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**2021 Annual Groundwater Monitoring Report for  
FAR I Residual Solid Waste Landfill  
Cardinal Operating Company – Cardinal Plant  
306 County Road 7E  
Brilliant, Ohio**

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January 27, 2022

Submitted to:

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## **Executive Summary**

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2021 Annual Groundwater Monitoring Report for the Fly Ash Reservoir (FAR) I Residual Solid Waste (RSW) Landfill 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.

At the start of the 2021 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 2021 annual reporting period.

During this annual reporting period, no statistically significant increases (SSIs) above background were identified. As such, no testing for statistically significant levels (SSLs) above groundwater protection standards (GWPSs) was necessary or performed.

## **I.0 Introduction**

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2021 Annual Groundwater Monitoring Report for the Fly Ash Reservoir (FAR) I Residual Solid Waste (RSW) Landfill 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 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.

### **I.1 Site Summary**

The Site is located one mile west and south of Brilliant, Ohio in Jefferson County and is operated by Cardinal Operating Company (Cardinal). Located along the Ohio River, the generating plant 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).

### **I.2 CCR Unit Description**

The RSW Landfill unit is a dry landfill disposal facility located approximately one mile north of the 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, fly ash, and bottom ash from the Bottom Ash Pond (BAP). Two of the six cells of the RSW Landfill were in operation at the time the CCR Rules became effective. Construction of future cells would be considered lateral expansions. The RSW Landfill previously used FAR II as a leachate and stormwater collection pond (Geosyntec 2016), but these are now managed in settling tanks following initiation of FAR II closure activities in 2021.

The FAR I RSW Landfill and associated monitoring wells are shown in Figure 1-2.

### **I.3 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. 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. 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 (Geosyntec 2016).

The uppermost aquifer at the FAR I RSW Landfill is comprised of unconsolidated mine waste and shallow sandstone and limestone deposits overlying a discontinuous shale aquitard above the Morgantown Sandstone. Groundwater in the uppermost aquifer generally flows south-southeast towards the Ohio River with hydraulic conductivity ranging from  $1 \times 10^{-1}$  to  $1 \times 10^{-4}$  centimeters per second (cm/s). The hydraulic conductivity of the confining shale layer ranges from  $1 \times 10^{-7}$  to  $1 \times 10^{-9}$  cm/s (Geosyntec 2016).

## **2.0 Groundwater Monitoring System**

The FAR I RSW Landfill'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 Site. Monitoring well construction and soil boring logs were provided in the Groundwater Monitoring Network Evaluation (Geosyntec 2016).

The FAR I RSW Landfill groundwater monitoring network consists of 16 monitoring wells, shown in Figure 1-2. Nine (9) upgradient monitoring wells (0AE 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 (7) 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.<sup>1</sup>

No CCR monitoring wells were installed or decommissioned during 2021.

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<sup>1</sup> In January 2018, network monitoring wells S-2 and S-19A were switched from downgradient monitoring wells to upgradient monitoring wells based on a better understanding of groundwater flow.

## **3.0 Groundwater Monitoring Program**

In accordance with §257.94 of the CCR Rules, the FAR I RSW Landfill remained in the detection monitoring program through December 2021.

### **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 Rules. No revisions were made to the Statistical Analysis Plan during 2021.

### **3.2 Monitoring Frequency**

In accordance with §257.94 of the CCR Rules, monitoring wells are sampled semi-annually for constituents listed in Appendix III of the CCR Rules.

There was no suspension of groundwater monitoring requirements at the FAR I RSW Landfill under §257.90(g) of the CCR Rules.



## 4.0 Key Actions Completed

The sections below summarize key actions completed in 2021 with respect to CCR Rules groundwater monitoring and corrective actions at the FAR I RSW Landfill.

### 4.1 Groundwater Elevation and Flow

Prior to sampling, a synoptic round of groundwater level measurements was collected from the background and downgradient monitoring wells. Potentiometric surface maps based on groundwater elevations measured on April 5, 2021, and October 11, 2021, are presented in Figures 4-1 and 4-2, respectively. The potentiometric maps show that groundwater near the RSW Landfill flows southeast towards the Ohio River. Groundwater flow rate calculations relative to the RSW Landfill 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 at the FAR I RSW Landfill. The first (Spring) semi-annual monitoring event of 2021 was completed in April, with resampling in June 2021. The second (Fall) semi-annual monitoring event of 2021 was completed in October 2021, with resampling<sup>2</sup> conducted in December 2021 and January 2022. A total of 42 samples were collected. Analytical results are summarized in Tables 4-4 through 4-7.

### 4.3 Data Evaluation

Data evaluations performed in 2021 consisted of the following:

- Comparison of Spring 2021 monitoring data to background levels, including resampling data, for Appendix III constituents
- Comparison of Fall 2021 monitoring data, including resampling data, to background levels for Appendix III constituents

As discussed below, no statistically significant increases (SSIs) above background were identified. As such, no testing for statistically significant levels (SSLs) above groundwater protection standards (GWPSs) was necessary or performed.

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<sup>2</sup> Although one pH value for S-7 was collected in 2022 and laboratory reports for resampling of S-7, S-18, and S-20 were received in 2022, the resampling was related to the Fall 2021 sampling event. For clarity, the resampling is presented in this 2021 annual report and will not be included in the 2022 annual report.

#### **4.3.1 Background Levels**

Background levels in the FAR I RSW Landfill groundwater were established for Appendix III constituents<sup>3</sup> in December 2019. In November 2021, these background levels were updated using additional data collected since 2019.

There were no confirmed SSIs above background concentrations during 2021 groundwater monitoring (Tables 4-4 and 4-6).

