

**2020 ANNUAL GROUNDWATER
MONITORING REPORT**

FEDERAL CCR RULE

**CARDINAL PLANT – BOTTOM ASH POND
BRILLIANT, OHIO**

Submitted to



Cardinal Operating Company

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Submitted by

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LIST OF ACRONYMS AND ABBREVIATIONS

BAP	Bottom Ash Pond
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
cm/s	centimeters per second
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
MCL	Maximum Contaminant Level
MW	Megawatt
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
USEPA	United States Environmental Protection Agency

1. EXECUTIVE SUMMARY

Geosyntec Consultants (Geosyntec) has prepared this 2020 Annual Groundwater Monitoring Report (Report) for the Bottom Ash Pond (BAP), an existing CCR unit at the Cardinal Generating Plant in Brilliant, Ohio (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule from January 1, 2020 through December 31, 2020 (the 2020 annual reporting period). This Report was prepared in accordance with 40 CFR 257.90(e).

At the start of the 2020 annual reporting period, the BAP was operating under the assessment monitoring program (40 CFR 257.95). The BAP remained in the assessment monitoring program throughout the 2020 annual reporting period. Statistical evaluations of two assessment monitoring events were completed during this annual reporting period – the second semiannual event of 2019 (October 2019) and the first semiannual event of 2020 (April 2020). The statistical analysis of the second semi-annual sampling event of 2020 (October 2020) will be completed in 2021 and presented in next year's Annual Groundwater Monitoring Report.

For the second semiannual assessment monitoring event of 2019, no statistically significant levels (SSLs) above the groundwater protection standard were identified. The following statistically significant increases (SSIs) over background were identified:

- Boron SSIs were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3.
- Chloride SSIs were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3.
- Fluoride SSIs were identified at MW-BAP-1 and MW-BAP-2.
- pH SSIs were identified at MW-BAP-1 and MW-BAP-2. A pH SSI was also identified at MW-BAP-3, where the reported value was below the lower prediction limit.

For the first semiannual event of 2020, no SSLs were identified. The following SSIs over background were identified:

- Boron SSIs were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3.
- Chloride SSIs were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3.
- Fluoride SSIs were identified at MW-BAP-1 and MW-BAP-2.

2. INTRODUCTION

The Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.90(e)) (USEPA, 2015) requires owners and or operators of existing CCR landfills and surface impoundments to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than January 31 annually. Geosyntec Consultants (Geosyntec) has prepared this Report for the Bottom Ash Pond (BAP), an existing CCR unit at the Cardinal Generating Plant in Brilliant, Ohio (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2020.

3. SITE DESCRIPTION

3.1 Site Description

The Site is located one mile south of Brilliant, Ohio in Jefferson County (**Figure 1**) 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 and annual coal use of 5.2 million tons (Geosyntec, 2016). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. As of 2012, all three units were equipped with an electrostatic precipitator (ESP), a selective catalytic reduction (SCR) system, and a flue gas desulfurization (FGD) system.

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 receives bottom ash, pyrite, and other wastes from the coal burning process in addition to stormwater drainage and wastewater flows from the property. The BAP and associated sampling locations are outlined in **Figure 2**.

3.2 Regional Physiographic Setting

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Conemaugh Group, 500 ft thick in Jefferson County, consists of shale, sandstone, limestone, claystone, and coal. This group includes the Morgantown Sandstone underlain by the Elk Lick Limestone, the Skelly Limestone and Shale, the Ames Limestone, and the Cow Run Sandstone (Geosyntec, 2016). Above the current grade of the Residual Solid Waste (RSW) Landfill lies the Monongahela Group consisting of shale, sandstone, limestone, coal, claystone, and siltstone. Overlying the Monongahela Group, at approximately 1,250 feet in elevation, is the Permian-age Dunkard Group.

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

4. GROUNDWATER MONITORING SYSTEM

The BAP's groundwater monitoring network was designed to comply with 40 CFR 257.91. 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 Site. Monitoring well construction and soil boring logs were provided in the *Groundwater Monitoring Network Design Report* (Geosyntec, 2016).

The BAP groundwater monitoring well network consists of five monitoring wells, as shown in **Figure 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.

