

**2019 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
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. 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 Plant in Brilliant, Ohio (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2019.

2. SITE DESCRIPTION

2.1 Site Description

The Site is located one-mile south of Brilliant, Ohio in Jefferson County (**Figure 1**) and is operated by Buckeye Power, Inc. (Buckeye Power). 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. Site features and locations are outlined in **Figure 2**.

2.2 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 Site 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).

3. 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.

4. CCR RULE GROUNDWATER KEY ACTIVITIES COMPLETED

4.1 2018 Statistical Evaluation Activities

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, 2017). 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. GWPSs determined in 2018 are provided in the *2018 Annual Groundwater Monitoring Report* (Geosyntec, 2019a).

A statistical evaluation of the 2018 assessment monitoring data compared against the GWPSs was completed in January 2019 and is described in the *Statistical Analysis Summary – Bottom Ash Pond* (Geosyntec, 2019b). The statistical analysis report included an evaluation of 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 2018 assessment monitoring events. No SSLs were identified at the BAP. SSIs for boron and chloride were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3 and SSIs for fluoride were identified at MW-BAP-1 and MW-BAP-2 (Geosyntec, 2019b). Based on these results, the CCR unit remained in assessment monitoring.

4.2 2019 Sampling and Data Evaluation Activities

4.2.1 Assessment Monitoring Program

The BAP remained in assessment monitoring throughout 2019. Assessment monitoring sampling events were conducted in April and October 2019 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 1**. A revision of the GWPS and statistical evaluation of the 2019 assessment monitoring data is ongoing and will be completed outside of the timeframe of this report.

4.2.2 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 2019 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 1.4 days at well MW-BAP-3 to 6.5 days at MW-BAP-2 and MW-BAP-3. A summary of hydraulic gradients and groundwater residence times at the BAP is provided in **Table 2**.

4.2.3 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 2019 were considered complete and usable.

5. PROBLEMS ENCOUNTERED AND RESOLUTIONS

No problems were encountered during 2019 that were related to assessment monitoring activities at the BAP. No monitoring wells were gauged dry, abandoned, or added to the well network during 2019. All analytical data received were deemed to be of acceptable quality.

6. STATUS OF MONITORING PROGRAM

During the time period of this report, the Site has remained in assessment monitoring. Assessment monitoring events were conducted in April and October 2019. The BAP's status will be re-evaluated after completion of the ongoing statistical evaluation.

7. PLANNED KEY ACTIVITIES FOR 2020

The following activities are planned for 2020 at the BAP:

- The 2019 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 2019 assessment monitoring event will be completed in January 2020, which will evaluate potential SSIs against revised GWPSs. The BAP's monitoring well status will be confirmed following the evaluation;
- 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 2020 Annual Groundwater Monitoring will be prepared for submittal in January 2021.

8. REFERENCES

Geosyntec Consultants, Inc. 2016. Groundwater Monitoring Network Evaluation, Cardinal Site – Bottom Ash Pond, July.

Geosyntec Consultants, Inc. 2017. Statistical Analysis Plan. January.

