Annual Groundwater Monitoring Report

Appalachian Power Company

John E. Amos Plant

Landfill CCR Management Unit

Winfield, West Virginia

January 2024

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Abbreviations:
ASD – Alternate Source Demonstration
CCR – Coal Combustion Residual
GWPS – Groundwater Protection Standard
SSI – Statistically Significant Increase
SSL – Statistically Significant Level
AMLF – Amos Landfill

I. Overview

This *Annual Groundwater Monitoring and Corrective Action Report* (Report) has been prepared to report the status of activities for the preceding year for an existing Landfill CCR unit at Appalachian Power Company's, a wholly-owned subsidiary of American Electric Power Company (AEP), John E. Amos Power Plant. The USEPA's CCR rules require that the Annual Groundwater Monitoring Report be posted to the operating record for the preceding year no later than January 31.

In general, the following activities were completed:

- Groundwater data underwent various validation tests, including tests for completeness, valid values, transcription errors, and consistent units.
- Groundwater data summary tables, groundwater velocity, and flow direction maps are included in **Appendix 1**.
- The Amos Landfill (AMLF) continued in detection monitoring throughout all of 2023.
- Data and statistical analysis not available in the previous reporting period for the November 2022 detection monitoring sampling event indicates the following Appendix III parameters exceeding background concentrations:
    - Chloride at MW-4, MW-1801, and MW-1802.

  Statistical analysis for this event was completed in May 2023. An alternative source demonstration (ASD) was successfully completed in August 2023. The AMLF continued in detection monitoring. The statistical analysis is included in **Appendix 2** and the ASD is included in **Appendix 3**.
- During the May 2023 detection monitoring sampling event the following parameters exceeded background concentrations:
    - Chloride at MW-1801 and MW-1802.

  The statistical analysis for this event was completed in October 2023 An alternative source demonstration (ASD) was successfully completed in early January 2024. The AMLF continued in detection monitoring. The statistical analysis is included in **Appendix 2** and the ASD is included in **Appendix 3**.
- A detection monitoring event was conducted at the AMLF in October 2023. From the initial sampling, potential SSI's have been noted. Those are:
    - MW-1801: Chloride
    - MW-1802: Calcium and Sulfate

  A re-sampling event will occur in the first quarter of 2024 for the above-mentioned parameters and well locations in accordance with the statistical analysis plan. If any of the above potential SSIs are confirmed following statistical analysis, an ASD will be

completed to determine if the unit can remain in detection monitoring or if it must transition to assessment monitoring in accordance with the CCR rule.

The major components of this annual report, to the extent applicable at this time, are presented in sections that follow:

- A map/aerial photograph showing the Amos Landfill CCR management unit, all groundwater monitoring wells, and monitoring well identification numbers.
- All of the monitoring data collected, including the rate and direction of groundwater flow, plus a summary showing the number of samples collected per monitoring well, the dates the samples were collected and whether the sample was collected as part of detection monitoring or assessment monitoring programs (**Appendix 1**).
- Statistical comparison of monitoring data to determine if there have been SSI(s) or SSL(s) (Attached as **Appendix 2**, where applicable);
- Discussion of the alternative source demonstrations (**Appendix 3**).
- A summary of any transition between monitoring programs or an alternate monitoring frequency, for example the date and circumstances for transitioning from detection monitoring to assessment monitoring, in addition to identifying the constituents detected at a statistically significant increase over background concentrations, if applicable (Appendix 4). This is not applicable to this report
- Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a statement as to why that happened (Appendix 5). This is not applicable to this report.
- Other information required to be included in the annual report such as assessment of corrective measures, if applicable.

In addition, this report summarizes key actions completed, and where applicable, describes any problems encountered and actions taken to resolve those problems. The report includes a projection of key activities for the upcoming year.

II. Groundwater Monitoring Well Locations and Identification Numbers

Figure 1 depicts the PE-certified groundwater monitoring network, the monitoring well locations, and their corresponding identification numbers. The groundwater monitoring well network was updated in 2020. MW-1801 and MW-1802 replaced MW-1 and MW-5.

The monitoring well distribution adequately covers downgradient and upgradient areas as detailed in the revised *Groundwater Monitoring Well Network Evaluation Report*, referenced above, that was placed on the American Electric Power CCR public internet site on June 5, 2020.The groundwater quality monitoring network includes the following:

- Five upgradient wells: MW-6, MW-7R, MW-8, MW-9, and MW-10; and
- Four downgradient wells: MW-1801, MW-1802, MW-2, and MW-4.

Legend

- Upgradient Sampling Location
- Downgradient Sampling Location
- FGD Landfill

Notes

- Monitoring well coordinates provided by AEP.

700 350 0 700 Feet

Site Layout
FGD Landfill

AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2022/01/26

Figure **1**

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\AEP-Amos_Landfill_Site_Layout_v2.mxd. ASoltero. 1/26/2022. CHA8423/04/08.

III. Monitoring Wells Installed or Decommissioned

No monitoring wells were installed or decommissioned in 2023. The network design, as summarized in the *Groundwater Monitoring Well Network Evaluation* (2020) and as posted at the CCR website for Amos Plant's John E. Amos Landfill, did not change. That network design report, viewable on the AEP CCR web site, discusses the facility location, the hydrogeological setting, the hydrostratigraphic units, the uppermost aquifer, downgradient monitoring well locations and the upgradient monitoring well locations.

IV. Groundwater Quality Data and Static Water Elevation Data, With Flow Rate and Direction Calculations and Discussion

Appendix 1 contains tables showing the groundwater quality data collected since initiating CCR background sampling through results received in 2023. Static water elevation data from each monitoring event in 2023 are also shown in **Appendix 1**, along with the groundwater velocity calculations, groundwater flow direction, and potentiometric maps developed after each sampling event.

V. Groundwater Quality Data Statistical Analysis

Appendix 2 contains the statistical analysis reports. Statistical analysis of the November 2022 detection monitoring samples was completed in May 2023. An SSI in the Appendix III parameter of chloride at MW-4, MW-1801, and MW-1802 was documented in the May 2023 *Evaluation of Detection Monitoring Data at Amos Plant's Landfill* memorandum (**Appendix 2**). An alternative source demonstration was undertaken for this parameter at these monitoring wells and it was successful. That demonstration is discussed in the next section of this report.