5. CCR RULE GROUNDWATER KEY ACTIVITIES COMPLETED

5.1 Statistical Analysis Plan Revision

A statistical analysis plan was previously prepared for the BAP during the background monitoring period (Geosyntec, 2017). Geosyntec's *Statistical Analysis Plan* (Geosyntec, 2020a) describes a logic process regarding the statistical analysis of groundwater data collected in compliance with the Federal CCR Rule. The revised statistical analysis plan primarily incorporates statistical procedures and reporting requirements for corrective action monitoring and incorporates a revision to the CCR rules that specifies screening levels for constituents that do not have a maximum contaminant level.

5.2 2020 Statistical Evaluation Activities

For each assessment monitoring event, a Groundwater Protection Standard (GWPS) was established for each Appendix IV parameter in accordance with the United States Environmental Protection Agency (USEPA's) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (Unified Guidance; USEPA, 2009) and the Site's *Statistical Analysis Plan* (Geosyntec, 2020a). The established GWPSs were determined to be the greater value of the background concentration and the maximum contaminant level (MCL) or risk-based screening level for each Appendix IV parameter. The current GWPSs are presented in **Table 1**.

A statistical evaluation of the October 2019 assessment monitoring data compared against the GWPSs was completed in January 2020 and is described in the *Statistical Analysis Summary – Bottom Ash Pond* (Geosyntec, 2020c). The statistical analysis report included an evaluation of statistically significant levels (SSLs) for Appendix IV parameters and an evaluation of statistically significant increases (SSIs) for Appendix III parameters. Additionally, prediction limits for interwell tests were recalculated using data collected during the 2019 assessment monitoring events. No SSLs were identified at the BAP. SSIs for boron, chloride, and pH were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3. SSIs for fluoride were identified at MW-BAP-1 and

MW-BAP-2 (Geosyntec, 2020c). Based on these results, the CCR unit remained in assessment monitoring.

A statistical evaluation of the April 2020 assessment monitoring data was completed in August 2020 and is described in the *Statistical Analysis Summary – Bottom Ash Pond* (Geosyntec, 2020d). The GWPSs were recalculated using the April 2020 data, with these GWPSs provided in **Table 1**. The statistical analysis report included an evaluation of SSLs for Appendix IV parameters and an evaluation of SSIs for Appendix III parameters. Additionally, prediction limits for interwell tests were recalculated using data collected during the April 2020 assessment monitoring event. No SSLs were identified at the BAP. SSIs for boron, chloride, and pH were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3. SSIs for fluoride were identified at MW-BAP-1 and MW-BAP-2 (Geosyntec, 2020d). Based on these results, the CCR unit remained in assessment monitoring.

5.3 2020 Sampling and Data Evaluation Activities

5.3.1 Assessment Monitoring Program

The BAP remained in assessment monitoring throughout 2020. Assessment monitoring sampling events were conducted in April and October 2020 in accordance with 40 CFR 257.95(b) and 40 CFR 257.95(d)(1), respectively. Samples from both events were analyzed for all Appendix III and Appendix IV parameters; results are shown in **Table 2**. A revision of the GWPSs and statistical evaluation of the October 2020 assessment monitoring data is ongoing and will be completed outside of the timeframe of this report.

5.3.2 Groundwater Elevation and Flow Velocities

Prior to sampling, a synoptic round of groundwater level measurements was collected from compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the April and October 2020 assessment monitoring events are presented in **Figure 3** and **Figure 4**, respectively. The potentiometric maps show that groundwater near the BAP flows southeast towards the Ohio River. The groundwater residence time (inverse of velocity) at the BAP ranged from 1.5 days at well MW-BAP-1 to 6.7 days at MW-BAP-5. A summary of hydraulic gradients and groundwater residence times at the BAP is provided in **Table 3**.

5.3.3 Data Usability

Upon receipt of laboratory analytical reports, the data were evaluated for usability. Analytical data were checked for the following:

- Samples were analyzed within the method specified hold times;
- Samples were received within holding temperature;
- The chain of custody form was complete;

- Precision was within control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the control limits; and
- Potential for positive bias was evaluated using method blanks.

All data received during 2020 were considered complete and usable.

6. PROBLEMS ENCOUNTERED AND RESOLUTIONS

No problems were encountered during 2020 that were related to assessment monitoring activities at the BAP. No monitoring wells were gauged dry, abandoned, or added to the well network during 2020. All analytical data received were deemed to be of acceptable quality.

7. STATUS OF MONITORING PROGRAM

During the time period of this report, the BAP has remained in assessment monitoring. Assessment monitoring events were conducted in April and October 2020. The BAP's status will be re-evaluated after completion of the ongoing statistical evaluation of the October 2020 analytical results.

