

**2018 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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January 2019

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## LIST OF ACRONYMS AND ABBREVIATIONS

BAP	Bottom Ash Pond
BAC	Bottom Ash Complex
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
LPL	Lower Prediction Limit
MCL	Maximum Contaminant Level
MW	Megawatt
RSL	Regional Screening Level
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
UPL	Upper Prediction Limit
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, 2019. 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, 2018.

## 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, 2017). 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 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  $1 \times 10^{-1}$  to  $1 \times 10^{-4}$  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 *Groundwater Monitoring Network Design Report* (Geosyntec, 2016).

The BAP groundwater monitoring 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

Eight background monitoring events were conducted between October 2016 and July 2017. Following the eight background monitoring events, the BAP progressed into detection monitoring. The first detection monitoring event was conducted in September 2017 and January 2018. Based on the results of the detection monitoring event, the unit transitioned to assessment monitoring in 2018. Assessment sampling events were completed in May and August 2018. Analytical results from the 2018 sampling events are summarized in **Table 1**.

#### 4.1 Groundwater Elevation and Flow Velocities

Prior to sampling, a synoptic round of groundwater measurements was collected from compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the May and August 2018 assessment monitoring event are presented on **Figures 3 and Figure 4**. The potentiometric maps show overall groundwater around the BAP flows southeast, towards the Ohio River. The groundwater residence time within the wells at the BAP ranged from 0.1 days at well MW-BAP-3 to 5.2 days, also at MW-BAP-3. A summary of hydraulic gradients and groundwater residence times at the FAR II is provided in **Table 2**.

#### 4.2 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.

Upon completion of the data usability assessment, the data were qualified as needed and added to the data tables. All data received during 2018 were considered complete and usable.

### **4.3 Background Statistical Evaluation**

In accordance with 40 CFR 257.94(b), groundwater samples collected during the background groundwater monitoring period were analyzed for 40 CFR 257 Appendix III and Appendix IV list parameters. The results were used to statistically determine upper prediction limits (UPLs) for all Appendix III parameters and a lower prediction limit (LPL) for pH. The *Statistical Analysis Summary-Bottom Ash Pond* report (Geosyntec, 2018) summarizes the analysis and results of the background statistical evaluation.

### **4.4 Detection Monitoring Program**

Detection monitoring events at the BAP were conducted in accordance with 40 CFR 257.94(a) of the CCR Rule. Samples collected during the detection monitoring event were analyzed for Appendix III parameters only. A statistical analysis was performed following the first detection monitoring event. Detection monitoring data was compared to the calculated UPLs and LPL, developed from background monitoring data, to identify statistically significant increases (SSIs) at the CCR unit.

The first detection monitoring event at the BAP was conducted in September 2017 and January 2018 and is described in the *Annual Groundwater Monitoring Report* (AEP, 2018). SSIs were identified using a 1-of-2 retesting procedure. An evaluation of detection monitoring analytical results is shown in **Table 3**. Boron and chloride were detected at all compliance wells above the UPLs and fluoride was detected above UPLs at MW-BAP-1 and MW-BAP-2. An alternate source was not identified for the SSIs and the CCR unit transitioned into assessment monitoring.

### **4.5 Assessment Monitoring Program**

Assessment sampling events were conducted in May and August 2018 in accordance with 40 CFR 257.95(b) and 40 CFR 257.95(d)(1). Samples from both events were analyzed for all Appendix III and Appendix IV parameters, which are provided in **Table 1**.

#### **4.6 Establishment of GWPS**

A Groundwater Protection Standard (GWPS) was established for each Appendix IV parameter in accordance with United States Environmental Protection Agency's (USEPA's) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities- Unified Guidance* (Unified Guidance; USEPA, 2009). The established GWPS was determined to be the greater value of the background concentration and the maximum contaminant level (MCL) or regional screening level (RSL) for each Appendix IV parameter. The GWPS are summarized in **Table 4**. A statistical evaluation of the 2018 assessment monitoring data compared against the GWPS is ongoing and will be completed outside of the timeframe of this report.