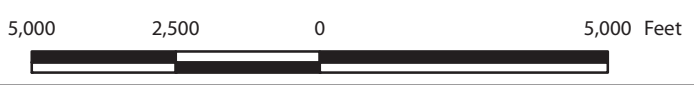
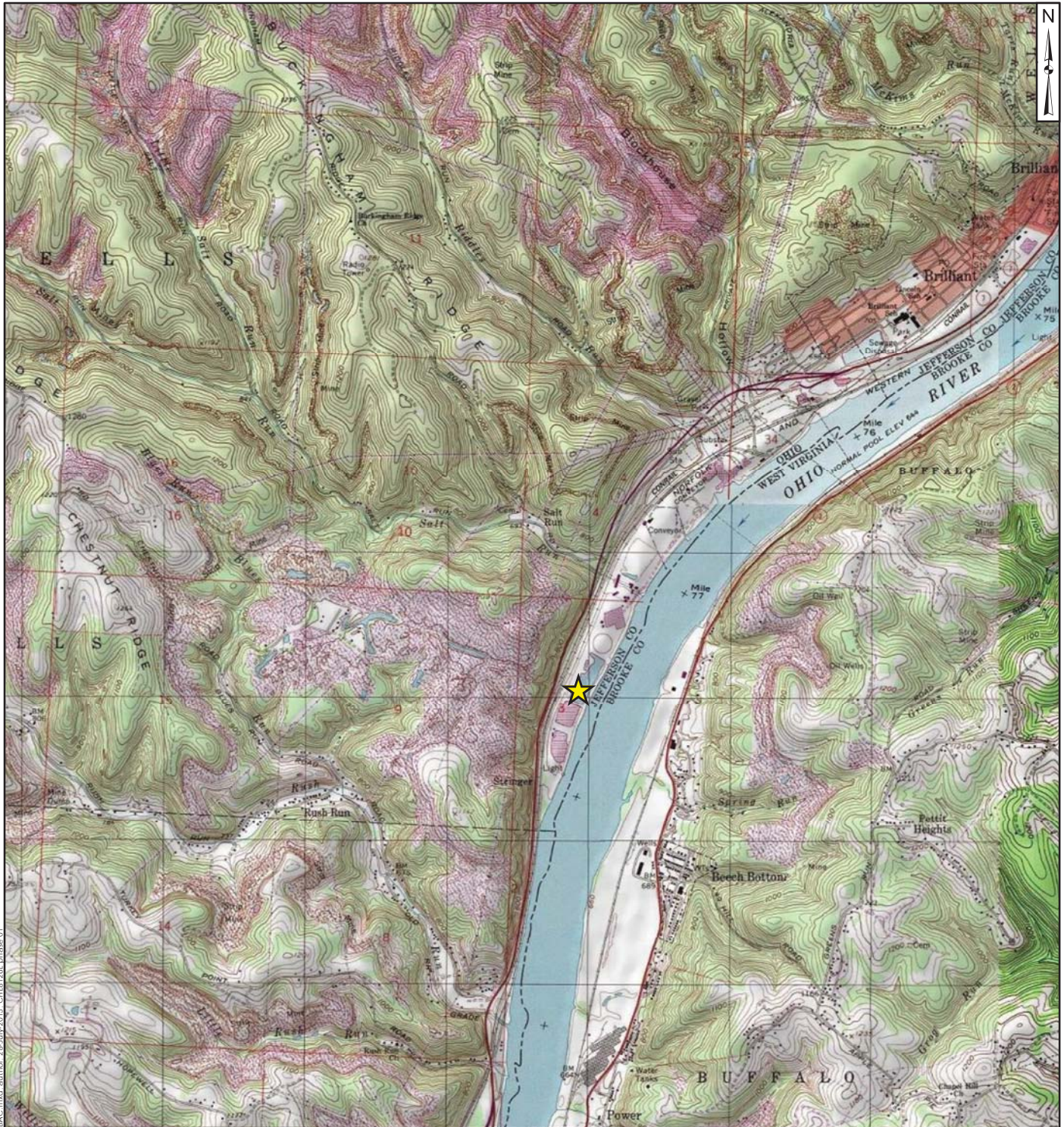
Geosyntec Consultants, Inc. 2019a. 2018 Annual Groundwater Monitoring Report, Federal CCR Rule, Cardinal Plant – Bottom Ash Pond. January.

Geosyntec Consultants, Inc. 2019b. Statistical Analysis Summary – Bottom Ash Pond, Cardinal Plant. 2019.

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.

FIGURES



Legend

★ Site Location

Notes

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

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

Geosyntec consultants

Ann Arbor, Michigan 28-July-2015

Figure
1

P:\Project\AEP\Cardinal\NCE Compliance Document\Figures\Site Location Map.ppt BAC.mxd author: 28 July 2015 - CHEE1261 (phase 01)

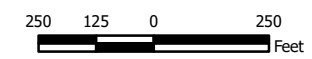


Monitoring Well Network

- ◆ 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 Complex**

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio

2018/01/25

Figure

2

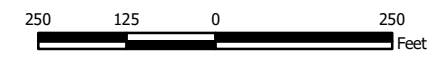


Legend

- ⊕ Groundwater Monitoring Well
- ➔ Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- - - Groundwater Elevation Contour (Inferred)

Notes

- Monitoring well coordinates and water level data (collected on March 21, 2019) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.



**Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
March 2019**

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

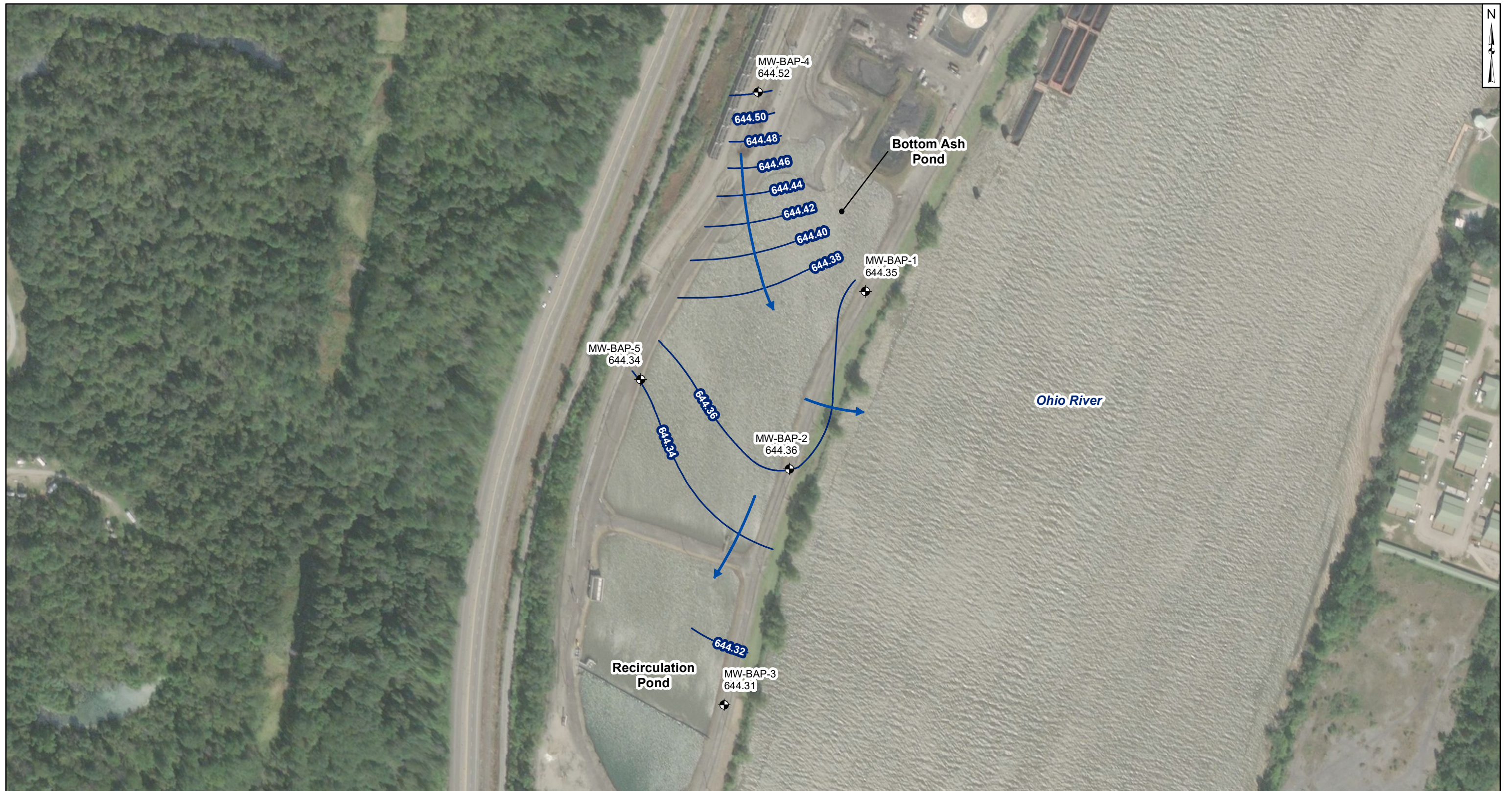
Geosyntec
consultants

Figure

3

Columbus, Ohio

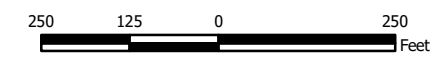
2020/01/03



- Legend**
- ⊕ Groundwater Monitoring Well
 - ➔ Approximate Groundwater Flow Direction
 - Groundwater Elevation Contour