8. PLANNED KEY ACTIVITIES FOR 2021

The following activities are planned for 2021 at the BAP:

- The 2020 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 2020 assessment monitoring event will be completed, including a recalculation of the Site-specific GWPSs in accordance with the *Statistical Analysis Plan* (Geosyntec, 2020a). The BAP's monitoring status will be confirmed following the evaluation;
- The BAP will initiate retrofit, per the BAP Retrofit Plan. A new CCR monitoring network will be installed per 40 CFR 257.91 (Geosyntec, 2020e);
- Assuming the unit remains in assessment monitoring, two semi-annual groundwater assessment monitoring program events will be conducted and tested for potential SSLs and SSIs; and
- The 2021 Annual Groundwater Monitoring will be prepared for submittal in January 2022.

9. REFERENCES

- Geosyntec Consultants, Inc. 2016. Groundwater Monitoring Network Evaluation, Cardinal Site – Bottom Ash Pond. July.
- Geosyntec Consultants, Inc. 2017. Statistical Analysis Plan. January
- Geosyntec Consultants, Inc. 2020a. Statistical Analysis Plan – Revision 01. July.
- Geosyntec Consultants, Inc. 2020b. 2019 Annual Groundwater Monitoring Report, Federal CCR Rule, Cardinal Plant – Bottom Ash Pond. January.
- Geosyntec Consultants, Inc. 2020c. Statistical Analysis Summary – Bottom Ash Pond, Cardinal Plant. January.
- Geosyntec Consultants, Inc. 2020d. Statistical Analysis Summary – Bottom Ash Pond, Cardinal Plant. August.
- Geosyntec Consultants, Inc. 2020e. Groundwater Monitoring Network for Proposed Retrofitted Bottom Ash Pond, Cardinal Site. October.
- United States Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007. March.
- United States Environmental Protection Agency (USEPA). 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (Final Rule). Fed. Reg. 80 FR 21301, pp. 21301-21501, 40 CFR Parts 257 and 261, April.

TABLES

**Table 1 – Groundwater Protection Standards
Cardinal Plant – Bottom Ash Pond**

Geosyntec Consultants, Inc.

Analyte	MCL	CCR-Rule Specified	Background Limit	GWPS
Antimony, Total (mg/L)	0.006		0.0005	0.006
Arsenic, Total (mg/L)	0.01		0.055	0.055
Barium, Total (mg/L)	2		0.12	2
Beryllium, Total (mg/L)	0.004		0.0002	0.004
Cadmium, Total (mg/L)	0.005		0.00014	0.005
Chromium, Total (mg/L)	0.1		0.005	0.1
Cobalt, Total (mg/L)	n/a	0.006	0.02	0.02
Combined Radium, Total (pCi/L)	5		1.6	5
Fluoride, Total (mg/L)	4		0.18	4
Lead, Total (mg/L)	n/a	0.015	0.0057	0.015
Lithium, Total (mg/L)	n/a	0.04	0.018	0.04
Mercury, Total (mg/L)	0.002		0.000007	0.002
Molybdenum, Total (mg/L)	n/a	0.1	0.0035	0.1
Selenium, Total (mg/L)	0.05		0.0007	0.05
Thallium, Total (mg/L)	0.002		0.0005	0.002