#### **4.3.2 Groundwater Protection Standards**

Because there were no SSIs above background levels, the FAR I RSW Landfill remains in detection monitoring. In the absence of an SSI, there is no reason to anticipate SSLs of Appendix IV constituents above GWPSs. In accordance with CCR Rules, laboratory analysis of Appendix IV constituents was, therefore, neither necessary nor performed.

### **4.4 Corrective Actions**

In the absence of an identified release from the FAR I RSW Landfill, no corrective actions or remedies were either necessary or performed during 2021.

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<sup>3</sup> “Appendix III” and “Appendix IV” constituents refer to those constituents listed in the respective appendices of the CCR Rules. In compliance with §257.94(b) of the CCR Rules, groundwater samples collected in 2016 and 2017 were analyzed for both Appendix III and IV constituents in order to establish an initial background dataset. Since that time, there has been no need to use the background data set to establish background levels of Appendix IV constituents.

## **5.0 Problems Encountered and Resolutions**

Problems with low water levels at monitoring wells during detection monitoring in 2021 were encountered at the RSW Landfill. Monitoring well S-17 was purged dry during sampling in both semi-annual detection monitoring events and samples were not collected due to insufficient recovery. Because S-17 is an upgradient (background) well, and not a downgradient (compliance) monitoring well, the failure to collect samples from S-17 during 2021 will not result in a failure to identify an SSI.

During the April 2021 sampling event, fluoride was detected in groundwater at monitoring well S-18 at a concentration above its background level. In accordance with the Statistical Analysis Plan (Geosyntec 2020), resampling was performed in June 2021. The exceedance of background levels was not confirmed. As such, no SSI was identified.

During the October 2021 sampling event, analytical results for chloride, fluoride, sulfate, and pH at S-7, S-18, and S-20 had apparent quality control issues, as evidenced by both comparison to previous sampling results and review of results from duplicate samples collected from wells on the same day. To ensure that representative data was available for evaluation, resamples were collected in December 2021 and January 2022. The analytical data received during resampling was deemed to be of acceptable quality, as was the remainder of data collected during the initial October 2021 sampling.

No monitoring wells were abandoned or added to the network during 2021.

Because there was not an SSI above background levels, no alternative source demonstrations under §257.94(e)(2) were considered or performed during 2021.

## **6.0 Projected Key Activities**

It is anticipated that the FAR I RSW Landfill will remain in detection monitoring in 2022. The following activities are projected for the FAR I RSW Landfill:

- The 2021 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 sampling events will be conducted, and the resulting data will be evaluated for SSIs over background levels. The FAR I RSW Landfill's monitoring status will be confirmed following the SSI evaluation.
- The 2022 Annual Groundwater Monitoring Report will be prepared for submittal in January 2023.

## 7.0 References

Geosyntec. 2016. *Groundwater Monitoring Network Evaluation; Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill; Brilliant, Ohio*. Oak Brook, IL: Geosyntec Consultants.