#### **5. PROBLEMS ENCOUNTERED AND RESOLUTIONS**

No problems were encountered during 2018 which were related to detection monitoring activities or assessment monitoring activities at the BAP. No monitoring wells were gauged dry, abandoned, or added to the well network during 2018. All analytical data received were deemed to be of acceptable quality.

#### **6. STATUS OF MONITORING PROGRAM**

The Site was in the detection monitoring program from September 2017 through January 2018. SSIs for boron, chloride, and fluoride were identified at BAP compliance wells and the CCR unit transitioned into assessment monitoring. An assessment monitoring event was conducted in May and August 2018. The BAP's monitoring status will be re-evaluated after the completion of the ongoing statistical evaluation.

#### **7. PLANNED KEY ACTIVITIES FOR 2019**

The following activities are planned for 2019 at the BAP.

- The 2018 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 2018 assessment monitoring event will be completed in January 2019 which will evaluate potential SSIs against established GWPS. The BAP's monitoring 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 a potential Statistically Significant Level (SSL) or SSI over background. The BAP's monitoring status will be confirmed following the evaluation; and
- The 2019 Annual Groundwater Monitoring will be prepared for submittal in January 2020.

## **8. REFERENCES**

American Electric Power (AEP) and Geosyntec Consultants, Inc. May 2006. Hydrogeological Investigation Report.

American Electric Power (AEP) Service Corporation. 2018. Annual Groundwater Monitoring Report, Cardinal Operating Company, Cardinal Plant, Bottom Ash Pond, January.

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

Geosyntec Consultants, Inc. 2018. Statistical Analysis Summary Bottom Ash Pond, Cardinal Plant, January 11, 2018.

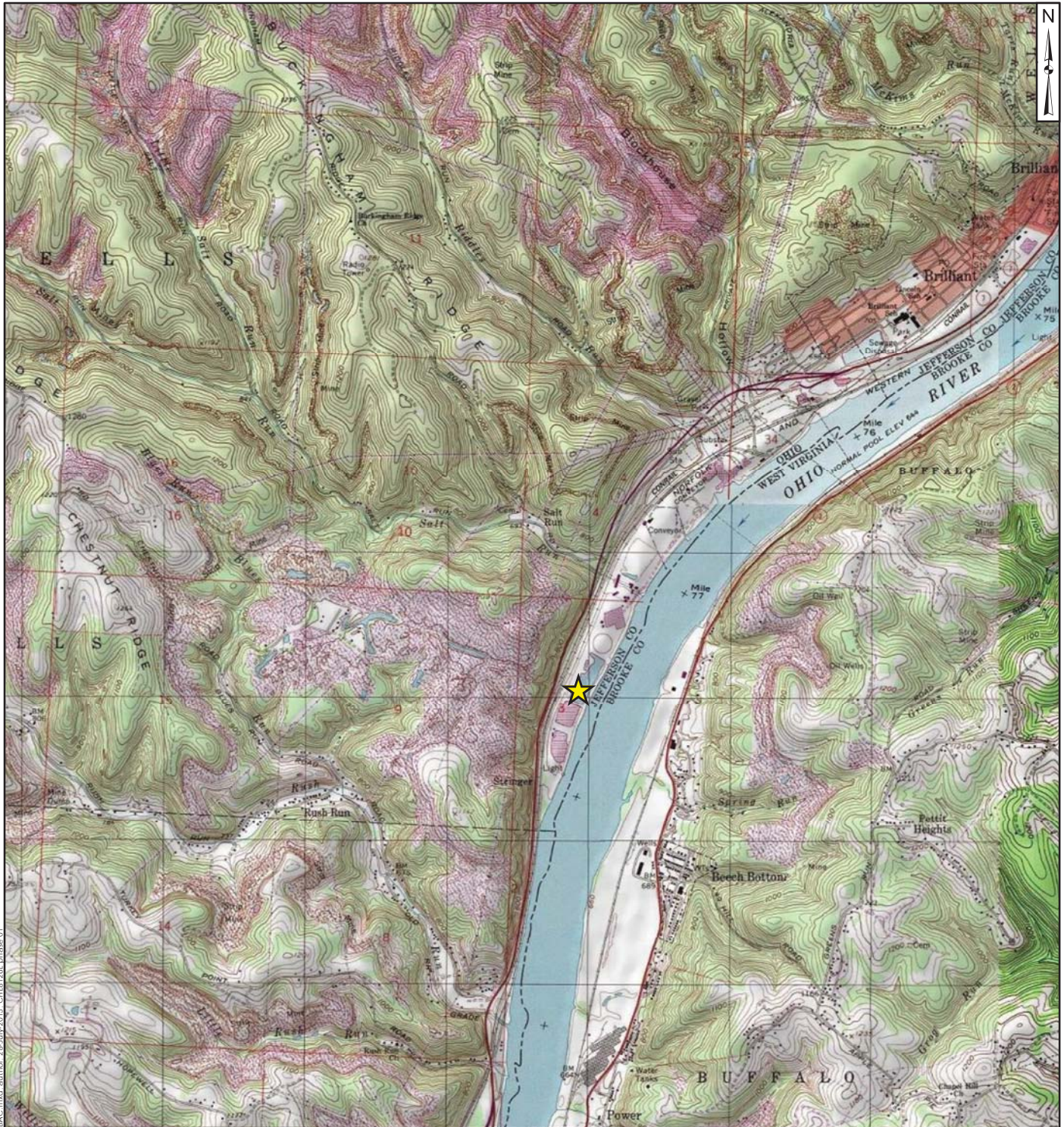
United States Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. March.

