

2020 ANNUAL GROUNDWATER MONITORING REPORT

FEDERAL CCR RULE

CARDINAL PLANT FAR I RESIDUAL SOLID WASTE LANDFILL BRILLIANT, OHIO

Submitted to



Cardinal Operating Company

306 County Road 7E
Brilliant, Ohio 43913

Submitted by

Geosyntec 
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January 24, 2021

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LIST OF ACRONYMS AND ABBREVIATIONS

CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
LPL	Lower Prediction Limit
MW	Megawatt
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
SSI	Statistically Significant Increase
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency

1. EXECUTIVE SUMMARY

Geosyntec Consultants (Geosyntec) has prepared this 2020 Annual Groundwater Monitoring Report (Report) for the Fly Ash Reservoir (FAR) I Residual Solid Waste Landfill (RSW Landfill), 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 RSW Landfill was operating under the detection monitoring program (40 CFR 257.94). The RSW Landfill remained in the detection monitoring program throughout the 2020 annual reporting period. During this annual reporting period, no statistically significant increases of Appendix III constituents over background or statistically significant levels of Appendix IV constituents above groundwater protection standards were identified.

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 no later than January 31, annually. Geosyntec Consultants (Geosyntec) has prepared this 2020 Annual Groundwater Monitoring Report (Report) for the Fly Ash Reservoir (FAR) I Residual Solid Waste Landfill (RSW Landfill) at the Cardinal 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 RSW Landfill unit is a dry landfill disposal facility located approximately one mile north of the plant site in a portion of Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) that was formerly surface mined for the Pittsburgh No. 8 coal. The footprint of the RSW Landfill overlies approximately 75 acres of the FAR I. The FAR I RSW Landfill is an existing, active CCR landfill which receives gypsum waste and solid waste from the Bottom Ash Pond. Two of the six cells of the RSW Landfill were in operation at the time the CCR rule became effective. Construction of future cells would be considered lateral expansions. The RSW Landfill uses FAR II as its leachate and stormwater collection pond (Geosyntec, 2016). Site features and locations are shown 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 feet (ft) thick in Jefferson County, consists of shale, sandstone, limestone, claystone, and coal. The Conemaugh 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, which consists 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 lies within unconsolidated mine waste, the Connellsville Sandstone, the Summerfield Limestone, and the Bellaire Sandstone. These units are underlain by a shale aquitard, which is underlain by the Morgantown Sandstone. Groundwater in the uppermost aquifer generally flows southeast towards the Ohio River with hydraulic conductivity from 1×10^{-1} to 1×10^{-9} centimeters per second (cm/s). The hydraulic conductivity of the confining shale layer ranges from 1×10^{-7} to 1×10^{-9} cm/s (AEP, 2006).

4. GROUNDWATER MONITORING SYSTEM

The RSW Landfill'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 Evaluation* (Geosyntec, 2016).

The RSW Landfill groundwater monitoring network consists of sixteen monitoring wells, shown in **Figure 2**. Nine upgradient monitoring wells (OAE 2005 10C, CA-0623A, S-2, S-GS-3, S-4, S-5, S-6, S-17, and S-19A) are used to establish background conditions and seven downgradient monitoring wells (S-GS-1, S-GS-2, S-1, S-7, S-10, S-18, and S-20) are used as compliance wells.

5. CCR RULE GROUNDWATER KEY ACTIVITIES

The RSW Landfill remained in detection monitoring during 2020. The first semi-annual detection monitoring event of 2020 was completed in April and June 2020 and the second semi-annual detection monitoring event of 2020 was completed in October 2020. Analytical results from the 2020 sampling events are summarized in **Table 1**.

5.1 Groundwater Elevation and Flow Velocities

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 2020 detection monitoring sampling events are presented in **Figure 3** and **Figure 4**, respectively. The potentiometric maps show overall groundwater around the RSW Landfill flows from northwest to southeast towards the Ohio River. The groundwater residence times within the wells at the RSW Landfill ranged from 2.1 days at well S-20 to 24.7 days at S-18. A summary of hydraulic gradients and groundwater residence times at the RSW Landfill is provided in **Table 2**.

5.2 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;
- Chain of custody forms were 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.