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

# Figures

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## Legend

-  FAR I RSW Landfill
- USGS Topographical Map



0 0.5 1 1.5 2 mi



Figure




# 1-1

Site Location Map  
FAR I RSW Landfill  
Cardinal Plant  
Brilliant, Ohio



2020 Aerial Imagery from Ohio Statewide Imagery Program (OSIP)

### Legend

-  FAR I RSW Landfill
- Monitoring Wells
  -  Background
  -  Downgradient

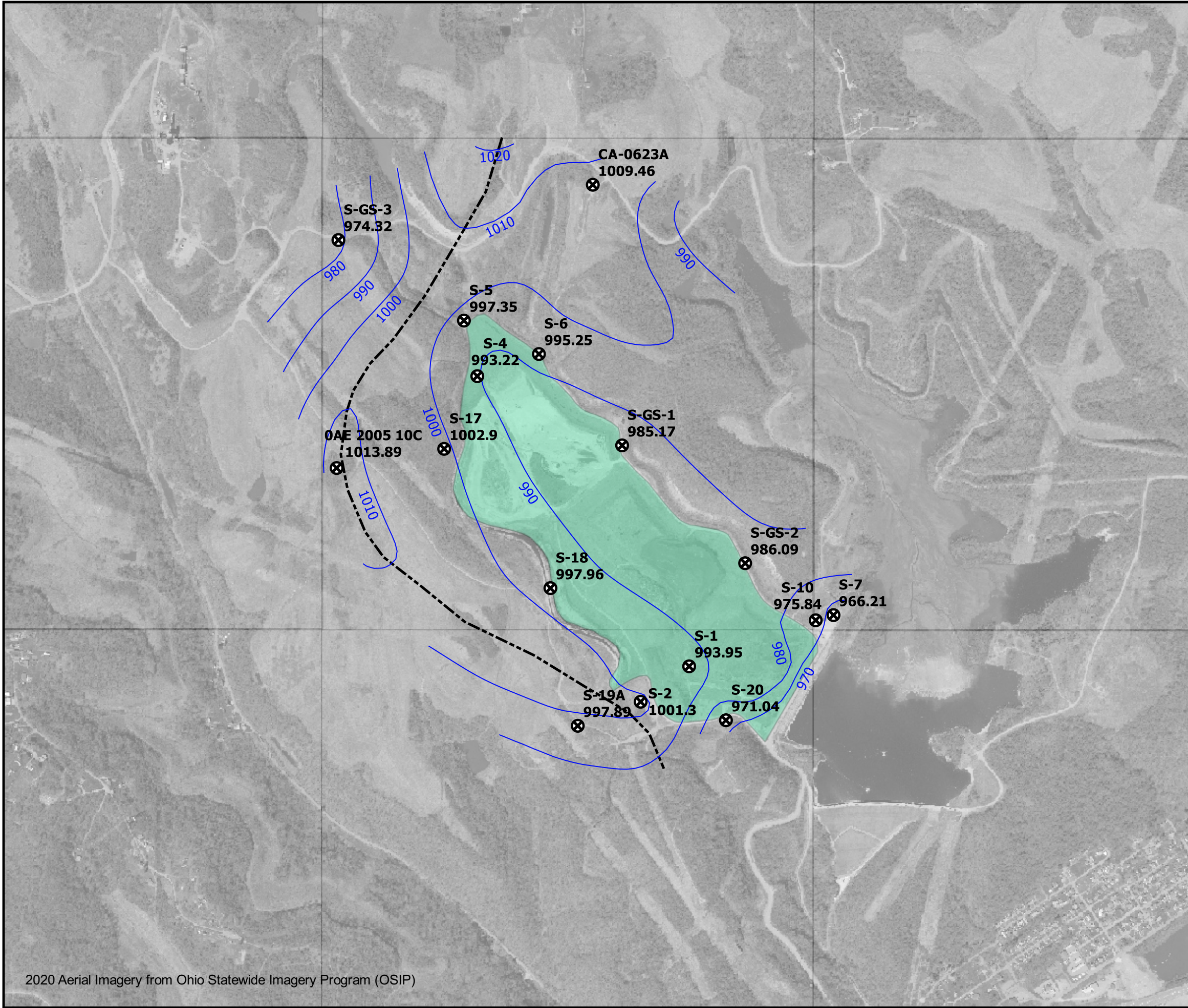


Figure





# 1-2

CCR Unit and Monitoring Wells  
 FAR I RSW Landfill  
 Cardinal Plant  
 Brilliant, Ohio





### Legend

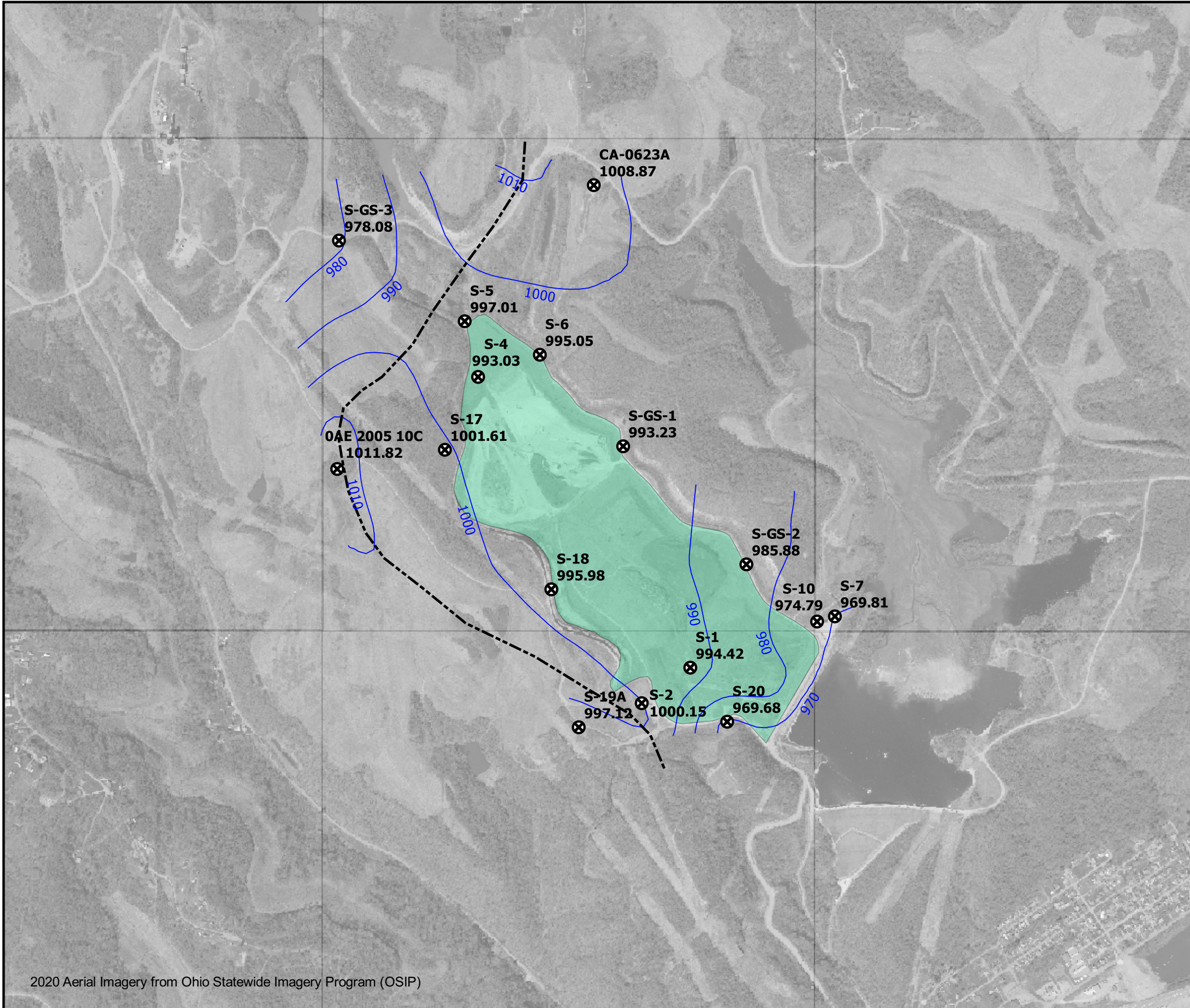
-  FAR I Network Monitoring Well and Groundwater Elevation
-  Groundwater Elevation Contour
-  FAR I RSW Landfill
-  Approximate Location of Groundwater Divide



Figure

# 4-1

Potentiometric Surface Map - Shallow Aquifer  
 FAR I RSW Landfill - April 5, 2021  
 Cardinal Plant  
 Brilliant, Ohio



2020 Aerial Imagery from Ohio Statewide Imagery Program (OSIP)

### Legend

- FAR I Network Monitoring Well and Groundwater Elevation
- Groundwater Elevation Contour
- FAR I RSW Landfill
- Approximate Location of Groundwater Divide



Figure

# 4-2

Potentiometric Surface Map - Shallow Aquifer  
 FAR I RSW Landfill - October 11, 2021  
 Cardinal Plant  
 Brilliant, Ohio

# Tables

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Tables

Table 4-1. Groundwater Flow Calculations, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, April 2021

Program	Groundwater Zone	Well	Hydraulic Location <sup>1</sup>	Depth to Water (ft)	Potentiometric Elevation (ft) <sup>2</sup>	Gradient <sup>3</sup> (ft/ft)	Hydraulic Conductivity <sup>4</sup> (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter <sup>5</sup> (in.)	Residence Time <sup>6</sup> (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
FAR I	Fly Ash Shallow	0AE 2005 10C	Upgradient	226.96	1013.89	0.00474	0.0001	0.05	0.1	0.32	0.004197	2.098579	4.197158	6	0.1	0.2	119
FAR I	Fly Ash Shallow	CA-0623A	Upgradient	153.26	1009.46	0.00526	0.0001	0.05	0.1	0.32	0.004662	2.331139	4.662279	6	0.1	0.2	107
FAR I	Fly Ash Shallow	S-1	Downgradient	8.46	993.95	0.00921	0.0001	0.05	0.1	0.32	0.008158	4.078990	8.157980	3	0.0	0.1	31
FAR I	Fly Ash Shallow	S-2	Upgradient	38.15	1001.3	0.00468	0.0001	0.05	0.1	0.32	0.004142	2.071218	4.142437	3	0.1	0.1	60
FAR I	Fly Ash Shallow	S-4	Upgradient	19.72	993.22	0.01586	0.0001	0.05	0.1	0.32	0.014051	7.025559	14.051119	3	0.0	0.0	18
FAR I	Fly Ash Shallow	S-5	Upgradient	4.85	997.35	0.01383	0.0001	0.05	0.1	0.32	0.012247	6.123415	12.246830	3	0.0	0.0	20
FAR I	Fly Ash Shallow	S-6	Upgradient	11.41	995.25	0.01329	0.0001	0.05	0.1	0.32	0.011775	5.887720	11.775440	3	0.0	0.0	21
FAR I	Fly Ash Shallow	S-7	Downgradient	44.4	966.21	0.01151	0.0001	0.05	0.1	0.32	0.010200	5.099811	10.199621	3	0.0	0.0	25
FAR I	Fly Ash Shallow	S-10	Downgradient	29.35	975.84	0.01531	0.0001	0.05	0.1	0.32	0.013559	6.779438	13.558876	6	0.0	0.1	37
FAR I	Fly Ash Shallow	S-17	Upgradient	195.1	1002.9	0.01054	0.0001	0.05	0.1	0.32	0.009340	4.669800	9.339600	6	0.1	0.1	54
FAR I	Fly Ash Shallow	S-18	Downgradient	157.41	997.96	0.00989	0.0001	0.05	0.1	0.32	0.008765	4.382302	8.764604	6	0.1	0.1	57
FAR I	Fly Ash Shallow	S-19A	Upgradient	100.71	997.89	0.01056	0.0001	0.05	0.1	0.32	0.009353	4.676267	9.352533	6	0.1	0.1	53
FAR I	Fly Ash Shallow	S-20	Downgradient	34.84	971.04	0.02187	0.0001	0.05	0.1	0.32	0.019374	9.686930	19.373860	6	0.0	0.1	26
FAR I	Fly Ash Shallow	S-GS-1	Downgradient	29.4	985.17	0.00471	0.0001	0.05	0.1	0.32	0.004174	2.086875	4.173749	6	0.1	0.2	120
FAR I	Fly Ash Shallow	S-GS-2	Downgradient	25.66	986.09	0.00474	0.0001	0.05	0.1	0.32	0.004199	2.099722	4.199445	6	0.1	0.2	119
FAR I	Fly Ash Shallow	S-GS-3	Upgradient	65.1	974.32	0.01320	0.0001	0.05	0.1	0.32	0.011693	5.846746	11.693492	6	0.0	0.1	43

K:\CCA\PROJECTS\Buckeye\_Power\Cardinal\FAR I RSW Landfill\Annual Groundwater and Corrective Measures Reports\2021\Tables\Table 4-1 - April GW Flow.xlsx\Sheet1

Measurements and calculations represent conditions on April 5, 2021.

<sup>1</sup> Groundwater Monitoring Network Evaluation; Cardinal Site – Former Fly Ash Reservoir 1 - Residual Solid Waste Landfill, Brilliant, Ohio prepared by Geosyntec Consultants in July 2016.

<sup>2</sup> Elevations datum is National Geodetic Vertical Datum of 1929 (NGVD29).

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

<sup>4</sup> Low and high conductivity values are from the 2016 Groundwater Monitoring Network Evaluation, with a representative value chosen at the midpoint of this range.

<sup>5</sup> Well diameter represents the diameter of the borehole (sandpack).