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





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

**Legend**

Site Location

**Notes**

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

5,000      2,500      0      2,500      5,000 Feet



**Site Location Map  
Bottom Ash Complex**

Cardinal Power Plant  
Brilliant, Ohio

**Geosyntec**   
consultants

Figure

**1**

Ann Arbor, Michigan

28-July-2015



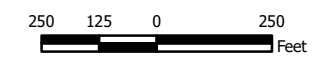


**Monitoring Well Network**

- ◆ 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**

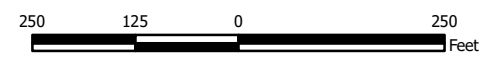




- Legend**
-  Groundwater Monitoring Well
  -  Approximate Groundwater Flow Direction
  -  Groundwater Elevation Contour

**Notes**

- Monitoring well coordinates and water level data (collected on May 14, 2018) 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.
- Groundwater elevation units are feet above mean sea level.



**Potentiometric Surface Map - Uppermost Aquifer  
Bottom Ash Complex  
May 2018**

Buckeye Power Cardinal Generating Plant  
Brilliant, Ohio

**Geosyntec**  
consultants

Figure

**3**

Columbus, Ohio

2019/01/16

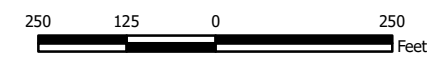




- Legend**
- ⊕ Groundwater Monitoring Well
  - ➔ Approximate Groundwater Flow Direction
  - Groundwater Elevation Contour
  - - - Groundwater Elevation Contour (Inferred)

**Notes**

- Monitoring well coordinates and water level data (collected on August 21, 2018) 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.
- Groundwater elevation units are feet above mean sea level.