5.3 Detection Monitoring Program

Detection monitoring events at the RSW Landfill were conducted in accordance with 40 CFR 257.94(a) of the CCR Rule. Samples were analyzed for Appendix III parameters only, with results provided in **Table 1**.

The first semi-annual detection monitoring event of 2020 was conducted in April and June 2020. An evaluation of the first semi-annual detection monitoring sampling analytical results are shown in **Table 3**. No SSIs were identified for this detection monitoring event.

The second semi-annual detection monitoring event was conducted in October 2020. An evaluation of the second semi-annual detection monitoring sampling analytical results are shown in **Table 4**. No SSIs were identified for this detection monitoring event.

6. PROBLEMS ENCOUNTERED AND RESOLUTIONS

Problems with low water levels at monitoring wells during detection monitoring in 2020 were encountered at the RSW Landfill. Upgradient monitoring well S-17 was purged dry during sampling in the second semi-annual detection monitoring event and a sample was not collected.

No monitoring wells were abandoned or added to the network during 2020. All analytical data received were deemed to be of acceptable quality.

7. STATUS OF MONITORING PROGRAM

The Site remained in the detection monitoring program through December 2020. It is anticipated the RSW Landfill will remain in detection monitoring in 2021.

8. PLANNED KEY ACTIVITIES FOR 2021

The following activities are planned for 2021 at the RSW Landfill:

- The 2020 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site;
- Two semi-annual groundwater detection monitoring program events will be conducted and tested for SSIs over background. The RSW Landfill's monitoring status will be confirmed following the SSI evaluation;
- The calculated background values (prediction limits) will be updated following the first semi-annual detection monitoring event of 2021 in accordance with the Site's *Statistical Analysis Plan* (Geosyntec, 2020); and
- The 2021 Annual Groundwater Monitoring Report will be prepared for submittal in January 2022.

9. REFERENCES

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

Geosyntec Consultants, Inc. 2016. Groundwater Monitoring Network Evaluation, Cardinal Site – Former Fly Ash Reservoir I – Residual Solid Waste Landfill, August.

Geosyntec Consultants, Inc. 2019a. Cardinal Plant RSW Landfill Alternate Source Demonstration, April.

Geosyntec Consultants, Inc. 2019b. Statistical Analysis Summary – Background Update Calculations – Landfill, Cardinal Plant. December.

Geosyntec Consultants, Inc. 2020. Statistical Analysis Plan – Revision 01. July.

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: 2020 Groundwater Data Summary
Cardinal Plant - Landfill**

Parameter	Unit	CA-0623A		OAE-2005-10-C		S-1		S-2		S-4		S-5		S-6		S-7	
		4/9/2020	10/15/2020	4/14/2020	10/8/2020	4/16/2020	10/7/2020	4/15/2020	10/8/2020	4/14/2020	10/14/2020	4/14/2020	10/14/2020	4/14/2020	10/13/2020	4/14/2020	10/7/2020
Boron	mg/L	0.441	0.461	0.461	0.467	0.83	0.758	2.28	2.64	0.272	0.227	0.0202	0.0205	2.21	2.35	1.96	1.97
Calcium	mg/L	1.12	1.07	4.99	5.96	309	316	398	405	438	454	267	274	414	439	256	258
Chloride	mg/L	14.4	15.2	15.1	20.2	4.8	5.1	5.1	4.4	3.2	3.8	7.9	7.6	40.4	38.6	30.9	29.2
Fluoride	mg/L	2.1	2.1	1.3	1.3	0.13	0.2	0.43	0.37	0.25	0.23	0.093	0.094	0.12	0.14	0.15	0.17
pH	SU	8.6	9.2	7.9	8.0	7.2	7.2	7.5	7.5	8.1	7.5	8.1	7.6	7.4	7.2	7.7	7.4
Sulfate	mg/L	22.8	23.2	320	294	899	963	1900	1830	1430	1380	661	693	1260	1390	1010	1100
Total Dissolved Solids	mg/L	611	591	1320	1280	1780	1770	2940	2900	2460	2440	1280	1270	2460	2340	1850	1730