<sup>6</sup> 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, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, October 2021

Program	Groundwater Zone	Well	Hydraulic Location <sup>1</sup>	Depth to Water (ft)	Potentiometric Elevation (ft) <sup>2</sup>	Gradient <sup>3</sup> (ft/ft)	Hydraulic Conductivity <sup>4</sup> (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter <sup>5</sup> (in.)	Residence Time <sup>6</sup> (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
FAR I	Fly Ash Shallow	OAE 2005 10C	Upgradient	229.03	1011.82	0.00182	0.0001	0.05	0.1	0.32	0.001612	0.805989	1.611978	6	0.3	0.6	310
FAR I	Fly Ash Shallow	CA-0623A	Upgradient	153.85	1008.87	0.01215	0.0001	0.05	0.1	0.32	0.010765	5.382540	10.765080	6	0.0	0.1	46
FAR I	Fly Ash Shallow	S-1	Downgradient	7.99	994.42	0.00976	0.0001	0.05	0.1	0.32	0.008647	4.323720	8.647440	3	0.0	0.1	29
FAR I	Fly Ash Shallow	S-2	Upgradient	39.3	1000.15	0.00635	0.0001	0.05	0.1	0.32	0.005628	2.814235	5.628469	3	0.0	0.1	44
FAR I	Fly Ash Shallow	S-4	Upgradient	19.91	993.03	0.00564	0.0001	0.05	0.1	0.32	0.004994	2.497226	4.994451	3	0.1	0.1	50
FAR I	Fly Ash Shallow	S-5	Upgradient	5.19	997.01	0.00255	0.0001	0.05	0.1	0.32	0.002263	1.131562	2.263124	3	0.1	0.2	110
FAR I	Fly Ash Shallow	S-6	Upgradient	11.61	995.05	0.00397	0.0001	0.05	0.1	0.32	0.003517	1.758520	3.517041	3	0.1	0.1	71
FAR I	Fly Ash Shallow	S-7	Downgradient	40.8	969.81	0.00769	0.0001	0.05	0.1	0.32	0.006814	3.406851	6.813702	3	0.0	0.1	37
FAR I	Fly Ash Shallow	S-10	Downgradient	30.4	974.79	0.01316	0.0001	0.05	0.1	0.32	0.011656	5.827990	11.655979	6	0.0	0.1	43
FAR I	Fly Ash Shallow	S-17	Upgradient	196.39	1001.61	0.00818	0.0001	0.05	0.1	0.32	0.007243	3.621391	7.242782	6	0.1	0.1	69
FAR I	Fly Ash Shallow	S-18	Downgradient	159.39	995.98	0.00503	0.0001	0.05	0.1	0.32	0.004455	2.227601	4.455201	6	0.1	0.2	112
FAR I	Fly Ash Shallow	S-19A	Upgradient	101.48	997.12	0.00930	0.0001	0.05	0.1	0.32	0.008237	4.118339	8.236678	6	0.1	0.1	61
FAR I	Fly Ash Shallow	S-20	Downgradient	36.2	969.68	0.01419	0.0001	0.05	0.1	0.32	0.012568	6.283884	12.567769	6	0.0	0.1	40
FAR I	Fly Ash Shallow	S-GS-1	Downgradient	21.34	993.23	0.00227	0.0001	0.05	0.1	0.32	0.002011	1.005507	2.011015	6	0.2	0.5	249
FAR I	Fly Ash Shallow	S-GS-2	Downgradient	25.87	985.88	0.00863	0.0001	0.05	0.1	0.32	0.007642	3.821217	7.642434	6	0.1	0.1	65
FAR I	Fly Ash Shallow	S-GS-3	Upgradient	61.34	978.08	0.01176	0.0001	0.05	0.1	0.32	0.010414	5.207134	10.414269	6	0.0	0.1	48

K:\CCA\PROJECTS\Buckeye\_Power\Cardinal\FAR I RSW Landfill\Annual Groundwater and Corrective Measures Reports\2021\Tables\Table 4-2 - October GW Flow.xlsx\Sheet1

Measurements and calculations represent conditions on October 11, 2021.

<sup>1</sup> Groundwater Monitoring Network Evaluation; Cardinal Site – Former Fly Ash Reservoir 1 - Residual Solid Waste Landfill, Brilliant, Ohio prepared by Geosyntec Consultants in July 2016.

<sup>2</sup> Elevations datum is National Geodetic Vertical Datum of 1929 (NGVD29).

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

<sup>4</sup> Low and high conductivity values are from the 2016 Groundwater Monitoring Network Evaluation, with a representative value chosen at the midpoint of this range.

<sup>5</sup> Well diameter represents the diameter of the borehole (sandpack).

<sup>6</sup> 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, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio

Well Name	Type of Well	Sample Date	Constituents Analyzed	Purpose
0AE 2005 10C	Background	4/12/2021	Appendix III	Detection monitoring program
0AE 2005 10C	Background	10/25/2021	Appendix III	Detection monitoring program
CA-0623A	Background	4/20/2021	Appendix III	Detection monitoring program
CA-0623A	Background	10/27/2021	Appendix III	Detection monitoring program
CA-0623A	Background	10/27/2021	Appendix III	Detection monitoring program (duplicate)
S-1	Downgradient	4/15/2021	Appendix III	Detection monitoring program
S-1	Downgradient	10/13/2021	Appendix III	Detection monitoring program
S-2	Background	4/14/2021	Appendix III	Detection monitoring program
S-2	Background	10/12/2021	pH	Detection monitoring program
S-2	Background	10/13/2021	Appendix III, except pH	Detection monitoring program
S-4	Background	4/14/2021	Appendix III	Detection monitoring program
S-4	Background	10/19/2021	Appendix III	Detection monitoring program
S-5	Background	4/13/2021	Appendix III	Detection monitoring program
S-5	Background	10/19/2021	Appendix III	Detection monitoring program
S-6	Background	4/14/2021	Appendix III	Detection monitoring program
S-6	Background	10/14/2021	Appendix III	Detection monitoring program
S-7	Downgradient	4/8/2021	Appendix III	Detection monitoring program
S-7	Downgradient	10/15/2021	Appendix III	Detection monitoring program
S-7	Downgradient	1/5/2022	pH	Detection monitoring program (resample)
S-10	Downgradient	4/8/2021	Appendix III	Detection monitoring program
S-10	Downgradient	4/8/2021	Appendix III	Detection monitoring program (duplicate)
S-10	Downgradient	10/13/2021	Appendix III	Detection monitoring program
S-17	Background	4/14/2021	Appendix III	Detection monitoring program
S-17	Background	4/21/2021	Appendix III	Detection monitoring program
S-18	Downgradient	4/12/2021	Appendix III	Detection monitoring program
S-18	Downgradient	6/4/2021	Fluoride	Detection monitoring program (resample)
S-18	Downgradient	10/22/2021	Appendix III	Detection monitoring program
S-18	Downgradient	10/22/2021	Appendix III	Detection monitoring program (duplicate)
S-18	Downgradient	12/17/2021	Chloride, Fluoride, Sulfate	Detection monitoring program (resample)
S-19A	Background	4/13/2021	Appendix III	Detection monitoring program
S-19A	Background	10/25/2021	Appendix III	Detection monitoring program
S-20	Downgradient	4/9/2021	Appendix III	Detection monitoring program
S-20	Downgradient	10/21/2021	Appendix III	Detection monitoring program
S-20	Downgradient	12/17/2021	Chloride, Fluoride, Sulfate	Detection monitoring program (resample)
S-GS-1	Downgradient	4/19/2021	Appendix III	Detection monitoring program
S-GS-1	Downgradient	10/13/2021	Appendix III	Detection monitoring program
S-GS-1	Downgradient	10/13/2021	Appendix III	Detection monitoring program (duplicate)
S-GS-2	Downgradient	4/19/2021	Appendix III	Detection monitoring program
S-GS-2	Downgradient	10/13/2021	Appendix III	Detection monitoring program
S-GS-3	Background	4/8/2021	Appendix III	Detection monitoring program
S-GS-3	Background	4/8/2021	Appendix III	Detection monitoring program (duplicate)
S-GS-3	Background	10/14/2021	Appendix III	Detection monitoring program

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Table 4-4. Downgradient Well Monitoring Results, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, April and June 2021

Location		S-1	RSW	S-7	RSW	S-10	RSW	RSW	S-18	RSW	RSW	S-20	RSW	S-GS-1	RSW	S-GS-2	RSW
Sample Name		Intrawell	S-1	Intrawell	S-7	Intrawell	S-10	S-10 Dup	Intrawell	S-18	S-18	Intrawell	S-20	S-GS-1	S-GS-1	Intrawell	S-GS-2
Sample Date		Upper	4/15/2021	Upper	4/8/2021	Upper	4/8/2021	4/8/2021	Upper	4/12/2021	6/4/2021	Upper	4/9/2021	Upper	4/19/2021	Upper	4/19/2021
Sample Type		Prediction	Monitor Well	Prediction	Monitor Well	Prediction	Monitor Well	Monitor Well	Prediction	Monitor Well	Monitor Well	Prediction	Monitor Well	Prediction	Monitor Well	Prediction	Monitor Well
Laboratory	Concentration		Pace Analytical		Pace Analytical		Pace Analytical	Pace Analytical		Pace Analytical	Pace Analytical		Pace Analytical		Pace Analytical		Pace Analytical
Lab ID	Units	Limit	50285181002	Limit	50284604001	Limit	50284604002	50284604003	Limit	50284743001	50289324001	Limit	50284604005	Limit	50285372002	Limit	50285372001
<b>METALS</b>																	
Boron	MG/L	<i>1.01</i>	<b>0.757</b>	<i>2.15</i>	<b>1.74</b>	<i>2.13</i>	<b>0.712</b>	<b>0.715</b>	<i>0.659</i>	<b>0.525</b>	NA	<i>0.360</i>	<b>0.284</b>	<i>1.11</i>	<b>0.806</b>	<i>0.98</i>	<b>0.498</b>
Calcium	MG/L	<i>353</i>	<b>334</b>	<i>275</i>	<b>264</b>	<i>342</i>	<b>291</b>	<b>283</b>	<i>246</i>	<b>93</b>	NA	<i>390</i>	<b>274</b>	<i>198</i>	<b>104</b>	<i>33</i>	<b>5.62</b>
<b>INDICATORS/FIELD PARAMETERS</b>																	
Chloride	MG/L	<i>6.83</i>	<b>4.4</b>	<i>39.2</i>	<b>28.4</b>	<i>30.5</i>	<b>24.2</b>	<b>24</b>	<i>3.07</i>	<b>2.4</b>	NA	<i>3.90</i>	<b>3.4</b>	<i>28.6</i>	<b>23.9</b>	<i>125</i>	<b>99.2</b>
Fluoride	MG/L	<i>0.267</i>	<b>0.13</b>	<i>0.258</i>	<b>0.14</b>	<i>0.293</i>	<b>0.21</b>	<b>0.22</b>	<i>0.411</i>	<b>0.47</b>	<b>0.32</b>	<i>0.362</i>	<b>0.3</b>	<i>0.788</i>	<b>0.67</b>	<i>3.23</i>	<b>3</b>
pH*	SU	<i>6.6 / 7.5</i>	<b>7.02</b>	<i>6.7 / 7.9</i>	<b>7.64</b>	<i>6.6 / 7.7</i>	<b>6.78</b>	NA	<i>6.7 / 7.4</i>	<b>6.9</b>	NA	<i>6.3 / 7.9</i>	<b>6.4</b>	<i>5.9 / 8.8</i>	<b>7.04</b>	<i>7.2 / 8.8</i>	<b>7.84</b>
Sulfate	MG/L	<i>1400</i>	< 0.25	<i>1178</i>	<b>1100</b>	<i>1098</i>	<b>966</b>	<b>920</b>	<i>1192</i>	<b>661</b>	NA	<i>1257</i>	<b>976</b>	<i>1045</i>	<b>890</b>	<i>488</i>	<b>20.8</b>
Total Dissolved Solids	MG/L	<i>1961</i>	<b>1760</b>	<i>1957</i>	<b>1760</b>	<i>1828</i>	<b>1670</b>	<b>1650</b>	<i>1982</i>	<b>1100</b>	NA	<i>2248</i>	<b>1800</b>	<i>1982</i>	<b>1680</b>	<i>2125</i>	<b>1500</b>

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\* Both Upper Prediction Limit and Lower Prediction Limit  
 NA Not Analyzed  
 < Not detected at laboratory reporting limit.  
**Bold** Detection  
  Exceeded prediction limit.  
*Italics* Prediction Limit

Table 4-5. Background Well Monitoring Results, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, April 2021

Location		RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW
Sample Name		0AE-2005-10-C	CA-0623A	S-2	S-4	S-5	S-6	S-17*	S-19A	S-GS-3	S-GS-3 Dup
Sample Date		4/12/2021	4/20/2021	4/14/2021	4/14/2021	4/13/2021	4/14/2021	4/21/2021	4/13/2021	4/8/2021	4/8/2021
Sample Type		Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well
Laboratory	Concentration	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical
Lab ID	Units	50284743002	50285384002	50284863003	50284863004	50284863001	50285181001	NA	50284863002	50284606001	50284606002
<b>METALS</b>											
Boron	MG/L	<b>0.451</b>	<b>0.461</b>	<b>2.9</b>	<b>0.248</b>	<b>0.0199</b>	<b>2.3</b>	NA	<b>0.39</b>	<b>0.277</b>	<b>0.28</b>
Calcium	MG/L	<b>5.01</b>	<b>1.05</b>	<b>443</b>	<b>459</b>	<b>290</b>	<b>418</b>	NA	<b>414</b>	<b>5.4</b>	<b>5.41</b>
<b>INDICATORS/FIELD PARAMETERS</b>											
Chloride	MG/L	<b>15.2</b>	<b>19.6</b>	<b>3.1</b>	<b>2.1</b>	<b>7</b>	<b>38.3</b>	NA	<b>1.7</b>	<b>434</b>	<b>413</b>
Fluoride	MG/L	<b>1.4</b>	<b>2.4</b>	<b>0.17</b>	<b>0.18</b>	<b>0.051</b>	<b>0.12</b>	NA	<b>0.18</b>	<b>2.3</b>	<b>2.3</b>
pH	SU	<b>7.84</b>	<b>8.53</b>	<b>6.84</b>	<b>6.67</b>	<b>6.83</b>	<b>6.75</b>	NA	<b>6.82</b>	<b>7.88</b>	NA
Sulfate	MG/L	<b>296</b>	<b>17.2</b>	<b>1890</b>	<b>1460</b>	<b>701</b>	<b>1370</b>	NA	<b>1950</b>	<b>158</b>	<b>157</b>
Total Dissolved Solids	MG/L	<b>1200</b>	<b>587</b>	<b>2810</b>	<b>2340</b>	<b>1230</b>	<b>2250</b>	NA	<b>2790</b>	<b>1970</b>	<b>1950</b>

K:\CCA\PROJECTS\Buckeye\_Power\Cardinal\FAR I RSW Landfill\Annual Groundwater and Corrective Measures Reports\2021\Tables\Table 4-5 - Background Wells Results - Spring.xlsx\Sheet1

\* A sample was not collected because there was insufficient groundwater in the well during the April 2021 sampling event.

NA Not Analyzed

**Bold** Detection



Table 4-6. Downgradient Well Monitoring Results, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, October 2021 - January 2022

Location		S-1	RSW	S-7	RSW	RSW	S-10	RSW	S-18	RSW	RSW	RSW	S-20	RSW	RSW	S-GS-1	RSW	RSW	S-GS-2	RSW
Sample Name		Intrawell	S-1	Intrawell	S-7	S-7	Intrawell	S-10	Intrawell	S-18	S-18 Dup	S-18	Intrawell	S-20	S-20	Intrawell	S-GS-1	S-GS-1 Dup	Intrawell	S-GS-2
Sample Date		Upper	10/13/2021	Upper	10/15/2021	1/5/2022	Upper	Upper	Upper	Upper	10/22/2021	10/22/2021	Upper	Upper	Upper	Upper	Upper	Upper	Upper	Upper
Sample Type		Prediction	Monitor Well	Prediction	Monitor Well	Monitor Well	Prediction	Monitor Well	Prediction	Monitor Well	Monitor Well	Monitor Well	Prediction	Monitor Well	Monitor Well	Prediction	Monitor Well	Monitor Well	Prediction	Monitor Well
Laboratory		Limit	Pace Analytical	Limit	Pace Analytical	Test America	Limit	Pace Analytical	Limit	Pace Analytical	Pace Analytical	Pace Analytical	Limit	Pace Analytical	Pace Analytical	Limit	Pace Analytical	Pace Analytical	Limit	Pace Analytical
Lab ID	Concentration Units		50300372004		50300372010	S-7: 01/05/2022		50300372006		50301001002	50301001003	50305657005		50301001001	50305657006		50300372001	50300372002		50300372003
<b>METALS</b>																				
Boron	MG/L	1.02	<b>0.659</b>	2.21	<b>1.86</b>	NA	2.137	<b>0.838</b>	0.642	<b>0.506</b>	<b>0.499</b>	NA	0.346	<b>0.28</b>	NA	1.079	<b>0.816</b>	<b>0.81</b>	0.716	<b>0.447</b>
Calcium	MG/L	357	<b>342</b>	273	<b>264</b>	NA	335	<b>296</b>	236	<b>113</b>	<b>152</b>	NA	388	<b>275</b>	NA	133.2	<b>102</b>	<b>100</b>	18.6	<b>5.3</b>
<b>INDICATORS/FIELD PARAMETERS</b>																				
Chloride	MG/L	7.1	<b>5.1</b>	39.5	<b>26.4</b>	NA	30.9	<b>18.8</b>	3.8	<b>47.5</b>	<b>2.7</b>	2	4.1	<b>46</b>	<b>2.2</b>	28.6	<b>23.3</b>	<b>22.9</b>	122.3	<b>91.5</b>
Fluoride	MG/L	0.25	<b>0.18</b>	0.24	<b>0.17</b>	NA	0.29	<b>0.25</b>	0.42	<b>0.1</b>	<b>2.1</b>	<b>0.3</b>	0.37	<b>0.51</b>	<b>0.11</b>	0.78	<b>0.74</b>	<b>0.73</b>	3.23	<b>3.0</b>
pH*	SU	6.69 / 7.50	<b>6.76</b>	7.00 / 7.75	<b>6.85</b>	<b>7.21</b>	6.61 / 7.60	<b>6.68</b>	6.62 / 7.39	<b>6.79</b>	<b>6.79</b>	<b>7.06</b>	6.30 / 7.94	<b>6.64</b>	<b>6.75</b>	6.72 / 8.86	<b>7.01</b>	<b>7.01</b>	7.35 / 8.64	<b>7.68</b>
Sulfate	MG/L	1400	<b>1070</b>	1164	<b>1010</b>	NA	1105	<b>977</b>	1162	<b>926</b>	<b>34.3**</b>	<b>620</b>	1255	<b>390</b>	<b>952</b>	1044	<b>898</b>	<b>900</b>	208.1	<b>17.6</b>
Total Dissolved Solids	MG/L	1926	<b>1810</b>	1971	<b>1830</b>	NA	1835	<b>1630</b>	1982	<b>1080</b>	<b>1220</b>	NA	2175	<b>1740</b>	NA	1964	<b>1890</b>	<b>1740</b>	2083	<b>1590</b>

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\* Both Upper Prediction Limit and Lower Prediction Limit

NA Not Analyzed

< Not detected at laboratory reporting limit.

**Bold** Detection

**Exceeded prediction limit.**

*Italics* Prediction Limit

\*\* Although sulfate in the S-18 Dup sample collected 10/22/2021 did not exceed the upper prediction limit, it was substantially different than the S-18 sample collected the same day and previous results.

To ensure representative concentrations were available for evaluation, analysis of sulfate was performed on the resample collected 12/17/2021.

Table 4-7. Background Well Monitoring Results, FAR I RSW Landfill, Cardinal Plant, Brilliant, Ohio, October 2021

Location		RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW	RSW
Sample Name		0AE-2005-10-C	CA-0623A	CA-0623A Dup	S-2	S-2	S-4	S-5	S-6	S-17*	S-19A	S-GS-3
Sample Date		10/25/2021	10/27/2021	10/27/2021	10/12/2021**	10/13/2021**	10/19/2021	10/19/2021	10/14/2021	10/25/2021	10/25/2021	10/14/2021
Sample Type		Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well	Monitor Well
Laboratory	Concentration	Pace Analytical	Pace Analytical	Pace Analytical	Test America	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical
Lab ID	Units	50301329001	50301597001	50301597002	S-2: 10/13/2021	50300372005	50300748001	50300748002	50300372008	NA	50301329002	50300372007
<b>METALS</b>												
Boron	MG/L	<b>0.436</b>	<b>0.457</b>	<b>0.466</b>	NA	<b>2.2</b>	<b>0.235</b>	<b>0.0218</b>	<b>1.56</b>	NA	<b>0.367</b>	<b>0.3</b>
Calcium	MG/L	<b>4.77</b>	<b>1.05</b>	<b>&lt; 0.5</b>	NA	<b>410</b>	<b>479</b>	<b>284</b>	<b>181</b>	NA	<b>359</b>	<b>5.47</b>
<b>INDICATORS/FIELD PARAMETERS</b>												
Chloride	MG/L	<b>12.3</b>	<b>21.8</b>	<b>21.6</b>	NA	<b>5.6</b>	<b>3.1</b>	<b>7.8</b>	<b>25.8</b>	NA	<b>2.9</b>	<b>480</b>
Fluoride	MG/L	<b>1.4</b>	<b>1.9</b>	<b>1.9</b>	NA	<b>0.33</b>	<b>0.29</b>	<b>0.12</b>	<b>0.28</b>	NA	<b>0.41</b>	<b>2.4</b>
pH	SU	<b>8.68</b>	<b>8.83</b>	<b>8.83</b>	<b>7.01</b>	NA	<b>6.58</b>	<b>7.07</b>	<b>7.1</b>	NA	<b>7.27</b>	<b>8.07</b>
Sulfate	MG/L	<b>237</b>	<b>23.8</b>	<b>23.7</b>	NA	<b>1740</b>	<b>1520</b>	<b>702</b>	<b>951</b>	NA	<b>1880</b>	<b>121</b>
Total Dissolved Solids	MG/L	<b>1250</b>	<b>622</b>	<b>626</b>	NA	<b>2820</b>	<b>2320</b>	<b>1240</b>	<b>1820</b>	NA	<b>2930</b>	<b>1940</b>

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\* A sample was not collected because there was insufficient groundwater in monitor well S-17 during the October 2021 sampling event.

\*\* Monitor well S-2 was purged dry on 10/12/2021, with enough water obtained for only one round of field measurements. On 10/13/2021, there was sufficient recovery to collect a sample, but not for additional field parameters.

NA Not Analyzed

**Bold** Detection