**Potentiometric Surface Map - Uppermost Aquifer  
Bottom Ash Complex  
August 2018**

Buckeye Power Cardinal Generating Plant  
Brilliant, Ohio

**Geosyntec**  
consultants

Figure  
**4**

Columbus, Ohio

2019/01/17



# TABLES

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

Parameter	Unit	BAP-1			BAP-2			BAP-3			BAP-4		BAP-5	
		1/23/2018	5/17/2018	8/29/2018	1/23/2018	5/17/2018	8/29/2018	1/23/2018	5/17/2018	8/29/2018	5/21/2018	8/29/2018	5/21/2018	8/29/2018
		Detection	Assessment		Detection	Assessment		Detection	Assessment		Assessment		Assessment	
Antimony	µg/L	-	0.0400 J	0.5 U	-	0.0300 J	0.5 U	-	0.0200 J	0.5 U	0.0300 J	0.5 U	0.0400 J	0.5 U
Arsenic	µg/L	-	0.430	0.5 U	-	12.4	122	-	0.270	0.5 U	34.1	44.2	7.78	6.20
Barium	µg/L	-	56.0	57.6	-	92.3	135	-	48.1	46.8	38.8	49.7	72.1	78.7
Beryllium	µg/L	-	0.0100 J	0.1 U	-	0.0200 J	0.1 U	-	0.00800 J	0.1 U	0.0360	0.100	0.0500	0.1 U
Boron	mg/L	2.91	2.70	3.44	1.97	1.57	1.92	1.91	1.97	2.45	0.137	0.0217	0.112	0.0956
Cadmium	µg/L	-	0.100	0.140	-	0.0200	0.1 U	-	0.110	0.1 U	0.0200	0.1 U	0.0200 J	0.1 U
Calcium	mg/L	-	159	153	-	82.0	79.5	-	66.8	69.4	202	216	203	222
Chloride	mg/L	86.2	76.9	74.4	61.1	60.0	70.0	64.1	67.2	67.2	27.7	28.5	17.0	19.2
Chromium	µg/L	-	0.598	1 U	-	0.345	1 U	-	0.270	1 U	0.715	2.10	1.45	1 U
Cobalt	µg/L	-	0.649	0.790	-	1.16	1.30	-	0.521	0.5 U	19.1	20.1	0.950	0.770
Combined Radium	pCi/L	-	0.227	0.686	-	0.643	0.225	-	0.385	0.312	0.987	1.06	0.865	1.01
Fluoride	mg/L	0.370	0.380	0.360	0.390	0.490	0.620	-	0.130	0.110	0.160	0.140	0.0900	0.0930
Lead	µg/L	-	0.246	0.5 U	-	0.217	0.5 U	-	0.0720	0.5 U	0.601	1.70	1.19	0.540
Lithium	mg/L	-	0.0100	0.0166	-	0.00400	10 U	-	0.001 U	10 U	0.00600	10 U	0.00300	10 U
Mercury	µg/L	-	0.00300 J	0.00126	-	0.005 U	0.000930	-	0.005 U	0.5 U	0.005 U	0.00266	0.005 U	0.00123
Molybdenum	µg/L	-	27.4	30.6	-	37.4	36.3	-	1.73	1.50	1.31	1.50	0.460	0.510
pH	SU	7.09	7.04	6.96	6.90	6.81	6.86	6.71	6.48	6.59	6.26	6.32	6.48	6.56
Selenium	µg/L	-	0.100	0.5 U	-	0.100 J	0.5 U	-	0.0400 J	0.5 U	0.200	0.5 U	0.200	0.5 U
Total Dissolved Solids	mg/L	-	924	927	-	518	519	-	416	415	1260	1240	1030	974
Sulfate	mg/L	-	446	494	-	228	217	-	157	159	590	628	433	464
Thallium	µg/L	-	0.0610	0.5 U	-	0.0300 J	0.5 U	-	0.0680	0.5 U	0.0500 J	0.5 U	0.0300 J	0.5 U

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

-: Not sampled

**Table 2: Residence Time Calculation Summary**      *Geosyntec Consultants, Inc.*  
**Cardinal Plant - Bottom Ash Pond**