**Grey cells indicate that the Background Limit is greater than the MCL*

**MCL = Maximum Contaminant Level*

**Table 2: 2020 Groundwater Data Summary
Cardinal Plant - Bottom Ash Pond**

Parameter	Unit	BAP-1		BAP-2		BAP-3		BAP-4		BAP-5	
		4/8/2020	10/14/2020	4/8/2020	10/14/2020	4/8/2020	10/14/2020	4/8/2020	10/15/2020	4/8/2020	10/15/2020
Antimony	µg/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Arsenic	µg/L	2.4	0.5 U	24.2	131	1.1	0.5 U	45.1	65.3	2.3	3.8
Barium	µg/L	89.1	48.6	160	172	83.6	46	42.8	47.2	80.1	76.8
Beryllium	µg/L	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.12	0.1 U	0.1 U
Boron	mg/L	2.77	2.84	1.86	2.15	1.94	1.89	0.0207	0.0201	0.138	0.132
Cadmium	µg/L	0.15	0.1	0.1 U	0.1 U	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Calcium	mg/L	147	152	88	86.2	69.7	72.2	186	188	234	213
Chloride	mg/L	73.9	70.4	83.7	78.5	77.3	74.7	29	27.9	22.1	18.9
Chromium	µg/L	4.6	2.8	1.5	1.1	3.5	1 U	1.4	2.3	1 U	1 U
Cobalt	µg/L	2.3	0.9	1.8	1.3	1.9	0.61	19.6	18.2	0.99	0.62
Combined Radium	pCi/L	1.63	0.0836	0.736	0.681	0.641	0.183	0.552	0.675	0.794	1.53
Fluoride	mg/L	0.38	0.37	0.58	0.92	0.12	0.13	0.11	0.095	0.08	0.052
Lead	µg/L	3.3	0.5 U	1.1	0.66	1.5	0.5 U	1.1	2	0.5 U	0.5 U
Lithium	µg/L	27.5	23.8	12.1	10.1	10 U	10 U	12.9	10 U	11.4	10 U
Mercury	ng/L	0.0137	0.00151	0.00249	0.00174	0.0084	0.00084	0.00223	0.00418	0.000734	0.00065
Molybdenum	µg/L	29.9	33.9	35.2	29.1	2.7	2.0	1.4	1.5	0.5 U	0.5 U
Selenium	µg/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Sulfate	mg/L	389	357	208	185	158	159	637	569	511	442
Thallium	µg/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Total Dissolved Solids	mg/L	825	820	527	515	430	416	1170	1170	1080	988
pH	SU	6.8	7.6	6.7	7.6	6.4	7.1	6.3	6.9	6.5	7.2

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter

ng/L: nanograms per liter

pCi/L: picocuries per liter

SU: standard unit

U: Parameter was not present in concentrations above method detection limit and is reported as the reporting limit

All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

**Table 3: Residence Time Calculation Summary
Cardinal Plant - Bottom Ash Pond**

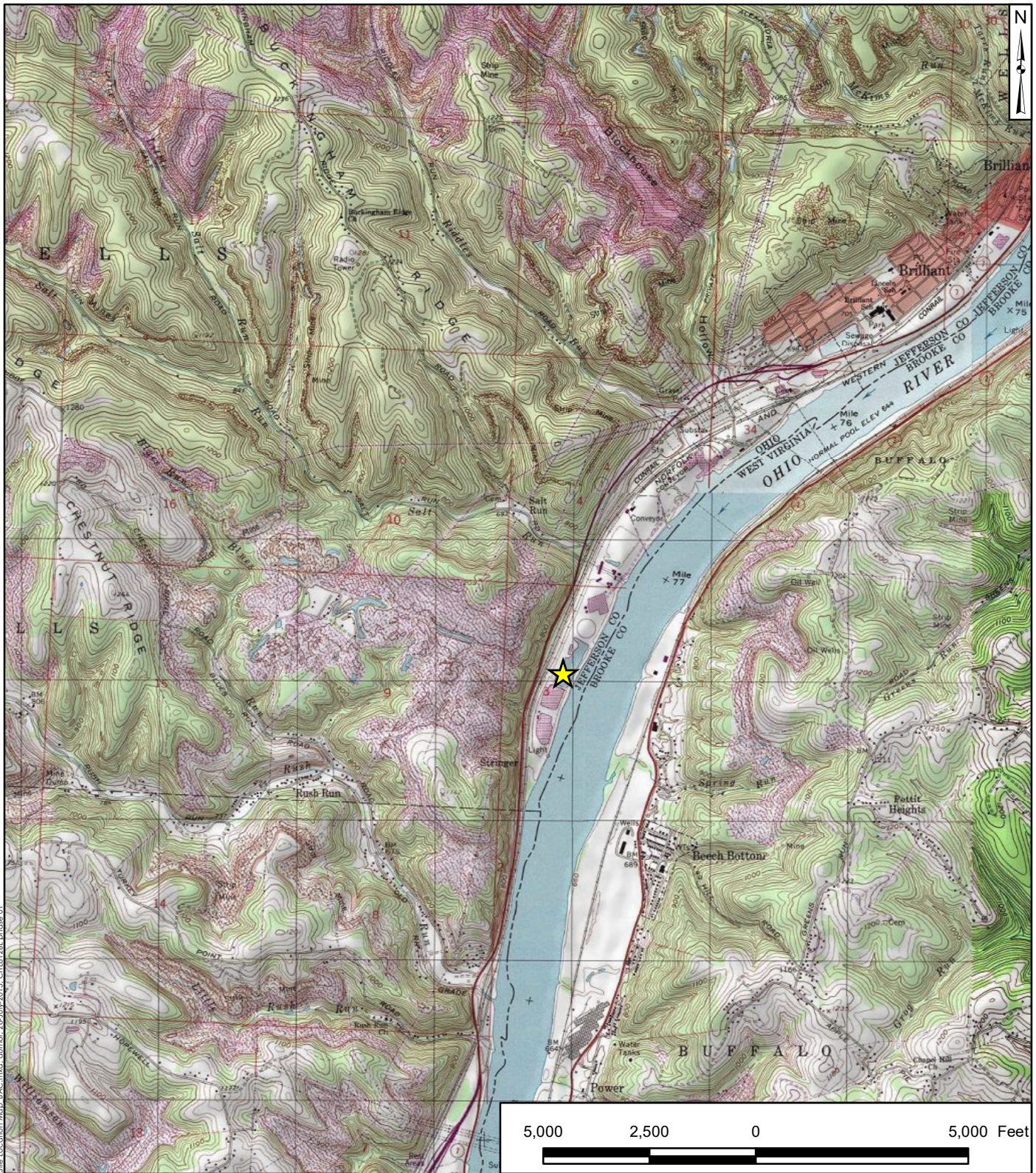
CCR Management Unit	Monitoring Well	Well Diameter (inches)	2020-04		2020-10	
			Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Bottom Ash Pond	MW-BAP-1 ^[2]	2.0	41.1	1.5	20.8	2.9
	MW-BAP-2 ^[2]	2.0	25.0	2.4	19.2	3.2
	MW-BAP-3 ^[2]	2.0	22.1	2.8	18.5	3.3
	MW-BAP-4 ^[1]	2.0	34.4	1.8	15.9	3.8
	MW-BAP-5 ^[1]	2.0	11.0	5.5	9.1	6.7