Notes

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



**Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
October 2019**

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
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Figure

4

Columbus, Ohio

2019/12/31

TABLES

**Table 1 - Groundwater Data Summary
Cardinal Plant - Bottom Ash Pond**

Parameter	Unit	BAP-1		BAP-2		BAP-3		BAP-4		BAP-5	
		4/8/2019	10/9/2019	4/8/2019	10/9/2019	4/8/2019	10/10/2019	4/8/2019	10/10/2019	4/8/2019	10/10/2019
Antimony	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Arsenic	µg/L	0.500 U	0.500 U	122	34.9	0.500 U	0.500 U	39.0	54.8	5.20	5.80
Barium	µg/L	52.3	50.0	225	121	44.4	44.3	42.4	47.1	77.4	83.4
Beryllium	µg/L	0.100 U	0.100 U	0.260	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Boron	µg/L	2,680	3,050	1,960	1,560	2,020	2,100	19.8	19.5	92.0	118
Cadmium	µg/L	0.130	0.120	0.230	0.100 U	0.100 U	0.100	0.100 U	0.100 U	0.100 U	0.100 U
Calcium	µg/L	167,000	158,000	91,100	82,800	76,000	71,900	209,000	184,000	224,000	213,000
Chloride	mg/L	64.7	68.9	59.4	64.5	64.6	68.4	20.9	25.3	14.9	16.7
Chromium	µg/L	1.00 U	1.00 U	5.50	1.00 U	1.00 U	1.00 U	1.20	1.70	1.00 U	2.20
Cobalt	µg/L	1.00	0.700	4.60	1.20	0.570	0.500 U	17.8	19.1	1.00	1.10
Combined Radium	pCi/L	1.10	6.52	0.617	1.06	0.552	0.371	0.564	1.48	0.765	1.27
Fluoride	mg/L	0.380	0.370	0.800	0.560	0.140	0.110	0.150	0.140	0.0990	0.0680
Lead	µg/L	0.500 U	0.500 U	5.30	0.500 U	0.500 U	0.500 U	1.20	1.40	1.10	1.20
Lithium	µg/L	17.1	19.8	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Mercury	µg/L	0.000500 U	0.000500 U	0.00965	0.000670	0.000500 U	0.000500 U	0.00186	0.00117	0.00123	0.000785
Molybdenum	µg/L	30.4	32.3	36.3	40.0	1.30	1.60	1.30	1.40	0.500 U	0.500 U
Selenium	µg/L	0.500 U	0.500 U	0.570	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Sulfate	mg/L	419	416	167	202	149	164	471	560	404	433
Thallium	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Total Dissolved Solids	mg/L	905	874	563	484	415	425	1,260	1,210	1,050	983
pH	SU	6.82	7.10	7.12	6.95	6.53	6.05	6.35	6.26	6.65	6.43

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter

SU: standard unit

pCi/L: picocuries per liter

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

J: Estimated value. Parameter was detected in concentrations below the reporting limit

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

**Table 2: Residence Time Calculation Summary
Cardinal Plant - Bottom Ash Pond**

CCR Management Unit	Monitoring Well	Well Diameter (inches)	2019-03		2019-10	
			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	30.6	2.0	32.4	1.9
	MW-BAP-2 ^[2]	2.0	9.4	6.5	12.4	4.9
	MW-BAP-3 ^[2]	2.0	20.8	2.9	9.3	6.5
	MW-BAP-4 ^[1]	2.0	16.6	3.7	42.8	1.4
	MW-BAP-5 ^[1]	2.0	10.1	6.0	20.1	3.0

Notes:

[1] - Upgradient Well

[2] - Compliance Well