CCR Management Unit	Monitoring Well	Well Diameter (inches)	2018-05		2018-08	
			Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Bottom Ash Pond	MW-BAP-1 <sup>[2]</sup>	2.0	51.9	1.2	22.4	2.7
	MW-BAP-2 <sup>[2]</sup>	2.0	14.8	4.1	16.6	3.7
	MW-BAP-3 <sup>[2]</sup>	2.0	11.7	5.2	630.7	0.1
	MW-BAP-4 <sup>[1]</sup>	2.0	30.1	2.0	14.9	4.1
	MW-BAP-5 <sup>[1]</sup>	2.0	27.0	2.3	22.8	2.7

Notes:

[1] - Upgradient Well

[2] - Compliance Well



**Table 3: Detection Monitoring Data Evaluation  
Cardinal Plant - Bottom Ash Pond**

*Geosyntec Consultants, Inc.*

Parameter	Unit	Description	MW-BAP-1		MW-BAP-2		MW-BAP-3	
			9/26/2017	1/23/2018	9/26/2017	1/23/2018	9/26/2017	1/23/2018
Boron	mg/L	Interwell Background Value (UPL)	0.137					
	mg/L	Detection Monitoring Result	<b>2.7</b>	<b>2.91</b>	<b>1.73</b>	<b>1.97</b>	<b>2.03</b>	<b>1.91</b>
Calcium	mg/L	Interwell Background Value (UPL)	237					
	mg/L	Detection Monitoring Result	175	-	86.8	-	69.1	-
Chloride	mg/L	Interwell Background Value (UPL)	30.6					
	mg/L	Detection Monitoring Result	<b>93.7</b>	<b>86.2</b>	<b>68.2</b>	<b>61.1</b>	<b>63.8</b>	<b>64.1</b>
Fluoride	mg/L	Interwell Background Value (UPL)	0.152					
	mg/L	Detection Monitoring Result	<b>0.33</b>	<b>0.37</b>	<b>0.33</b>	<b>0.39</b>	0.1	-
pH	SU	Interwell Background Value (UPL)	7.04					
	SU	Interwell Background Value (LPL)	6.16					
	SU	Detection Monitoring Result	6.76	-	6.94	-	6.53	-
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	979.7		648.4		438.4	
	mg/L	Detection Monitoring Result	977	-	552	-	421	-
Sulfate	mg/L	Intrawell Background Value (UPL)	489		269		157	
	mg/L	Detection Monitoring Result	469	-	230	-	146	-

Notes:

UPL: Upper prediction limit

LPL: Lower prediction limit

**Bold values exceed the background value.**

Background values are shaded gray.

**Table 4: Groundwater Protection Standards  
Cardinal Plant - Bottom Ash Pond**

<b>Constituent Name</b>	<b>MCL</b>	<b>RSL</b>	<b>Calculated UTL</b>
Antimony, Total (mg/L)	0.006		0.00013
Arsenic, Total (mg/L)	0.01		0.045
Barium, Total (mg/L)	2		0.13
Beryllium, Total (mg/L)	0.004		0.00022
Cadmium, Total (mg/L)	0.005		0.00020
Chromium, Total (mg/L)	0.1		0.0056
Cobalt, Total (mg/L)	n/a	0.006	0.0203
Combined Radium, Total (pCi/L)	5		1.61
Fluoride, Total (mg/L)	4		0.16
Lead, Total (mg/L)	n/a	0.015	0.006
Lithium, Total (mg/L)	n/a	0.04	0.023
Mercury, Total (mg/L)	0.002		0.000007
Molybdenum, Total (mg/L)	n/a	0.1	0.0038
Selenium, Total (mg/L)	0.05		0.0009
Thallium, Total (mg/L)	0.002		0.00013

Notes:

Grey cell indicates calculated UTL is higher than the MCL or RSL, whichever is greater.

MCL = Maximum Contaminant Level

RSL = Regional Screening Level

Calculated UTL (Upper Tolerance Limit) represents site-specific background values. The higher of the calculated UTL or MCL/RSL is used as the GWPS.