Parameter	Unit	S-10		S-17		S-18		S-20		S-19A		SGS-1		SGS-2			SGS-3	
		4/14/2020	10/15/2020	4/21/2020	10/8/2020 ⁽¹⁾	4/14/2020	10/9/2020	4/20/2020	10/12/2020	4/15/2020	10/8/2020	4/14/2020	10/15/2020	4/13/2020	6/3/2020	10/15/2020	4/13/2020	10/15/2020
Boron	mg/L	1.55	0.594	0.194	NS	0.549	0.561	0.245	0.272	0.357	0.391	0.794	0.865	0.467	--	0.487	0.297	0.308
Calcium	mg/L	190	271	151	NS	126	130	307	274	412	401	104	98.7	6.26	--	5.64	5.74	6.2
Chloride	mg/L	22.7	15.5	4.6	NS	2.8	2.8	3.5	3.3	2.5	3.2	23.4	24.3	103	--	101	432	458
Fluoride	mg/L	0.13	0.24	0.29	NS	0.41	0.37	0.34	0.3	0.45	0.38	0.66	0.65	3.4	2.5	3	2.4	1.9
pH	SU	7.2	6.8	6.8	NS	6.9	7.2	6.6	7.2	7.0	7.2	7.1	6.9	8.0	--	7.7	8.2	8.0
Sulfate	mg/L	694	939	702	NS	475	432	1010	911	2060	2030	848	884	28.5	--	24.7	190	183
Total Dissolved Solids	mg/L	1390	1710	1140	NS	921	902	1720	1680	2820	2880	1750	1730	1530	--	1520	1900	1890

Notes:

mg/L: milligrams per liter

SU: standard unit

NS: not sampled

(1): unable to collect sample due to insufficient water level in well

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

**Table 2: Residence Time Calculation Summary
Cardinal Plant - RSW Landfill**

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)
Residual Solid Waste Landfill	OAE-2005-10C ^[1]	2.0	16.2	3.8	3.0	20.5
	CA-0623A ^[1]	2.0	9.7	6.3	8.3	7.3
	S-1 ^[2]	1.3	9.6	4.0	6.5	5.9
	S-10 ^[2]	2.0	11.0	5.5	18.6	3.3
	S-17 ^[1]	2.0	5.5	11.0	4.3	14.3
	S-18 ^[2]	2.0	2.5	24.7	5.7	10.6
	S-19 ^[2]	2.0	3.7	16.6	3.8	15.9
	S-2 ^[2]	1.3	16.3	2.3	11.2	3.4
	S-20 ^[2]	2.0	23.5	2.6	28.5	2.1
	S-4 ^[1]	1.0	4.2	7.3	5.4	5.6
	S-5 ^[1]	1.0	3.7	8.2	4.9	6.2
	S-6 ^[1]	1.0	8.7	3.5	6.8	4.5
	S-7 ^[2]	1.0	10.6	2.9	11.0	2.8
	S-GS-1 ^[2]	2.0	4.5	13.5	6.0	10.1
	S-GS-2 ^[2]	2.0	4.3	14.3	2.6	23.3
	S-GS-3 ^[1]	2.0	13.2	4.6	14.7	4.1

Notes:

[1] - Background Well

[2] - Compliance Well

**Table 3: Detection Monitoring Data Evaluation
Cardinal Plant - RSW Landfill**

Parameter	Unit	Description	S-1	S-7	S-10	S-18	S-20	SGS-1	SGS-2	
			4/16/2020	4/14/2020	4/14/2020	4/14/2020	4/20/2020	4/14/2020	4/13/2020	6/3/2020
Boron	mg/L	Intrawell Background Value (UPL)	1.01	2.15	2.13	0.659	0.360	1.11	0.980	
		Detection Monitoring Result	0.830	1.96	1.55	0.549	0.245	0.794	0.467	--
Calcium	mg/L	Intrawell Background Value (UPL)	353	275	342	246	390	198	32.6	
		Detection Monitoring Result	309	256	190	126	307	104	6.26	--
Chloride	mg/L	Intrawell Background Value (UPL)	6.83	39.2	30.5	3.07	3.90	28.6	125	
		Detection Monitoring Result	4.80	30.9	22.7	2.80	3.50	23.4	103	--
Fluoride	mg/L	Intrawell Background Value (UPL)	0.267	0.258	0.293	0.411	0.362	0.788	3.23	
		Detection Monitoring Result	0.130	0.150	0.130	0.410	0.340	0.660	3.40	2.5
pH	SU	Intrawell Background Value (UPL)	7.5	7.9	7.7	7.4	7.9	8.8	8.8	
		Intrawell Background Value (LPL)	6.6	6.7	6.6	6.7	6.3	5.9	7.2	
		Detection Monitoring Result	7.2	7.7	7.2	6.9	6.6	7.1	8.0	--
Total Dissolved Solids (TDS)	mg/L	Intrawell Background Value (UPL)	1960	1960	1830	1980	2250	1980	2130	
		Detection Monitoring Result	1780	1850	1390	921	1720	1750	1530	--
Sulfate	mg/L	Intrawell Background Value (UPL)	1400	1180	1100	1190	1260	1050	488	
		Detection Monitoring Result	899	1010	694	475	1010	848	28.5	--

Notes:

UPL: Upper prediction limit

LPL: Lower prediction limit

Bold values exceed the background value.

Background values are shaded gray.

**Table 4: Detection Monitoring Data Summary
Cardinal Plant - RSW Landfill**

Parameter	Unit	Description	S-1	S-10	S-18	S-20	S-7	SGS-1	SGS-2
			10/7/2020	10/15/2020	10/9/2020	10/12/2020	10/7/2020	10/15/2020	10/15/2020
Boron	mg/L	Intrawell Background Value (UPL)	1.01	2.13	0.659	0.360	2.15	1.11	0.980
		Analytical Result	0.758	0.594	0.561	0.272	1.97	0.865	0.487
Calcium	mg/L	Intrawell Background Value (UPL)	353	342	246	390	275	198	32.6
		Analytical Result	316	271	130	274	258	98.7	5.64
Chloride	mg/L	Intrawell Background Value (UPL)	6.83	30.5	3.07	3.90	39.2	28.6	125
		Analytical Result	5.10	15.5	2.80	3.30	29.2	24.3	101
Fluoride	mg/L	Intrawell Background Value (UPL)	0.267	0.293	0.411	0.362	0.258	0.788	3.23
		Analytical Result	0.200	0.240	0.370	0.300	0.170	0.650	3.00
pH	SU	Intrawell Background Value (UPL)	7.5	7.7	7.4	7.9	7.9	8.8	8.8
		Intrawell Background Value (LPL)	6.6	6.6	6.7	6.3	6.7	5.9	7.2
		Analytical Result	7.2	6.8	7.2	7.2	7.4	6.9	7.7
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1960	1830	1980	2250	1960	1980	2130
		Analytical Result	1770	1710	902	1680	1730	1730	1520
Sulfate	mg/L	Intrawell Background Value (UPL)	1400	1100	1190	1260	1180	1050	488
		Analytical Result	963	939	432	911	1100	884	24.7

Notes:

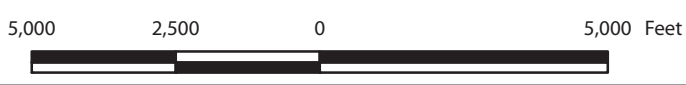
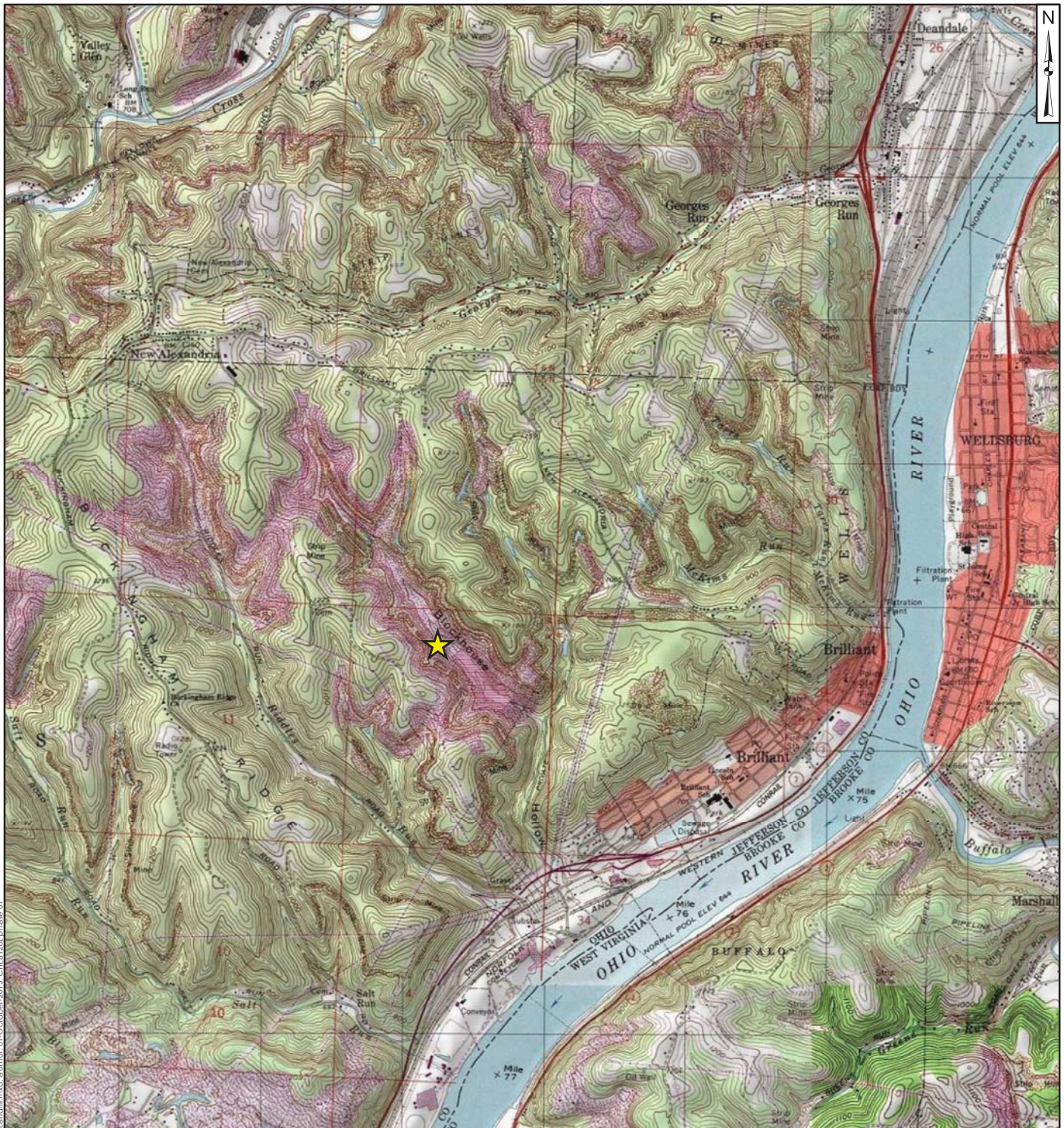
UPL: Upper prediction limit

LPL: Lower prediction limit

Bold values exceed the background value.

Background values are shaded gray.