Statistical analysis of the May 2023 detection monitoring samples was completed in October 2023. An SSI in the Appendix III parameter of chloride at MW-1801 and MW-1802 was documented in the October 2023 *Evaluation of Detection Monitoring Data at Amos Plant's Landfill* memorandum (**Appendix 2**). An alternative source demonstration was undertaken for this parameter at these monitoring wells and it was successful. That demonstration is discussed in the next section of this report.

The October 2023 detection monitoring samples received indicate potential SSIs at the following wells:

- MW-1801: Chloride
- MW-1802: Calcium and Sulfate

The re-sampling event, in accordance with the statistical analysis plan, will be completed in the first quarter of 2024 and the final statistical analysis will follow. If any SSIs are confirmed, an

ASD will be attempted. If successful, the AMLF will remain in detection monitoring. However, if unsuccessful, the AMLF will transition into assessment monitoring.

VI. Alternative Source Demonstrations

An alternative source demonstration (ASD) relative to the Appendix III SSIs (chloride at MW-4, MW-1801, and MW-1802) resulting from the November 2022 detection monitoring event was completed in August 2023. The demonstration concluded that the groundwater quality and Appendix III indicator parameter SSIs identified in the statistical evaluation is attributable to an alternative source. The successful ASD for this event is attached in **Appendix 3**.

Because the ASD for the November 2022 samples was successful, the landfill remained in detection monitoring for the first semiannual samples of 2023.

An ASD relative to the Appendix III SSIs (chloride at MW-1801 and MW-1802) resulting from the May 2023 detection monitoring event was completed in January 2024. The demonstration concluded that the groundwater quality and Appendix III indicator parameter SSIs identified in the statistical evaluation is attributable to an alternative source. The successful ASD for this event is attached in **Appendix 3**.

VII. Discussion About Transition Between Monitoring Requirements or Alternate Monitoring Frequency

As of this annual report date there has been no transition between detection monitoring and assessment monitoring. Detection monitoring will continue in 2024 pending the results of the aforementioned statistical analysis regarding the October 2023 groundwater sampling event. If the statistical analysis of the October 2023 event confirms any SSIs, an ASD will be investigated If the ASD is successful, the AMLF will remain in detection monitoring. If the ASD is not successful, the AMLF will proceed with assessment monitoring as required by 40 CFR 257.95.

Regarding defining an alternate monitoring frequency, the groundwater velocity and monitoring well production are high enough at this facility that no modification to the semiannual assessment monitoring frequency is needed.

VIII. Other Information Required

As required by the CCR detection monitoring rules in 40 CFR 257.94, sampling all CCR wells for the Appendix III parameters was completed in 2023. All required information has been included in this annual groundwater monitoring report.

IX. Description of Any Problems Encountered in 2023 and Actions Taken

No significant problems were encountered. The low flow sampling effort went smoothly and the schedule was met to support the 2023 annual groundwater report preparation covering the groundwater monitoring activities in 2023.

X. A Projection of Key Activities for the Upcoming Year

Key activities for 2024 include:

- Complete the resampling event and statistical evaluation for the October 2023 detection monitoring potential SSIs.
- Perform an ASD, if necessary, for the October 2023 detection monitoring event if any SSIs are confirmed. If the ASD if necessary and is unsuccessful, the CCR unit will transition into assessment monitoring. If it is successful or no SSIs are confirmed, the CCR unit will continue detection monitoring on a semi-annual basis.
- Respond to any new data received in light of what the CCR rule requires.
- Preparation of the 2024 annual groundwater report.

APPENDIX 1

Figures and Tables showing the groundwater monitoring network, data collected, and the rate and direction of groundwater flow.

Table 1. Groundwater Data Summary: MW-1
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/23/2016	Background	0.044	31.1	3.45	0.09 J1	6.2	30.6	182
10/18/2016	Background	0.060	29.0	3.31	0.09	6.5	30.8	232
11/9/2016	Background	0.076	29.9	3.42	0.10	6.5	31.3	194
12/13/2016	Background	0.065	29.3	3.08	0.07 J1	6.1	27.7	250
2/9/2017	Background	0.050	26.8	3.16	0.09	6.3	27.9	234
3/16/2017	Background	0.046	28.4	3.32	0.09	7.5	29.4	216
5/23/2017	Background	0.123	30.2	3.19	0.09	6.6	28.5	215
6/21/2017	Background	0.037	28.1	4.94	0.08	6.4	31.9	204
11/1/2017	Detection	0.047	28.7	3.08	0.10	6.4	30.2	224
5/2/2018	Detection	0.134	27.2	3.22	0.10	6.5	29.9	194
11/29/2018	Detection	0.143	26.4	3.07	0.11	6.7	27.8	191
12/18/2018	Detection	0.07 J1	--	--	--	6.5	--	--
6/11/2019	Detection	0.04 J1	28.1	2.86	0.11	7.0	29.9	184
11/6/2019	Detection	0.04 J1	30.1	3.20	0.10	6.2	29.4	193

Table 1. Groundwater Data Summary: MW-1
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/23/2016	Background	0.04 J1	0.27	207	0.024	0.02 J1	0.3	0.097	0.0848	0.09 J1	0.186	0.017	< 0.002 U1	0.04 J1	0.9	0.01 J1
10/18/2016	Background	0.04 J1	0.62	206	0.050	0.03	0.627	0.306	1.24	0.09	0.567	0.017	0.002 J1	0.08 J1	1.4	0.05 J1
11/9/2016	Background	0.04 J1	0.44	210	0.036	0.03	0.564	0.200	1.001	0.10	0.450	0.020	< 0.002 U1	0.14	1.3	0.088
12/13/2016	Background	0.05 J1	1.09	232	0.100	0.01 J1	2.16	0.613	0.6701	0.07 J1	1.45	0.027	< 0.002 U1	0.11	1.7	0.02 J1
2/9/2017	Background	0.03 J1	0.37	184	0.026	0.02 J1	0.401	0.174	0.836	0.09	0.340	0.015	< 0.002 U1	0.21	1.6	0.02 J1
3/16/2017	Background	0.06	0.67	200	0.057	0.06	0.993	0.393	0.73	0.09	1.03	0.012	0.003 J1	0.10	1.1	0.02 J1
5/23/2017	Background	0.08	0.40	211	0.032	0.05	0.555	0.292	3.243	0.09	0.697	0.026	< 0.002 U1	0.11	1.1	0.01 J1
6/21/2017	Background	0.07	0.43	200	0.031	0.06	0.547	0.289	1.379	0.08	0.753	0.013	< 0.002 U1	0.10	1.2	0.02 J1

Table 1. Groundwater Data Summary: MW-2
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/23/2016	Background	0.201	1.99	4.00	1.34	8.7	12.0	362
10/17/2016	Background	0.198	1.53	4.21	1.26	9.1	11.8	354
11/8/2016	Background	0.216	1.46	4.13	1.30	8.2	11.3	378
12/13/2016	Background	0.217	1.65	2.99	1.19	8.5	7.6	350
2/8/2017	Background	0.190	1.56	2.66	1.33	8.7	7.4	374
3/14/2017	Background	0.184	1.81	3.91	1.20	8.4	7.7	354
5/23/2017	Background	0.187	1.42	4.23	1.17	8.7	8.1	354
6/21/2017	Background	0.189	1.56	3.47	1.19	8.5	7.4	356
11/1/2017	Detection	0.202	1.88	2.34	1.46	8.8	8.6	394
1/8/2018	Detection	0.251	--	--	1.07	8.4	--	353
5/1/2018	Detection	0.241	3.50	3.90	1.45	8.5	9.4	344
6/19/2018	Detection	0.338	1.79	--	1.28	8.5	--	--
9/24/2018	Detection	0.215	--	--	--	--	--	--
11/28/2018	Detection	0.235	1.84	5.09	1.15	8.5	8.5	355
12/17/2018	Detection	--	--	--	--	8.6	--	--
1/24/2019	Detection	0.218	--	--	--	--	--	--
6/11/2019	Detection	0.215	1.80	3.26	1.63	8.7	9.4	379
7/22/2019	Detection	--	--	--	1.41	8.7	--	--
11/6/2019	Detection	0.203	1.73	3.44	1.66	8.6	9.5	379
2/11/2020	Detection	--	--	--	1.37	8.5	--	--
5/5/2020	Detection	0.174	2.76	5.08	1.37	8.6	7.8	368
7/7/2020	Detection	--	2.74	--	--	8.5	--	--
11/3/2020	Detection	0.179	1.69	4.31	1.45	8.8	9.0	378
5/4/2021	Detection	0.220	2.04	3.60	1.62	8.7	8.2	386
7/21/2021	Detection	--	--	--	1.41	8.4	--	--
11/2/2021	Detection	0.221	1.80	2.85	1.70	8.6	6.97	380
3/1/2022	Detection	--	--	--	0.09	6.3	--	--
5/24/2022	Detection	0.227	1.82	3.39	1.60	6.1	9.29	370 L1
7/27/2022	Detection	--	--	--	--	8.7	--	--
11/1/2022	Detection	0.215	1.89 M1	2.93	1.63	8.8	8.31	380
5/26/2023	Detection	0.187	1.52	3.55	1.68	8.7	9.5	380
10/17/2023	Detection	0.217	2.20	3.39	1.51	8.5	8.7	360

Table 1. Groundwater Data Summary: MW-2
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/23/2016	Background	0.03 J1	6.57	51.8	0.129	0.14	1.3	1.02	0.904	1.34	1.24	0.009	< 0.002 U1	6.04	0.2 J1	0.03 J1
10/17/2016	Background	0.01 J1	3.94	25.7	0.040	0.005 J1	0.592	0.290	0.208	1.26	0.258	0.010	< 0.002 U1	3.70	0.09 J1	0.067
11/8/2016	Background	0.01 J1	3.54	23.7	0.02 J1	< 0.004 U1	0.295	0.107	0.8825	1.30	0.077	0.008	< 0.002 U1	3.84	0.05 J1	< 0.01 U1
12/13/2016	Background	0.01 J1	4.36	27.1	0.009 J1	< 0.004 U1	0.952	0.075	0.288	1.19	0.068	0.011	< 0.002 U1	6.11	0.05 J1	< 0.01 U1
2/8/2017	Background	< 0.01 U1	4.09	25.5	0.032	0.005 J1	0.571	0.287	1.109	1.33	0.279	0.009	< 0.002 U1	5.55	0.1	0.02 J1
3/14/2017	Background	0.02 J1	3.72	31.9	0.071	0.02	1.01	0.573	2.863	1.20	0.651	0.010	0.002 J1	3.46	0.2	0.02 J1
5/23/2017	Background	0.03 J1	3.59	27.2	0.043	0.009 J1	0.605	0.341	0.796	1.17	0.333	0.010	< 0.002 U1	3.70	0.1	< 0.01 U1
6/21/2017	Background	0.03 J1	3.80	27.7	0.028	0.01 J1	0.490	0.234	1.1188	1.19	0.229	0.004	0.003 J1	4.57	0.08 J1	0.03 J1

Table 1. Groundwater Data Summary: MW-4
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/23/2016	Background	0.173	0.914	14.1	1.49	9.9	10.7	368
10/18/2016	Background	0.165	0.807	13.9	1.33	9.8	11.7	386
11/7/2016	Background	0.203	0.842	14.6	1.44	9.5	11.1	376
12/13/2016	Background	0.180	0.836	15.7	1.34	9.0	8.0	372
2/8/2017	Background	0.170	0.807	14.9	1.40	9.3	8.0	412
3/14/2017	Background	0.173	0.855	14.5	1.46	8.8	7.4	381
5/23/2017	Background	0.190	0.750	15.3	1.38	9.2	7.9	390
6/20/2017	Background	0.161	0.814	15.1	1.36	9.1	7.6	392
11/1/2017	Detection	0.194	0.766	14.2	1.36	9.4	9.3	404
1/8/2018	Detection	0.145	--	--	1.37	3.3	--	--
5/1/2018	Detection	0.199	0.783	14.9	1.47	9.2	9.0	380
11/27/2018	Detection	0.188	0.807	14.1	1.42	8.8	8.8	383
6/12/2019	Detection	0.167	0.788	14.4	1.46	8.6	9.0	415
11/6/2019	Detection	0.173	0.761	14.9	1.49	9.2	9.4	382
5/5/2020	Detection	0.150	0.790	15.2	1.37	9.2	8.4	397
11/3/2020	Detection	0.157	0.783	17.1	1.53	9.4	9.7	397
1/5/2021	Detection	--	--	18.0	1.48	9.4	--	--
5/4/2021	Detection	0.168	0.695	19.7	1.50	9.2	8.8	410
7/21/2021	Detection	--	--	20.8	--	9.0	--	--
11/4/2021	Detection	0.167	0.7	21.8	1.40	9.1	7.86	390
3/1/2022	Detection	--	--	25.1	--	9.3	--	--
5/25/2022	Detection	0.171	0.95	24.2	1.34	8.3	9.79	400 L1
7/26/2022	Detection	--	0.89	--	--	9.2	--	--
11/1/2022	Detection	0.170	0.87	26.1	1.28	9.3	9.39	400
2/8/2023	Detection	--	--	27.5	--	9.2	--	--
5/26/2023	Detection	0.151	0.77	23.8	1.39	9.0	9.8	400
10/17/2023	Detection	0.165	0.90 M1	23.3	1.35	9.4	9.5	370

Table 1. Groundwater Data Summary: MW-4
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/23/2016	Background	0.01 J1	9.61	24.1	0.020	0.11	0.9	0.158	0.444	1.49	0.371	0.008	< 0.002 U1	8.82	0.09 J1	< 0.01 U1
10/18/2016	Background	< 0.01 U1	8.81	20.2	< 0.005 U1	0.006 J1	0.064	0.014	0.152	1.33	0.021	0.002	< 0.002 U1	8.01	< 0.03 U1	0.03 J1
11/7/2016	Background	< 0.01 U1	9.07	21.5	< 0.005 U1	< 0.004 U1	1.68	0.029	1.56	1.44	0.007 J1	0.003	< 0.002 U1	8.14	< 0.03 U1	< 0.01 U1
12/13/2016	Background	< 0.01 U1	9.44	22.4	< 0.005 U1	< 0.004 U1	0.169	0.011	0.16	1.34	0.009 J1	0.007	< 0.002 U1	8.94	< 0.03 U1	0.02 J1
2/8/2017	Background	< 0.01 U1	8.78	19.2	0.006 J1	< 0.004 U1	0.122	0.043	0.567	1.40	0.064	0.006	< 0.002 U1	8.15	< 0.03 U1	0.03 J1
3/14/2017	Background	< 0.01 U1	10.1	20.4	0.005 J1	0.005 J1	0.523	0.041	1.456	1.46	0.114	0.006	< 0.002 U1	9.70	< 0.03 U1	< 0.01 U1
5/23/2017	Background	0.02 J1	8.96	21.1	< 0.004 U1	< 0.005 U1	0.104	0.008 J1	0.872	1.38	0.01 J1	0.012	< 0.002 U1	8.21	< 0.03 U1	< 0.01 U1
6/20/2017	Background	0.02 J1	9.15	21.8	0.004 J1	0.005 J1	0.157	0.037	0.905	1.36	0.039	0.005	< 0.002 U1	7.86	0.05 J1	< 0.01 U1

Table 1. Groundwater Data Summary: MW-5
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/23/2016	Background	0.032	18.4	3.59	0.14	9.9	29.3	124
10/18/2016	Background	0.034	15.6	3.61	0.12	6.4	29.3	148
11/8/2016	Background	0.034	14.3	3.52	0.11	6.3	25.5	92
12/13/2016	Background	0.015	14.6	3.61	0.07	8.2	24.3	100
2/8/2017	Background	0.030	14.1	3.54	0.09	6.4	24.0	126
3/16/2017	Background	0.026	15.9	3.72	0.09	7.0	24.9	158
5/23/2017	Background	0.032	13.7	3.70	0.09	6.3	24.2	108
6/20/2017	Background	0.017	14.5	3.66	0.08	6.0	27.8	102
11/1/2017	Detection	0.046	15.6	4.09	0.09	6.1	28.4	136
1/8/2018	Detection	--	--	4.22	--	6.7	--	--
5/2/2018	Detection	0.123	14.3	4.39	0.09	6.2	26.3	122
6/20/2018	Detection	0.126	--	4.61	--	6.1	--	--
11/29/2018	Detection	0.122	14.1	4.86	0.13	7.4	24.5	113
12/17/2018	Detection	--	--	4.77	--	6.2	--	--
6/12/2019	Detection	0.02 J1	16.2	4.60	0.11	6.1	26.4	132
7/22/2019	Detection	--	--	4.61	--	6.0	--	--
11/5/2019	Detection	0.03 J1	18.3	5.21	0.10	--	28.3	131
11/6/2019	Detection	--	--	--	--	6.0	--	--
2/11/2020	Detection	--	18.5	--	--	5.8	--	--

Table 1. Groundwater Data Summary: MW-5
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/23/2016	Background	0.04 J1	0.47	93.3	0.02 J1	0.07	0.3	0.188	1.025	0.14	0.263	0.006	< 0.002 U1	0.17	0.1	0.01 J1
10/18/2016	Background	0.04 J1	0.34	82.5	0.02 J1	0.02	0.546	0.198	0.353	0.12	0.250	0.005	< 0.002 U1	0.16	0.2	0.03 J1
11/8/2016	Background	0.04 J1	0.49	80.1	0.050	0.05	0.945	0.446	1.847	0.11	0.698	< 0.0002 U1	< 0.002 U1	0.14	0.1	0.01 J1
12/13/2016	Background	0.04 J1	0.51	80.9	0.033	0.03	0.622	0.339	1.18	0.07	0.442	0.010	< 0.002 U1	0.18	0.2	0.070
2/8/2017	Background	0.02 J1	0.30	70.2	0.022	0.02 J1	0.465	0.217	0.5868	0.09	0.257	0.005	< 0.002 U1	0.14	0.1	0.02 J1
3/16/2017	Background	0.09	2.32	121	0.183	0.21	4.43	2.92	1.096	0.09	3.77	0.002	0.008	0.40	0.9	0.04 J1
5/23/2017	Background	0.06	0.21	77.7	0.01 J1	0.02	0.248	0.072	1.312	0.09	0.093	0.011	< 0.002 U1	0.14	0.09 J1	< 0.01 U1
6/20/2017	Background	0.02 J1	0.25	80.6	0.01 J1	0.03	0.291	0.092	1.141	0.08	0.097	< 0.0002 U1	< 0.002 U1	0.09 J1	0.09 J1	< 0.01 U1

Table 1. Groundwater Data Summary: MW-6
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/24/2016	Background	0.095	40.7	7.78	0.26	7.6	41.3	408
10/19/2016	Background	0.093	39.8	7.67	0.23	7.9	51.1	438
11/7/2016	Background	0.147	42.7	7.76	0.25	7.7	51.6	426
12/12/2016	Background	0.109	44.4	8.17	0.20	7.5	54.0	414
2/7/2017	Background	0.122	36.7	7.20	0.23	7.5	31.1	380
3/16/2017	Background	0.098	37.1	7.09	0.24	7.9	29.1	388
5/22/2017	Background	0.171	33.7	6.89	0.23	7.7	24.7	359
6/19/2017	Background	0.154	37.2	7.01	0.21	7.4	33.1	386
11/2/2017	Detection	0.159	41.3	7.77	0.22	7.5	51.8	440
5/1/2018	Detection	0.163	33.4	6.94	0.26	7.4	24.7	358
11/28/2018	Detection	0.156	35.8	6.85	0.24	7.6	22.9	333
6/12/2019	Detection	0.08 J1	32.8	6.85	0.28	7.7	21.9	363
11/6/2019	Detection	0.100	39.8	8.00	0.24	7.4	33.2	390
5/7/2020	Detection	0.092	37.0	6.61	0.21	7.6	14.9	349
11/4/2020	Detection	0.088	38.4	7.63	0.28	7.7	32.5	375
5/4/2021	Detection	0.101	34.7	7.33	0.27	7.5	19.0	354
11/4/2021	Detection	0.093	35.1	7.51	0.25	7.4	22.1	360
5/26/2022	Detection	0.092	45.5	8.63	0.24	7.5	19.2	350 L1
11/2/2022	Detection	0.099	42.3	8.56	0.23	7.6	23.8	360
5/31/2023	Detection	0.091	39.1	8.84	0.23	7.3	19.9	350
10/18/2023	Detection	0.096	43.4	8.44	0.23	7.4	30.7	360

Table 1. Groundwater Data Summary: MW-6
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/24/2016	Background	0.04 J1	6.03	245	0.036	0.03	0.5	0.183	2.318	0.26	0.461	0.015	< 0.002 U1	0.77	0.09 J1	0.138
10/19/2016	Background	0.02 J1	6.42	235	0.033	0.005 J1	0.413	0.148	0.697	0.23	0.381	0.015	< 0.002 U1	0.36	0.09 J1	0.02 J1
11/7/2016	Background	0.01 J1	6.64	250	0.009 J1	< 0.004 U1	0.160	0.023	2.70	0.25	0.053	0.011	< 0.002 U1	0.36	< 0.03 U1	< 0.01 U1
12/12/2016	Background	0.01 J1	7.36	246	0.006 J1	0.01 J1	0.104	0.020	1.878	0.20	0.039	0.023	< 0.002 U1	0.39	0.04 J1	0.03 J1
2/7/2017	Background	< 0.01 U1	5.47	199	0.02 J1	< 0.004 U1	0.207	0.073	1.151	0.23	0.160	0.013	< 0.002 U1	0.44	0.05 J1	0.01 J1
3/16/2017	Background	0.03 J1	4.44	224	< 0.005 U1	0.005 J1	0.498	0.028	1.844	0.24	0.048	0.009	0.003 J1	0.53	0.03 J1	< 0.01 U1
5/22/2017	Background	0.04 J1	4.58	218	0.02 J1	0.009 J1	0.175	0.063	2.40	0.23	0.117	0.019	< 0.002 U1	0.50	0.04 J1	0.01 J1
6/19/2017	Background	0.03 J1	4.86	233	0.01 J1	< 0.005 U1	0.274	0.051	1.617	0.21	0.136	0.011	< 0.002 U1	0.44	0.04 J1	< 0.01 U1

Table 1. Groundwater Data Summary: MW-7R
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/24/2016	Background	0.106	31.0	4.13	0.36	7.7	228	678
10/18/2016	Background	0.083	30.9	3.86	0.32	8.0	229	706
11/8/2016	Background	0.102	33.5	3.78	0.31	7.0	209	618
12/14/2016	Background	0.084	32.2	3.94	0.26	7.6	217	606
2/9/2017	Background	0.071	37.7	3.45	0.22	7.6	186	542
3/14/2017	Background	0.078	33.6	3.79	0.30	7.7	215	640
5/24/2017	Background	0.072	30.4	3.80	0.29	7.6	226	663
6/21/2017	Background	0.092	32.5	3.60	0.26	7.6	246	680
11/2/2017	Detection	0.109	31.7	3.59	0.28	7.6	211	636
5/1/2018	Detection	0.145	30.3	4.09	0.36	7.7	239	688
11/28/2018	Detection	0.118	44.4	3.65	0.26	7.4	201	627
6/12/2019	Detection	0.1 J1	36.8	3.75	0.35	7.4	226	700
11/6/2019	Detection	0.099	26.6	4.15	0.34	7.5	217	655
5/6/2020	Detection	0.079	41.7	3.68	0.28	7.5	208	629
11/3/2020	Detection	0.077	37.9	3.93	0.35	7.6	247	731
5/4/2021	Detection	0.096	33.0	3.86	0.37	7.6	220	708
11/4/2021	Detection	0.090	29.0	3.76	0.33	7.5	210	730
5/26/2022	Detection	0.092	38.5	3.87	0.33	7.5	219	690 L1
11/2/2022	Detection	0.087	38.8	3.89	0.31	7.6	249	720
5/30/2023	Detection	0.071	46.8	3.55	0.26	7.3	198	650
10/17/2023	Detection	0.082	37.2	3.62	0.29	7.5	225	710

Table 1. Groundwater Data Summary: MW-7R
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/24/2016	Background	0.11	8.37	60.8	0.155	0.04	1.0	0.368	1.043	0.36	1.52	0.016	0.004 J1	25.7	0.4	0.061
10/18/2016	Background	0.07	7.13	51.4	0.111	0.01 J1	0.760	0.279	0.959	0.32	0.961	0.012	0.002 J1	23.2	0.3	0.03 J1
11/8/2016	Background	0.08	5.81	42.2	0.026	0.02	2.82	0.084	1.895	0.31	0.261	0.013	< 0.002 U1	17.5	0.2	0.01 J1
12/14/2016	Background	0.09	7.33	44.3	0.028	0.01 J1	1.73	0.103	0.962	0.26	0.249	0.014	< 0.002 U1	24.6	0.2	0.02 J1
2/9/2017	Background	0.05	4.21	41.7	0.01 J1	0.01 J1	0.217	0.065	0.0996	0.22	0.156	0.012	< 0.002 U1	11.7	0.08 J1	0.02 J1
3/14/2017	Background	0.08	7.02	40.2	0.01 J1	0.01 J1	0.234	0.064	2.735	0.30	0.154	0.010	< 0.002 U1	24.6	0.1	0.02 J1
5/24/2017	Background	0.10	7.48	42.0	0.01 J1	0.01 J1	0.242	0.080	0.3888	0.29	0.171	0.016	< 0.002 U1	25.7	0.2	0.01 J1
6/21/2017	Background	0.08	6.69	39.1	0.006 J1	0.006 J1	0.154	0.043	1.497	0.26	0.064	0.010	< 0.002 U1	22.9	0.1	0.01 J1

Table 1. Groundwater Data Summary: MW-8
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/24/2016	Background	0.021	141	13.3	0.16	7.0	73.6	578
10/19/2016	Background	0.037	135	12.6	0.15	7.2	66.5	538
11/9/2016	Background	0.029	137	5.12	0.07	6.9	26.1	532
12/14/2016	Background	0.017	136	14.2	0.13	6.8	59.7	504
2/8/2017	Background	0.092	132	12.9	0.15	6.9	67.5	540
3/15/2017	Background	0.074	151	13.5	0.16	7.2	74.5	623
5/24/2017	Background	0.031	137	13.9	0.14	6.8	73.2	596
6/20/2017	Background	0.034	139	12.6	0.13	6.9	77.2	574
11/2/2017	Detection	0.031	125	12.1	0.15	6.8	63.1	526
5/1/2018	Detection	0.065	136	13.1	0.17	6.9	78.8	592
11/29/2018	Detection	0.05 J1	126	13.2	0.17	6.8	58.8	558
6/12/2019	Detection	0.03 J1	125	8.58	0.20	7.6	54.5	540
11/6/2019	Detection	< 0.02 U1	134	21.2	0.16	6.8	78.6	613
5/7/2020	Detection	< 0.02 U1	115	15.3	0.15	7.0	98.4	590
11/4/2020	Detection	< 0.02 U1	112	9.87	0.20	6.8	87.3	549
5/4/2021	Detection	0.02 J1	94.1	6.32	0.20	7.1	73.8	472
11/3/2021	Detection	< 0.09 U1	111	60.9	0.18	7.0	64.9	570
5/26/2022	Detection	0.020 J1	102	63.8	0.17	7.4	76.3	560 L1
11/2/2022	Detection	0.023 J1	107	76.8	0.16	7.0	79.9	580
5/30/2023	Detection	0.045 J1	125	87.4	0.15	7.0	97.7	630
10/17/2023	Detection	0.023 J1	112	73.5	0.15	7.0	98.3	590

Table 1. Groundwater Data Summary: MW-8
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/24/2016	Background	0.04 J1	0.41	221	0.021	0.04	0.4	0.270	0.776	0.16	0.393	0.013	< 0.002 U1	0.40	0.2	0.03 J1
10/19/2016	Background	0.03 J1	0.35	195	0.01 J1	0.04	0.158	0.140	0.746	0.15	0.279	0.006	< 0.002 U1	0.07 J1	0.2	0.02 J1
11/9/2016	Background	0.02 J1	0.25	209	0.008 J1	< 0.004 U1	0.164	0.082	1.113	0.07	0.028	0.004	< 0.002 U1	0.08 J1	0.2	0.02 J1
12/14/2016	Background	0.03 J1	0.32	212	0.008 J1	0.008 J1	0.097	0.083	1.582	0.13	0.062	0.013	< 0.002 U1	0.10	0.2	0.02 J1
2/8/2017	Background	0.03 J1	0.37	192	0.01 J1	0.007 J1	0.131	0.059	1.223	0.15	0.109	0.007	< 0.002 U1	0.47	0.1	0.136
3/15/2017	Background	0.05 J1	1.44	270	0.069	0.02 J1	2.39	1.02	3.405	0.16	1.43	0.011	0.003 J1	0.28	0.4	0.02 J1
5/24/2017	Background	0.07	0.47	201	0.02 J1	0.009 J1	0.354	0.201	1.257	0.14	0.260	0.016	< 0.002 U1	0.11	0.2	0.01 J1
6/20/2017	Background	0.03 J1	0.35	182	0.02 J1	0.007 J1	0.192	0.077	1.065	0.13	0.142	0.005	< 0.002 U1	0.07 J1	0.3	0.02 J1

Table 1. Groundwater Data Summary: MW-9
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/24/2016	Background	0.064	80.1	6.30	0.24	7.3	37.3	414
10/19/2016	Background	0.042	103	6.09	0.18	7.5	36.4	444
11/9/2016	Background	0.076	90.6	6.11	0.22	7.2	34.5	420
12/13/2016	Background	0.057	94.4	6.59	0.18	7.1	35.1	390
2/8/2017	Background	0.052	99.0	6.22	0.16	7.1	34.9	382
3/15/2017	Background	0.093	99.1	6.26	0.22	7.4	35.8	402
5/23/2017	Background	0.084	86.4	6.21	0.18	7.1	34.8	438
6/20/2017	Background	0.079	93.8	6.17	0.15	7.0	38.4	424
11/2/2017	Detection	0.075	79.1	5.97	0.20	7.1	33.1	404
5/1/2018	Detection	0.200	73.1	6.14	0.26	7.2	30.9	402
11/29/2018	Detection	0.09 J1	78.8	6.08	0.21	7.1	31.6	412
6/11/2019	Detection	0.04 J1	97.6	6.03	0.20	7.3	37.9	436
11/7/2019	Detection	0.04 J1	85.8	6.11	0.19	7.3	38.2	442
5/6/2020	Detection	0.03 J1	80.3	2.53	0.22	7.2	22.4	333
11/4/2020	Detection	0.056	61.5	2.73	0.30	7.1	28.4	362
5/4/2021	Detection	0.064	57.0	3.96	0.28	7.2	29.8	396
11/3/2021	Detection	0.054	72.7	4.47	0.23	7.2	28.2	410
5/26/2022	Detection	0.052	99.4	4.78	0.21	7.7	33.9	410 L1
11/3/2022	Detection	0.064	84.7 M1	4.77	0.22	7.2	31.1	420
5/31/2023	Detection	0.041 J1	74.3	3.66	0.20	6.9	27.7	400
10/17/2023	Detection	0.052	60.6	3.67	0.22	7.1	28.1	380

Table 1. Groundwater Data Summary: MW-9
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/24/2016	Background	0.07	1.45	443	0.025	0.03	0.8	0.464	1.831	0.24	0.565	0.017	< 0.002 U1	0.48	0.2	0.03 J1
10/19/2016	Background	0.04 J1	3.75	441	0.025	0.01 J1	0.625	0.372	3.035	0.18	0.478	0.010	< 0.002 U1	0.27	0.1	0.03 J1
11/9/2016	Background	0.05 J1	1.12	491	< 0.005 U1	0.02 J1	0.207	0.020	1.735	0.22	0.046	0.008	< 0.002 U1	0.41	0.1	0.03 J1
12/13/2016	Background	0.04 J1	1.23	497	< 0.005 U1	0.04	0.540	0.032	0.39	0.18	0.084	0.019	< 0.002 U1	0.56	0.2	< 0.01 U1
2/8/2017	Background	0.02 J1	1.78	388	< 0.005 U1	0.03	0.078	0.033	1.448	0.16	0.058	0.012	< 0.002 U1	0.27	0.1	0.02 J1
3/15/2017	Background	0.04 J1	4.40	603	0.074	0.04	1.43	1.51	2.365	0.22	1.81	0.009	0.002 J1	0.37	0.5	0.04 J1
5/23/2017	Background	0.07	0.96	425	< 0.004 U1	0.02 J1	0.117	0.021	2.173	0.18	0.063	0.021	< 0.002 U1	0.37	0.2	0.02 J1
6/20/2017	Background	0.05 J1	1.35	441	< 0.004 U1	0.03	0.094	0.066	1.992	0.15	0.038	0.014	< 0.002 U1	0.33	0.07 J1	0.02 J1

Table 1. Groundwater Data Summary: MW-10
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
8/24/2016	Background	0.087	1.68	5.54	0.89	9.0	19.1	512
10/19/2016	Background	0.081	1.09	4.49	0.72	9.6	18.0	504
11/9/2016	Background	0.118	2.31	5.46	0.92	8.9	16.9	546
12/13/2016	Background	0.076	1.24	4.15	0.38	8.7	14.1	482
2/8/2017	Background	0.113	1.37	4.24	0.57	9.1	14.4	504
3/14/2017	Background	0.125	1.18	4.60	0.50	8.7	13.3	499
5/24/2017	Background	0.081	1.16	4.19	0.43	8.9	14.3	467
6/20/2017	Background	0.078	1.04	4.11	0.44	8.6	14.9	492
11/2/2017	Detection	0.095	1.12	5.08	0.55	9.2	17.0	508
5/2/2018	Detection	0.157	1.74	5.67	0.69	9.2	16.7	522
11/29/2018	Detection	0.174	1.03	5.27	0.59	8.7	15.3	506
6/11/2019	Detection	0.08 J1	1.03	5.12	0.72	9.0	16.0	524
11/6/2019	Detection	0.076	1.43	5.62	0.52	8.7	16.8	490
5/6/2020	Detection	0.074	1.25	4.90	0.60	8.6	13.0	526
11/4/2020	Detection	0.071	1.18	5.77	0.73	8.9	16.5	523
5/4/2021	Detection	0.081	0.916	5.48	0.73	9.0	14.7	519
11/5/2021	Detection	0.257	0.9	16.4	4.88	8.8	17.8	490
5/25/2022	Detection	0.083	1.44	4.10	0.51	6.0	14.1	510 L1
11/3/2022	Detection	0.088	1.68	5.60	0.65	7.5	14.4	520
5/30/2023	Detection	0.074	1.12	4.32	0.59	8.6	14.1	510
10/18/2023	Detection	0.068	1.96	5.22	0.57	8.4	15.2	450

Table 1. Groundwater Data Summary: MW-10
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
8/24/2016	Background	0.36	24.5	105	0.058	0.26	0.5	0.367	0.769	0.89	1.11	0.010	0.003 J1	3.08	0.5	0.01 J1
10/19/2016	Background	0.26	19.4	62.4	0.02 J1	0.01 J1	0.373	0.102	0.0283	0.72	0.357	0.008	< 0.002 U1	2.58	0.4	0.082
11/9/2016	Background	0.38	21.5	144	0.264	0.05	3.96	1.66	0.168	0.92	3.41	0.007	0.004 J1	2.53	1.1	0.057
12/13/2016	Background	0.63	17.1	69.8	0.029	0.20	1.63	0.212	0.0992	0.38	0.895	0.019	< 0.002 U1	2.79	0.7	< 0.01 U1
2/8/2017	Background	0.38	22.8	92.9	0.124	0.04	2.28	0.850	0.14643	0.57	1.89	0.008	0.003 J1	2.76	1.9	0.071
3/14/2017	Background	0.32	21.2	69.0	0.039	0.01 J1	0.965	0.280	2.089	0.50	0.635	0.010	0.003 J1	3.38	2.3	0.02 J1
5/24/2017	Background	0.23	9.07	55.6	0.022	0.02 J1	0.500	0.151	1.06	0.43	0.469	0.011	< 0.002 U1	3.52	0.5	0.01 J1
6/20/2017	Background	0.30	17.7	61.7	0.025	0.01 J1	0.577	0.170	0.1376	0.44	0.448	0.004	< 0.002 U1	2.40	1.0	0.01 J1

Table 1. Groundwater Data Summary: MW-1801
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
12/18/2018	Background	0.273	1.76	10.4	5.01	8.9	8.1	498
1/24/2019	Background	0.247	1.59	10.8	5.19	8.9	7.2	490
2/21/2019	Background	0.219	1.38	11.0	5.26	9.0	6.8	550
3/13/2019	Background	0.251	1.55	11.1	5.32	9.0	6.6	509
4/23/2019	Background	0.246	1.50	11.3	5.35	9.1	8.2	507
6/11/2019	Background	0.260	1.45	10.4	5.03	9.4	6.5	506
7/23/2019	Background	0.246	1.41	10.8	5.47	8.8	7.2	502
11/5/2019	Background	0.255	1.46	11.7	5.36	8.7	7.0	501
5/7/2020	Detection	0.252	1.65	11.6	4.98	8.9	6.8	541
11/4/2020	Detection	0.215	1.52	12.5	5.34	9.0	7.5	535
1/5/2021	Detection	--	--	11.7	--	9.0	--	--
5/5/2021	Detection	0.250	1.65	13.1	5.24	8.8	9.1	542
7/21/2021	Detection	--	--	13.1	--	8.6	7.63	--
11/4/2021	Detection	0.245	1.5	13.5	5.13	8.7	6.31	530
2/28/2022	Detection	--	--	13.2	--	8.8	--	--
5/25/2022	Detection	0.265	1.78	14.4	5.22	8.4	5.42	510 L1
7/27/2022	Detection	--	--	14.0	--	8.8	--	--
11/1/2022	Detection	0.253	1.57	15.0	5.38	8.9	5.66	520
2/8/2023	Detection	--	--	14.2	--	8.8	--	--
5/31/2023	Detection	0.220	1.47	14.9	5.32	8.6	4.6	510
7/19/2023	Detection	--	--	15.3	--	8.8	--	--
10/17/2023	Detection	0.239	1.76	15.2	5.13	8.7	5.3	510

Table 1. Groundwater Data Summary: MW-1801
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
12/18/2018	Background	0.30	13.5	39.3	0.113	0.07	3.30	0.876	0.816	5.01	0.966	< 0.009 U1	< 0.002 U1	58.4	0.3	< 0.1 U1
1/24/2019	Background	0.14	11.8	34.6	0.08 J1	< 0.01 U1	2.56	0.436	0.983	5.19	0.544	0.032	< 0.002 U1	64.5	0.2 J1	< 0.1 U1
2/21/2019	Background	0.14	10.4	28.7	0.02 J1	< 0.01 U1	0.585	0.162	0.175	5.26	0.272	< 0.009 U1	< 0.002 U1	66.3	0.1 J1	< 0.1 U1
3/13/2019	Background	0.1 J1	9.02	26.6	< 0.02 U1	< 0.01 U1	0.463	0.143	0.58	5.32	0.116	< 0.009 U1	< 0.002 U1	60.8	0.05 J1	< 0.1 U1
4/23/2019	Background	0.14	9.95	30.9	0.02 J1	< 0.01 U1	0.722	0.180	0.751	5.35	0.240	< 0.009 U1	< 0.002 U1	69.4	0.06 J1	< 0.1 U1
6/11/2019	Background	0.1 J1	7.80	25.4	< 0.02 U1	< 0.01 U1	0.336	0.120	0.208	5.03	0.09 J1	< 0.009 U1	< 0.002 U1	61.6	0.05 J1	< 0.1 U1
7/23/2019	Background	0.06 J1	7.95	26.2	< 0.02 U1	< 0.01 U1	0.229	0.092	0.569	5.47	0.07 J1	< 0.02 U1	< 0.002 U1	62.7	< 0.03 U1	< 0.1 U1
11/5/2019	Background	0.04 J1	7.74	25.9	< 0.02 U1	< 0.01 U1	0.483	0.073	0.29	5.36	0.07 J1	0.00829	< 0.002 U1	62.8	< 0.03 U1	< 0.1 U1

Table 1. Groundwater Data Summary: MW-1802
Amos - LF
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
12/17/2018	Background	0.267	0.821	8.33	4.79	9.1	20.6	482
1/25/2019	Background	0.249	0.924	8.87	4.82	9.1	20.3	451
2/21/2019	Background	0.233	0.840	8.94	4.87	9.3	20.1	532
3/13/2019	Background	0.234	0.860	9.21	4.75	9.3	18.8	477
4/24/2019	Background	0.242	0.910	9.13	5.04	9.2	21.2	478
6/12/2019	Background	0.253	0.876	9.01	4.54	9.0	19.1	476
7/23/2019	Background	0.236	0.865	8.80	5.16	9.0	20.7	476
11/5/2019	Background	0.254	0.892	9.90	4.84	8.9	19.7	460
5/7/2020	Detection	0.258	0.963	9.12	4.91	8.8	15.2	490
11/4/2020	Detection	0.223	0.974	10.7	4.89	9.2	19.0	494
1/5/2021	Detection	--	--	10.7	--	9.3	--	--
5/5/2021	Detection	0.258	0.800	11.5	4.88	9.1	17.9	508
7/22/2021	Detection	--	--	13.5	--	8.8	--	--
11/4/2021	Detection	0.082	1.0	5.47	0.73	9.0	13.2	510
3/1/2022	Detection	--	1.0	--	--	9.1	--	--
5/25/2022	Detection	0.273	1.14	17.0	4.71	6.1	19.0	520 L1
7/27/2022	Detection	--	1.16	14.9	--	9.1	--	--
11/4/2022	Detection	0.261	1.13	17.0	4.86	9.2	18.2	510
2/8/2023	Detection	--	0.99	16.8	--	8.8	--	--
5/26/2023	Detection	0.221	0.82	17.2	4.99	8.9	19.3	510
7/19/2023	Detection	--	--	16.3	--	9.1	--	--
10/17/2023	Detection	0.247	1.14	12.9	5.01	9.2	32.8	480

Table 1. