used to monitor groundwater quality in the uppermost aquifer at the BAP.

The BAP groundwater monitoring well network consists of five monitoring wells, as shown in Figure 1-2. Two upgradient monitoring wells (MW-BAP-4 and MW-BAP-5) are used to measure background conditions and three downgradient monitoring wells (MW-BAP-1, MW-BAP-2, and MW-BAP-3) are used as compliance wells. Monitoring well construction and soil boring logs were provided in the Groundwater Monitoring Network Evaluation (Geosyntec 2016).

No monitoring wells were installed or decommissioned during 2021 as part of the current BAP monitoring network. A retrofit is presently being performed on the Southern Bottom Ash Pond. Additional wells for CCR monitoring have been installed in the proximity of the Southern BAP, to conform to the CCR groundwater monitoring system requirements. Logs of these wells will be presented in the new CCR Units Groundwater Monitoring System Report. However, those wells are not necessary for, and have not been added to, the current monitoring network.

3.0 Groundwater Monitoring Program

In accordance with §257.95 of the CCR Rules, assessment monitoring at the BAP was initiated in May 2018 after a statistically significant increase (SSI) over groundwater background levels was detected for boron, chloride, and fluoride. The BAP remained in assessment monitoring throughout 2021.

Concentrations of CCR constituents in groundwater continue to be above background levels (Section 4.3.1), but no statistically significant levels (SSLs) above groundwater protection standards (GWPSs) have been identified at the BAP (Section 4.3.2). As such, the BAP is not eligible to return to detection monitoring, but not required to enter corrective action monitoring. In accordance with §257.95(f) of the CCR Rules, the BAP remains in assessment monitoring.

3.1 Statistical Analysis Plan

Evaluation of analytical data is performed in accordance with the Statistical Analysis Plan (Geosyntec 2020), which describes a logic process regarding the statistical analysis of groundwater data collected in compliance with the Federal CCR Rule. No revisions were made to the Statistical Analysis Plan during 2021.

3.2 Monitoring Frequency

In accordance with §257.95(d)(1) of the CCR Rules, monitoring wells are sampled semi-annually for constituents listed in Appendix III of the CCR Rules. Additionally, annual sampling of all Appendix IV constituents is performed, along with semiannual sampling of those constituents in Appendix IV that were detected during the annual sampling of all Appendix IV constituents.

In September 2021, a demonstration was made that an alternative monitoring frequency may be appropriate (Cox-Colvin 2021a). A copy is provided in Appendix A. The purpose of the alternative monitoring frequency, which is optional, is to permit semiannual monitoring of all Appendix IV parameters, rather than only those that were previously detected during annual monitoring. The alternative monitoring frequency results in more, rather than less, analysis of groundwater quality. All Appendix IV parameters were analyzed during both 2021 sampling events.

There has been no suspension of groundwater monitoring requirements at the BAP under §257.90(g) of the CCR Rule.

4.0 Key Actions Completed

The sections below summarize key actions completed in 2021 with respect to CCR Rule groundwater monitoring and corrective actions at the BAP.

4.1 Groundwater Elevation and Flow

Prior to sampling, a synoptic round of groundwater level measurements was collected from the compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the April and October 2021 sampling events are presented in Figures 4-1 and 4-2, respectively. The potentiometric maps show that groundwater near the BAP flows southeast towards the Ohio River. Groundwater flow rate calculations relative to the BAP are summarized in Tables 4-1 and 4-2.

4.2 Groundwater Sampling

Table 4-3 contains a summary of groundwater samples collected for analysis in association with CCR activities for the BAP monitoring program. The first semi-annual monitoring event of 2021 was completed in April 2021 and the second semi-annual monitoring event of 2021 was completed in October to November 2021. A total of 12 samples were collected. Analytical results are summarized in Tables 4-4.

4.3 Data Evaluation

Data evaluations performed in 2021 consisted of the following:

- Comparison of Fall 2020 monitoring data to GWPSs for Appendix IV constituents[2]
- Comparison of Spring 2021 monitoring data to background levels for Appendix III constituents
- Comparison of Spring 2021 monitoring data to GWPSs for Appendix IV constituents
- Comparison of Fall 2021 monitoring data to background levels for Appendix III constituents
- Comparison of Fall 2021 monitoring data to GWPSs for Appendix IV constituents is ongoing and will be included in the 2022 annual report.

[2] Although samples were collected in October 2020, evaluation of the laboratory results was performed in 2021 and discussion of the evaluation is, therefore, included in this annual report. The October 2020 sampling results were included in the 2020 Annual Groundwater Monitoring Report.

4.3.1 Background Levels

Background concentrations in BAP groundwater were previously updated for Appendix III constituents[3] in 2019. In February 2021, background concentrations were recalculated for the boron, calcium, chloride, fluoride, and pH. These background levels were based upon interwell upper prediction limits (UPLs). Insufficient new sample points were available to recalculate the intrawell prediction limits that represent the background concentrations for sulfate and total dissolved solids (TDS) (Geosyntec 2021b).

During 2021 groundwater monitoring, SSIs above background concentrations were identified for the constituents and wells listed below. While the prediction limits were calculated for a one-of-two retesting procedure, an SSI was conservatively assumed if a result was above its respective UPL. No resampling was performed to verify SSIs.

- Boron: MW-BAP-1, MW-BAP-2, MW-BAP-3
- Chloride: MW-BAP-1, MW-BAP-2, MW-BAP-3
- Fluoride: MW-BAP-1, MW-BAP-2
- pH: MW-BAP-1, MW-BAP-2
- Sulfate: MW-BAP-1, MW-BAP-3
- TDS: MW-BAP-3

Additionally, a statistically significant decrease (SSD) of pH below background levels was observed at MW-BAP-3.

Background concentrations of Appendix IV constituents in BAP groundwater were most recently updated in February 2021 (Geosyntec 2021b). Appendix IV background concentrations are used while determining GWPS values. Because the Appendix IV background levels are based upon upper threshold limits (UTLs), as opposed to UPLs, direct comparison of individual laboratory results to Appendix IV background levels is not appropriate. Instead, statistical evaluation is performed (using confidence bands) to determine whether GWPSs are exceeded, as discussed below.

4.3.2 Groundwater Protection Standards

A GWPS was established for each Appendix IV parameter in accordance with the United States Environmental Protection Agency's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance (EPA 2009) and the Site's Statistical Analysis Plan (Geosyntec 2020). The established GWPSs were determined to be the greater value of the background concentration and the maximum contaminant level (MCL) for each Appendix IV parameter. If an MCL was not available, values were obtained from §257.95(h)(2) of the CCR Rules. The current GWPSs are presented in Table 4-5.

[3] "Appendix III" and "Appendix IV" constituents refer to those constituents listed in the respective appendices of the CCR Rules.

Statistical analyses of October 2020 (Geosyntec 2021b, Geosyntec 2021a) and April 2021 (Cox-Colvin 2021b) monitoring data identified no SSLs at the BAP.

Statistical evaluation of the October 2021 assessment monitoring data is ongoing and will be discussed in the 2022 annual groundwater monitoring report.

4.4 Corrective Actions

There is no evidence that a release from the BAP has resulted in groundwater concentrations above GWPS values. As such, no corrective actions or remedies are necessary.

4.5 Closure Activities

Although not a corrective action under §257.96 to §257.98 of the CCR Rules, the BAP is currently being retrofitted and will be "clean" closed by removing all CCR materials at the time of closure and decontaminating all areas affected by releases (if any). These activities commenced in 2021 in accordance with the Unit's closure/retrofit plans. The removal and decontamination activities will eliminate the potential that contaminants from the BAP could result in a future exceedance of GWPS established pursuant to §257.95(h) of the CCR Rules (Sargent & Lundy 2020a, Sargent & Lundy 2020b).

5.0 Problems Encountered and Resolutions

No monitoring wells were gauged dry, abandoned, or added to the well network during 2021. All analytical data received were deemed to be of acceptable quality and no resampling was performed.

Additional monitoring wells were installed in the proximity of the Southern BAP in preparation for a new CCR monitoring system associated with a retrofitted bottom ash pond. During evaluation of groundwater elevation data from these new wells alongside data from previously existing wells, imprecisions in previous top-of-casing survey elevations were identified. Well elevations were resurveyed in October 2021, and the data presented on Figures 4-1 and 4-2 and Tables 4-1 and 4-2 is based upon the newly surveyed elevations. Estimated groundwater flow direction determinations changed only slightly as a result of the corrected elevations. The corrections had no impact on the appropriateness of background and downgradient well locations at the BAP. Background wells remain upgradient of the BAP, compliance wells remain downgradient of the BAP, and no changes to the groundwater monitoring system are necessary.

No alternative source demonstrations under either §257.94(e)(2) or §257.95(g)(3)(ii) of the CCR Rules were performed during 2021.

6.0 Projected Key Activities

The bottom ash pond is currently being retrofitted and will be "clean" closed by removing all CCR materials at the time of closure and decontaminating all areas affected by releases (if any). These activities commenced in 2021 in accordance with closure requirements in §257.102 of the CCR Rule. The removal and decontamination activities will eliminate the potential that contaminants from the BAP could result in a future exceedance of GWPS established pursuant to §257.95(h) of the CCR Rules (Sargent & Lundy 2020a, Sargent & Lundy 2020b).

As specified in §257.102(c) of the CCR Rules, closure activities at the BAP will be complete when all CCR has been removed and groundwater monitoring concentrations do not exceed GWPS. Furthermore, §257.104(a)(2) excludes the BAP from post-closure care criteria following removal of all CCR. Presuming that groundwater concentrations remain lower than GWPSs, the BAP groundwater monitoring system will no longer need to be maintained following completion of closure activities. Instead, a new groundwater monitoring system for the retrofitted bottom ash pond will be established in accordance with CCR Rules.