FIGURES



Legend

 Site Location

Notes

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

**Site Location Map
RSW Landfill**

Cardinal Power Plant
Brilliant, Ohio

Geosyntec
consultants

Figure

1

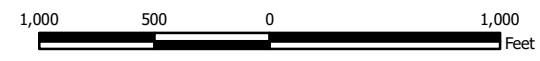
Ann Arbor, Michigan

08-Jan-2021

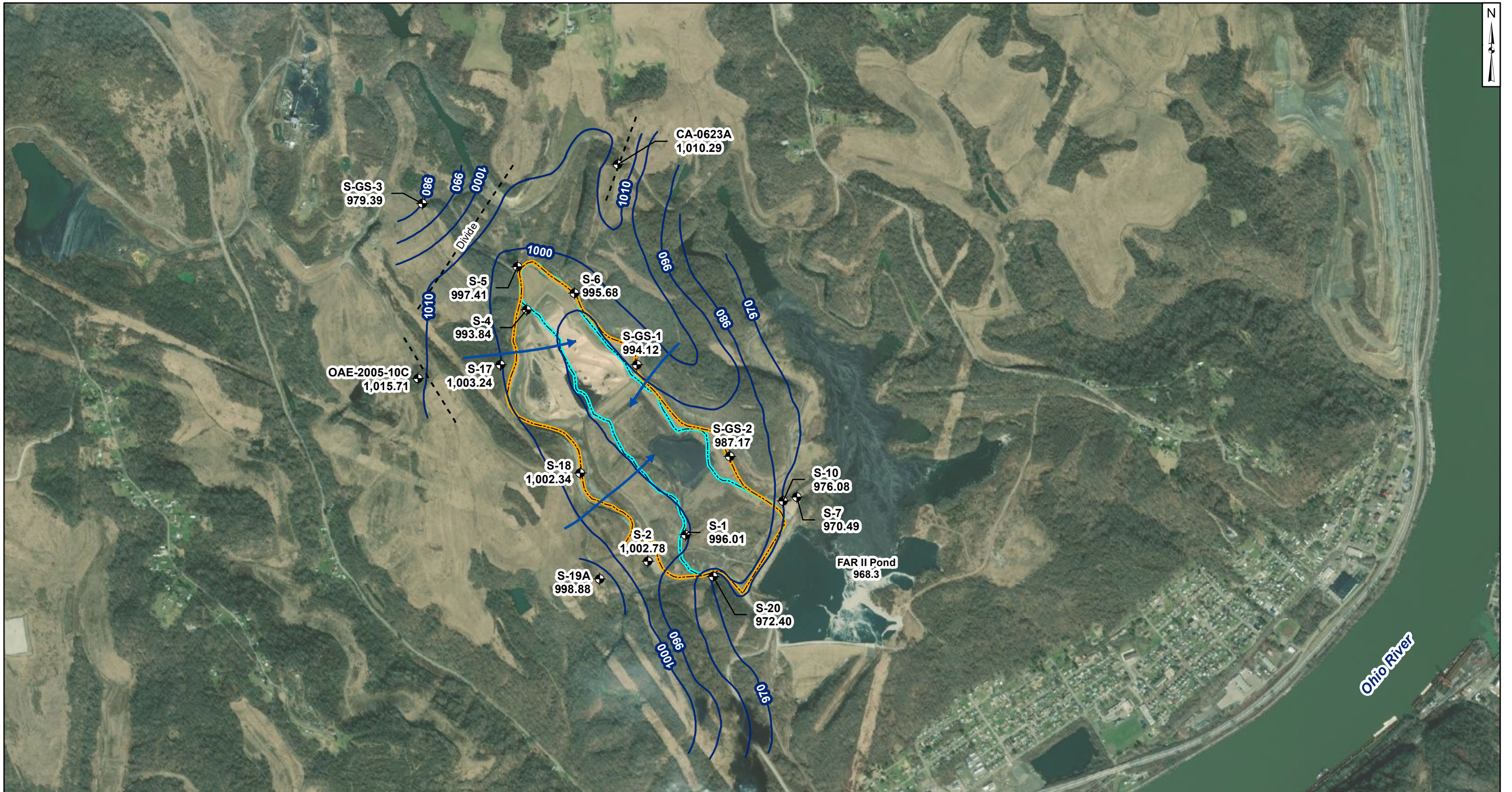


Monitoring Well Network
 ◆ Background Sampling Location
 ◆ Compliance Sampling Location
 - - - Residual Solid Waste (RSW) Landfill

Notes
 - Monitoring well coordinates provided by Buckeye Power.
 - Site features based on information available in Groundwater Monitoring Network Evaluation -Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.



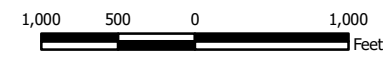
Site Layout RSW Landfill	
Buckeye Power Cardinal Generating Plant Brilliant, Ohio	
Geosyntec consultants	
Columbus, Ohio	2021/01/08
Figure 2	



- Legend**
- ⊕ Groundwater Monitoring Well
 - Groundwater Elevation Contour
 - ➔ Approximate Groundwater Flow Direction
 - ▭ Residual Solid Waste (RSW) Landfill
 - ▭ Former Fly Ash Reservoir (FAR) I

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 - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.