Notes:

[1] - Upgradient Well

[2] - Compliance Well

FIGURES



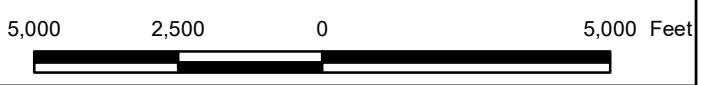
F:\Project\AEP\Cardinal\CCCE Compliance Document\Figures\Site Location Map_BAC.mxd; author: 28 July 2015; CHB1241; phase: 01

Legend

 Site Location

Notes

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



Site Location Map
Bottom Ash Pond
 Cardinal Power Plant
 Brilliant, Ohio

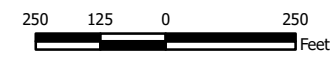
		Figure 1
Ann Arbor, Michigan	11-January-2021	



- Legend**
- ◆ Compliance Sampling Location
 - ◆ Background Sampling Location
 - Bottom Ash Pond

Notes

- Monitoring well coordinates provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by Buckeye Power.



**Site Layout
Bottom Ash Pond**

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Figure

2

Columbus, Ohio

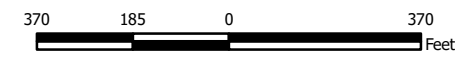
2021/01/11



- Legend**
- ⊕ Groundwater Monitoring Well
 - ➔ Approximate Groundwater Flow Direction
 - Groundwater Elevation Contour
 - ⬡ Bottom Ash Pond

Notes

- Monitoring well coordinates and water level data (collected on April 6 - 7, 2020) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016).
- Groundwater elevation units are feet above mean sea level.



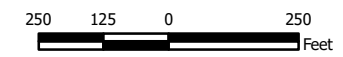
Potentiometric Surface Map - Uppermost Aquifer Bottom Ash Pond April 2020 Buckeye Power Cardinal Generating Plant Brilliant, Ohio		Figure 3
Columbus, Ohio	2021/01/04	



- Legend**
- ⊕ Groundwater Monitoring Well
 - ➔ Approximate Groundwater Flow Direction
 - Groundwater Elevation Contour
 - ⬡ Bottom Ash Pond

Notes

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



Potentiometric Surface Map - Uppermost Aquifer Bottom Ash Pond October 2020 Buckeye Power Cardinal Generating Plant Brilliant, Ohio		Figure 4
Columbus, Ohio	2021/01/11	