The following groundwater assessment monitoring activities are projected for the BAP:

- The 2021 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site.
- A statistical evaluation of the October 2021 assessment monitoring event will be completed.
- Two semi-annual groundwater assessment monitoring program events will be conducted.
- A statistical evaluation of the first semiannual assessment monitoring event of 2022 will be completed.
- The 2022 Annual Groundwater Monitoring Report will be prepared for submittal in January 2023.

7.0 References

Cox-Colvin. 2021a. *Alternative Monitoring Frequency for the BAP CCR Program; Cardinal Operating Company; Brilliant, Ohio.* Plain City, Ohio: Cox-Colvin & Associates, Inc.

Cox-Colvin. 2021b. *Cardinal Plant Bottom Ash Pond (BAP) Statistical Analysis Summary - 2021 First Semiannual Event. Technical Memorandum from Nate Wanner, CPG and Henry Stahl of Cox-Colvin to Nicholas Kasper of Ohio Electric Cooperative dated Augsut 16, 2021.* Plain City, OH: Cox-Colvin & Associates, Inc.

EPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance, March 2009 (EPA 530/R-09-007).* Environmental Protection Agency, Office of Resource Conservation and Recovery.

Geosyntec. 2021a. *Cardinal Plant Bottom Ash Pond Groundwater Protection Standard Evaluation. Memorandum from Allison Kreinberg and Bryan VanDuinen, P.E. (MI) of Geosyntec Consultants to Nicholas Kasper of Ohio Electric Cooperative dated March 12, 2021.* Columbus, OH: Geosyntec Consultants.

Geosyntec. 2021b. *Cardinal Plant Bottom Ash Pond Statistical Analysis Summary - 2020 Second Semiannual Event. Memorandum from Allison Kreinberg and Bryan VanDuinen, P.E. (MI) of Geosyntec Consultants to Nicholas Kasper of Ohio Electric Cooperative dated February 2, 2021.* Columbus, Ohio: Geosyntec Consultants.

Geosyntec. 2016. *Groundwater Monitoring Network Evaluation; Cardinal Site - Bottom Ash Pond; Brilliant, Ohio (Geosyntec Project No. CHE8126L).* Brilliant, Ohio: Geosyntec Consultants.

Geosyntec. 2020. *Statistical Analysis Plan; Cardinal Power Plant; Brilliant, Ohio (Revision 1).* Columbus, Ohio: Geosyntec Consultants.

Sargent & Lundy. 2020a. "Cardinal Power Plant Bottom Ash Pond Complex; Amendment of Existing Closure Plan; Revision 0, October 19, 2020 (Project No. 13770-005)."

Sargent & Lundy. 2020b. "Cardinal Power Plant Permit to Install Application Bottom Ash South Pond CCR Retrofit."

Figures

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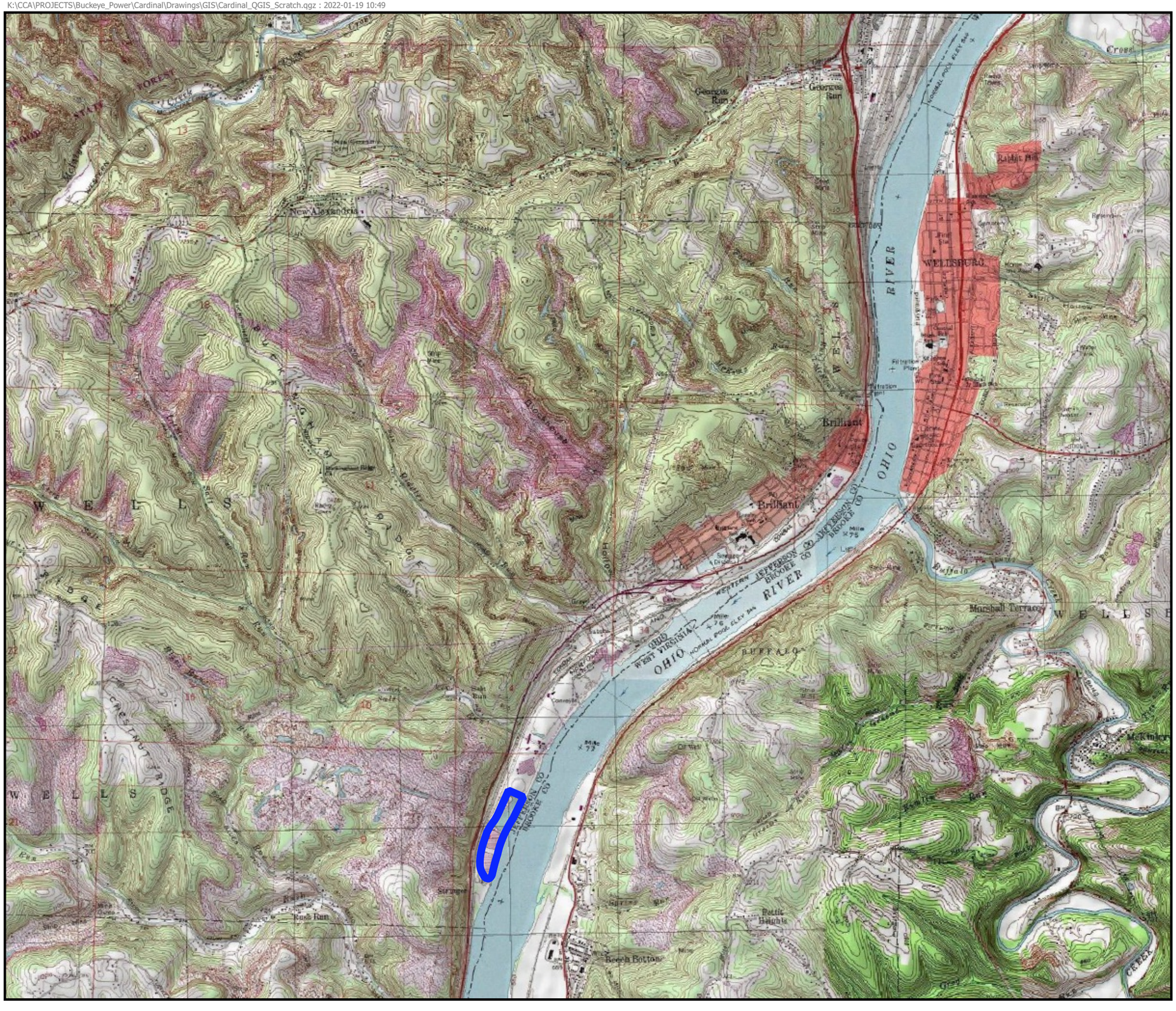

Legend

Bottom Ash Pond (BAP)

USGS Topographical Map

N

0 0.5 1 1.5 2 mi

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Figure

1-1

Site Location Map
Bottom Ash Pond (BAP)
Cardinal Plant
Brilliant, Ohio

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Legend

- Bottom Ash Pond (BAP)

Monitoring Wells

- Downgradient
- Upgradient

N

0 400 800 1,200 ft

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Figure

1-2

CCR Unit and Monitoring Wells
Bottom Ash Pond (BAP)
Cardinal Plant
Brilliant, Ohio

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Legend

- BAP Monitoring Well and Groundwater Elevation
- Non-BAP Monitoring Well and Groundwater Elevation
- Approximate Groundwater Elevation Contour
- Bottom Ash Pond (BAP)

N

0 200 400 600 800 1,000 ft

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Figure

4-1

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Pond (BAP) - April 5, 2021
Cardinal Plant
Brilliant, Ohio

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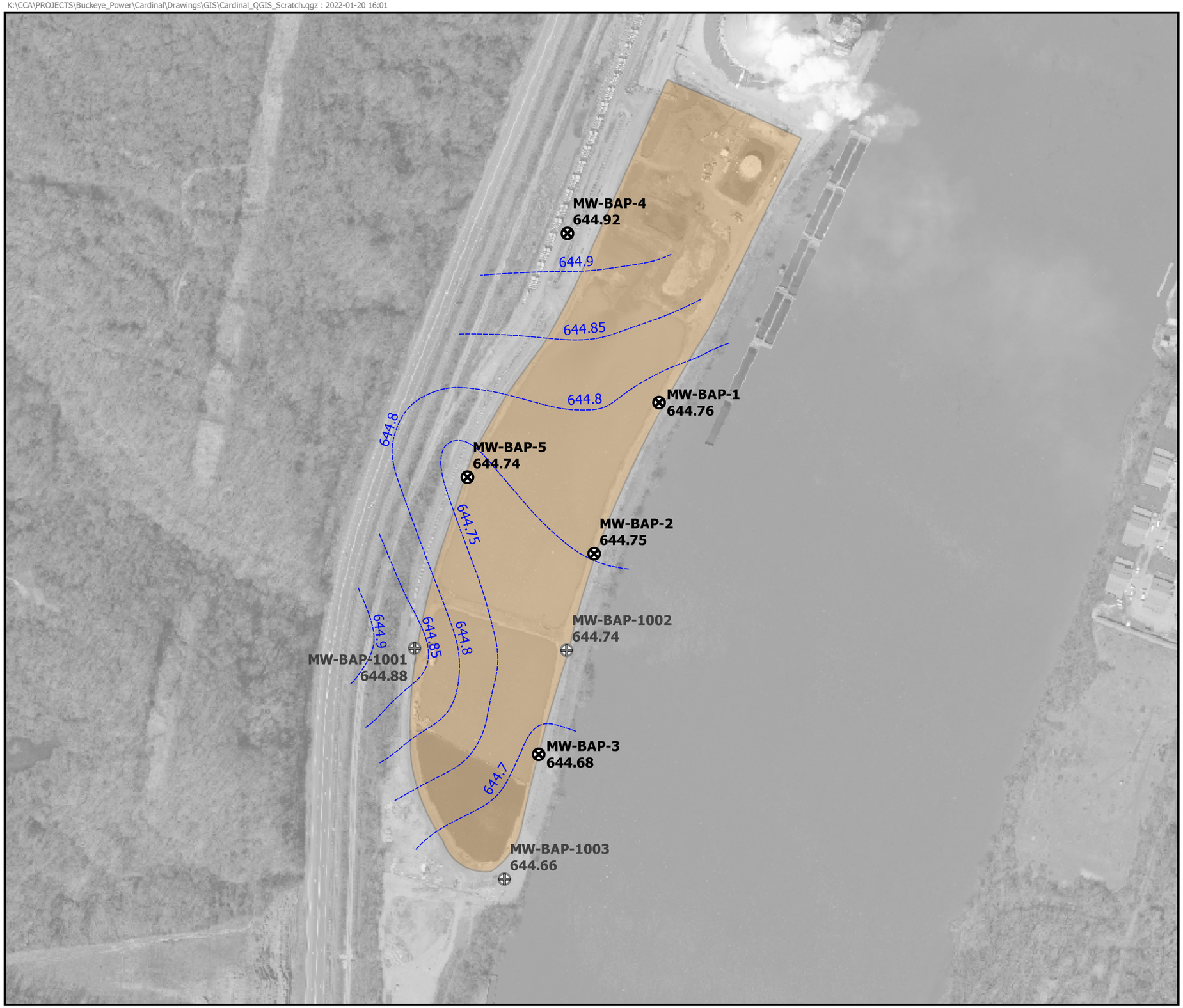

Legend

- BAP Monitoring Well and Groundwater Elevation
- Non-BAP Monitoring Well and Groundwater Elevation
- Approximate Groundwater Elevation Contour
- Bottom Ash Pond (BAP)

N

0 200 400 600 800 1,000 ft

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Figure

4-2

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Pond (BAP) - October 12, 2021
Cardinal Plant
Brilliant, Ohio

Tables

Table 4-1. Groundwater Flow Calculations, Bottom Ash Pond (BAP), Cardinal Plant, Brilliant, Ohio, April 2021

Program	Groundwater Zone	Well	Hyrdaulic Location[1]	Depth to Water (ft)	Potentiometric Elevation (ft)[2]	Gradient[3] (ft/ft)	Hydraulic Conductivity[4] (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter[5] (in.)	Residence Time[6] (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
BAP	BAP	MW-BAP-1	Downgradient	27.84	644.72	0.00117	0.0001	0.05	0.1	0.36	0.00092	0.46077	0.92155	8	0.7	1.4	723
BAP	BAP	MW-BAP-2	Downgradient	28.79	644.68	0.00100	0.0001	0.05	0.1	0.36	0.00079	0.39271	0.78541	8	0.8	1.7	849
BAP	BAP	MW-BAP-3	Downgradient	28.49	644.56	0.00214	0.0001	0.05	0.1	0.36	0.00169	0.84344	1.68688	8	0.4	0.8	395
BAP	BAP	MW-BAP-4	Upgradient	19	644.84	0.00059	0.0001	0.05	0.1	0.36	0.00047	0.23385	0.46769	8	1.4	2.9	1425
BAP	BAP	MW-BAP-5	Upgradient	27.53	644.61	0.00073	0.0001	0.05	0.1	0.36	0.00058	0.28893	0.57786	8	1.2	2.3	1154

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Measurements and calculations represent conditions on April 5, 2021.

[1] *Groundwater Monitoring Network Evaluation; Cardinal Site – Bottom Ash Pond, Brilliant, Ohio* prepared by Geosyntec Consultants in July 2016.

[2] Based on the National Geodetic Vertical Datum of 1929 (NGVD29) and top of casing elevations surveyed in October 2021.

[3] Hydraulic gradient was calculated from a potentiometric surface using GDAL software tools (https://gdal.org/programs/gdaldem.html).

[4] Low and high conductivity values are from the 2016 Groundwater Monitoring Network Evaluation, with a representative value chosen within this range that is consistent with previous velocity calculations.

[5] Well diameter represents the diameter of the borehole (sandpack).

[6] Residence time is an estimation of how long it would take groundwater to travel a distance equivalent to the well diameter at the calculated velocity.

Table 4-2. Groundwater Flow Calculations, Bottom Ash Pond (BAP), Cardinal Plant, Brilliant, Ohio, October 2021

Program	Groundwater Zone	Well	Hyrdaulic Location[1]	Depth to Water (ft)	Potentiometric Elevation (ft)[2]	Gradient[3] (ft/ft)	Hydraulic Conductivity[4] (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter[5] (in.)	Residence Time[6] (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
BAP	BAP	MW-BAP-1	Downgradient	27.8	644.76	0.00116	0.0001	0.05	0.1	0.36	0.00091	0.45475	0.90949	8	1	1	733
BAP	BAP	MW-BAP-2	Downgradient	28.72	644.75	0.00043	0.0001	0.05	0.1	0.36	0.00034	0.17117	0.34234	8	2	4	1947
BAP	BAP	MW-BAP-3	Downgradient	28.37	644.68	0.00119	0.0001	0.05	0.1	0.36	0.00094	0.46833	0.93667	8	1	1	712
BAP	BAP	MW-BAP-4	Upgradient	18.92	644.92	0.00043	0.0001	0.05	0.1	0.36	0.00034	0.17058	0.34116	8	2	4	1954
BAP	BAP	MW-BAP-5	Upgradient	27.4	644.74	0.00013	0.0001	0.05	0.1	0.36	0.00010	0.05008	0.10017	8	7	13	6655

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Measurements and calculations represent conditions on October 12, 2021.

[1] *Groundwater Monitoring Network Evaluation; Cardinal Site – Bottom Ash Pond, Brilliant, Ohio* prepared by Geosyntec Consultants in July 2016.

[2] Based on the National Geodetic Vertical Datum of 1929 (NGVD29) and top of casing elevations surveyed in October 2021.

[3] Hydraulic gradient was calculated from a potentiometric surface using GDAL software tools (https://gdal.org/programs/gdaldem.html).

[4] Low and high conductivity values are from the 2016 Groundwater Monitoring Network Evaluation, with a representative value chosen within this range that is consistent with previous velocity calculations.

[5] Well diameter represents the diameter of the borehole (sandpack).

[6] Residence time is an estimation of how long it would take groundwater to travel a distance equivalent to the well diameter at the calculated velocity.

Table 4-3 Summary of CCR Groundwater Samples, Bottom ash Pond (BAP), Cardinal Plant, Brilliant, Ohio

Well Name	Type of Well	Sample Date	Constituents Analyzed	Purpose
MW-BAP-1	Downgradient	4/19/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-1	Downgradient	10/28/2021	Appendix III and IV Metals	Assessment monitoring program
MW-BAP-1	Downgradient	11/2/2021	Appendix III Non-Metals	Assessment monitoring program
MW-BAP-2	Downgradient	4/19/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-2	Downgradient	11/2/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-3	Downgradient	4/19/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-3	Downgradient	10/28/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-3	Downgradient	10/28/2021	Appendix III and IV	Assessment monitoring program (Duplicate)
MW-BAP-4	Upgradient	4/19/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-4	Upgradient	10/28/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-5	Upgradient	4/19/2021	Appendix III and IV	Assessment monitoring program
MW-BAP-5	Upgradient	10/28/2021	Appendix III and IV	Assessment monitoring program

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Table 4-4: Sampling Data, Bottom Ash Pond (BAP), Cardinal Plant, Brilliant, Ohio

Well Name		MW-BAP-1	MW-BAP-1	MW-BAP-1	MW-BAP-2	MW-BAP-2	MW-BAP-3	MW-BAP-3	MW-BAP-3	MW-BAP-4	MW-BAP-4	MW-BAP-5	MW-BAP-5
Sample Name		MW-BAP-1	MW-BAP-1	MW-BAP-1	MW-BAP-2	MW-BAP-2	MW-BAP-3	MW-BAP-3	MW-BAP-3 DUP	MW-BAP-4	MW-BAP-4	MW-BAP-5	MW-BAP-5
Sample Date		4/19/2021	10/28/2021	11/2/2021	4/19/2021	11/2/2021	4/19/2021	10/28/2021	10/28/2021	4/19/2021	10/28/2021	4/19/2021	10/28/2021
Laboratory	Concentration	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical
Lab ID	Units	50285375002	50301592005	50301963002	50285375003	50301963001	50285375004	50301592006	50301592007	50285375005	50301592008	50285375006	50301592009
APPENDIX III CONSTITUENTS													
Boron	MG/L	**2.75**	**3.08**	NA	**2.42**	**1.83**	**1.96**	**2.17**	**2.12**	**0.03**	**0.0244**	**0.147**	**0.158**
Calcium	MG/L	**149**	**141**	NA	**87.5**	**89.2**	**69.2**	**72.9**	**73.4**	**192**	**185**	**211**	**229**
Chloride	MG/L	**59**	NA	**66.6**	**67.3**	**66.6**	**71.9**	**71.8**	**61.2**	**25.3**	**28.3**	**19.9**	**20.6**
Fluoride	MG/L	**0.35**	NA	**0.35**	**0.72**	**0.54**	**0.12**	**0.12**	**0.12**	**0.087**	**0.09**	< 0.05	**0.056**
Sulfate	MG/L	**736**	NA	**317**	**187**	**209**	**147**	**178**	**155**	**977**	**559**	**451**	**421**
Total Dissolved Solids	MG/L	**782**	NA	**814**	**508**	**533**	**397**	**466**	**426**	**1130**	**1080**	**962**	**918**
pH	SU	**6.53**	**7.18**	**7.36**	**6.44**	**7.2**	**6.09**	**6.55**	**6.55**	**6.08**	**6.3**	**6.25**	**6.53**
APPENDIX IV CONSTITUENTS													
Antimony	MG/L	< 0.0005	< 0.0005	NA	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Arsenic	MG/L	< 0.0005	< 0.0005	NA	**0.0282**	**0.0189**	< 0.0005	< 0.0005	< 0.0005	**0.0537**	**0.0541**	**0.0051**	**0.0049**
Barium	MG/L	**0.043**	**0.0534**	NA	**0.179**	**0.131**	**0.048**	**0.0502**	**0.0507**	**0.0434**	**0.0419**	**0.0759**	**0.0771**
Beryllium	MG/L	< 0.0001	< 0.0001	NA	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium	MG/L	< 0.0001	**0.00013**	NA	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	MG/L	**0.0049**	< 0.001	NA	< 0.001	< 0.001	**0.0019**	< 0.001	< 0.001	**0.002**	**0.0014**	< 0.001	< 0.001
Cobalt	MG/L	**0.0006**	**0.00075**	NA	**0.0012**	**0.0011**	**0.00068**	**0.00058**	**0.00057**	**0.0177**	**0.0175**	**0.00061**	**0.00053**
Fluoride	MG/L	**0.35**	NA	**0.35**	**0.72**	**0.54**	**0.12**	**0.12**	**0.12**	**0.087**	**0.09**	< 0.05	**0.056**
Lead	MG/L	< 0.0005	< 0.0005	NA	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	**0.0013**	**0.0014**	< 0.0005	< 0.0005
Lithium	MG/L	**0.0189**	**0.0237**	NA	< 0.01	**0.0127**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	MG/L	**0.00000052**	**0.00000235**	NA	**0.00000093**	**0.00000126**	**0.00000065**	< 5E-7	< 5E-7	**0.00000184**	**0.00000321**	< 5E-7	**0.000000979**
Molybdenum	MG/L	**0.0306**	**0.0352**	NA	**0.035**	**0.0283**	**0.0023**	**0.002**	**0.002**	**0.0014**	**0.0013**	< 0.0005	< 0.0005
Potassium	UG/L	**10100**	**9470**	NA	**5800**	**5800**	**3610**	**3610**	**3660**	**974**	**1180**	**793**	**844**
Selenium	MG/L	< 0.0005	< 0.0005	NA	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium	MG/L	< 0.0005	< 0.0005	NA	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Combined Radium	pCi/L	**0.209**	**0.47**	NA	**0.216**	**0.419**	**0**	**0.353**	**0.0711**	**0.906**	**0.132**	**0.923**	**0.187**

NA = Not Analyzed
< = Not detected at reporting limit
Bold = Detected

Table 4-5. Groundwater Protection Standards (GWPS), Revised 3/3/22
Bottom Ash Pond (BAP), Cardinal Plant, Brilliant, Ohio

	Concentration Units	MCL	CCR Rules § 257.95(h)(2)	Background Limit	BAP GWPS
APPENDIX IV CONSTITUENTS					
Antimony	MG/L	0.006	-	0.0005	0.006
Arsenic	MG/L	0.01	-	0.065	0.065
Barium	MG/L	2	-	0.12	2
Beryllium	MG/L	0.004	-	0.0002	0.004
Cadmium	MG/L	0.005	-	0.00018	0.005
Chromium	MG/L	0.1	-	0.005	0.1
Cobalt	MG/L	-	0.006	0.02	0.02
Fluoride	MG/L	4	-	0.17	4
Lead	MG/L	-	0.015	0.0056	0.015
Lithium	MG/L	-	0.04	0.0018	0.04
Mercury	MG/L	0.002	-	0.000005	0.002
Molybdenum	MG/L	-	0.1	0.0034	0.1
Radium, Combined	pCi/L	5	-	1.6	5
Selenium	MG/L	0.05	-	0.0007	0.05
Thallium	MG/L	0.002	-	0.0005	0.002

K:\CCA\PROJECTS\Buckeye_Power\Cardinal\BAP\Annual Groundwater and Corrective Measures Reports\2021\Tables\[Table 4-5 - BAP GWPS Values.xlsx]Sheet1

MCL = Maximum Contaminant Level
GWPS is the higher value of either the background limit or the MCL. If an MCL is not available, values from the CCR Rules are used.
Background values are based upon statistical upper threshold limit (UTL) calculations.
UTLs are intended for comparison to confidence bands, not individual observations.

Appendix A

Alternative Groundwater Sampling and Analysis Frequency

Alternative Monitoring Frequency for the BAP CCR Program Cardinal Operating Company Brilliant, Ohio

September 21, 2021

Submitted to:

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio 43913

Submitted by:

Cox-Colvin & Associates, Inc.
7750 Corporate Blvd.
Plain City, Ohio 43064
(614) 526-2040

Cox-Colvin
& ASSOCIATES, INC.
ENVIRONMENTAL SERVICES

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1.0 Introduction

Cox-Colvin & Associates, Inc. (Cox-Colvin) is pleased to provide this demonstration summarizing an alternative monitoring frequency for the Bottom Ash Pond (BAP) Coal Combustion Residuals (CCR) unit at the Cardinal Operating Company (Cardinal) power plant in Brilliant, Ohio. The purpose of this alternative monitoring frequency is to permit semiannual monitoring of all Appendix IV parameters, rather than only those that were previously detected during annual monitoring.

2.0 Analyses Required for Assessment Monitoring

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of CCR in landfills and surface impoundments (40 CFR 257.90-257.98, "CCR Rule"), groundwater monitoring at the BAP is performed semi-annually.

In accordance with CCR Rule 257.95(a), the BAP entered an assessment monitoring program following a statistically significant increase (SSI) over background levels for one or more of the constituents listed in CCR Rule Appendix III (Appendix III Constituents).

Once a CCR unit is subject to assessment monitoring, CCR Rule Section 257.95(b) requires initial and annual sampling and analysis of groundwater for all constituents listed in CCR Rule Appendix IV (Appendix IV Constituents). CCR Rule Section 257.95 requires semiannual sampling and statistical analysis of all Appendix III Constituents and also those Appendix IV Constituents previously detected during the initial or annual sampling. The CCR Rule does not require semiannual analysis of Appendix IV Constituents that were not previously detected. The above CCR Rule requirements for assessment monitoring are summarized in the following table:

Timeframe	Appendix III Constituents	Appendix IV Constituents
Start of Assessment Monitoring	All	All
Annually	All	All
Semiannually	All	Detected Only

Table 1: CCR Rule Monitoring Frequency

3.0 Alternative Monitoring Frequency

The alternative monitoring frequency in Table 2 is being implemented for the BAP program.

Timeframe	Appendix III Constituents	Appendix IV Constituents
Start of Assessment Monitoring	All	All
Semiannually	All	***All***

Table 2: Alternative Monitoring Frequency

The only change to the CCR Rule monitoring frequency is that all Appendix IV Constituents are sampled and analyzed semiannually, as opposed to only those that were previously detected. By analyzing **all** constituents on a semi-annual basis, the annual sampling event (to analyze detectable concentrations) is no longer needed. The alternative monitoring frequency is being implemented as an option (not a requirement) for sampling and analysis in order to:

- Simplify sampling and analysis with a consistent suite of analyses during each sampling event.
- Alleviate the need to track the particular Appendix IV Constituents that have been detected and whether a sample event meets requirements for annual or semiannual analyses.
- Reduce the likelihood that individual analyses are inadvertently omitted during a semiannual sampling.
- Provide flexibility to implement a conservative approach where the CCR Rule lacks details or clarity. For example, the CCR Rule does not specify whether "detected" in Section 257.95(d)(1) includes concentrations that the laboratory estimated below reporting limits ("J"-qualified), or whether results from all dates should be reviewed for "detected" constituents versus only results from the most recent annual sampling.

The alternative monitoring frequency in Table 2 is acceptable for the BAP assessment monitoring program. However, as noted above, its implementation is optional, not a requirement. If the alternative monitoring frequency is not used, then all requirements summarized in Table 1 above must be met (i.e., all Appendix IV Constituents are analyzed annually, and previously detected Appendix IV Constituents are analyzed semiannually).

4.0 Supporting Information and Demonstration

CCR Rule Section 257.95(c) allows operators to demonstrate the need for an alternative monitoring frequency for repeated sampling and analysis for Appendix IV Constituents. The need to vary monitoring frequency must be evaluated on a site-specific basis, and the demonstration supported by, at a minimum, the information specified in paragraphs (c)(1) and (2) of the regulation.

A demonstration that this alternative monitoring frequency is acceptable is provided below. CCR Rule paragraph text is provided in ***bold, italic*** font followed by supporting information in standard font.

(1) Information documenting that [sic] the need for less frequent sampling. The alternative frequency must be based on consideration of the following factors:

(i) Lithology of the aquifer and unsaturated zone;
(ii) Hydraulic conductivity of the aquifer and unsaturated zone; and
(iii) Groundwater flow rates.

The alternative monitoring frequency was not developed as a result of hydrogeological conditions of the aquifer (e.g., very slow flow velocities, poor well yields, etc.). The alternative monitoring frequency results in more frequent sampling of those Appendix IV Constituents that were not previously detected. Because sampling will not be performed less frequently, the requirements of this paragraph are not applicable.

(2) Information documenting that the alternative frequency will be no less effective in ensuring that any leakage from the CCR unit will be discovered within a timeframe that will not materially delay the initiation of any necessary remediation measures.

All requirements of CCR Rule assessment monitoring will be met. Additionally, Appendix IV Constituents that were not previously detected will be sampled and analyzed twice as frequently as required by the CCR Rule. As such, the alternative frequency could result in earlier detection of any leakage from the CCR unit containing the constituents. Initiation of any necessary remediation measures will not be delayed by the alternative monitoring frequency and could potentially be accelerated.

5.0 Certification of Qualified Professional Engineer

In accordance with CCR Rule Section 257.95(c)(3), this alternative groundwater sampling and analysis frequency is certified by Nick M. Petruzzi, PE, a qualified professional engineer licensed by the State of Ohio (PE #E-73052).

Nick M. Petruzzi, P.E.

9/21/21
Date

Stamp

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