**Potentiometric Surface Map - Shallow Water Table
RSW Landfill
April 2020**

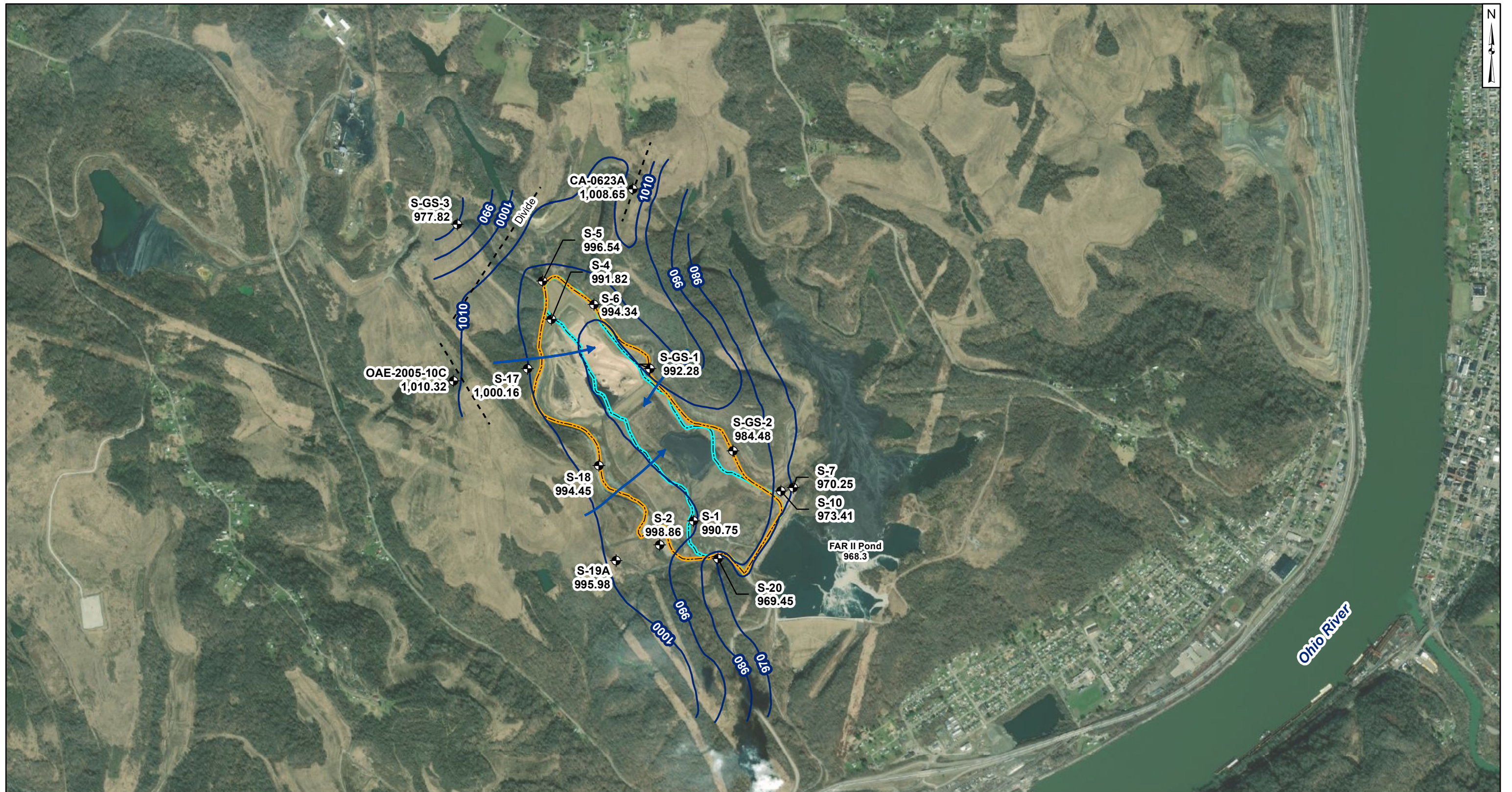
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio



Figure
3

Columbus, Ohio

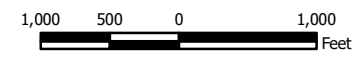
2021/01/08



- Legend**
- ⊕ Groundwater Monitoring Well
 - Groundwater Elevation Contour
 - ➔ Approximate Groundwater Flow Direction
 - ▭ Residual Solid Waste (RSW) Landfill
 - ▭ Former Fly Ash Reservoir (FAR) I
 - - - Watershed Divide

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 - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016).
- Groundwater elevation units are feet above mean sea level.



**Potentiometric Surface Map - Shallow Water Table
RSW Landfill
October 2020**

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio



Columbus, Ohio

2020/12/22

Figure
4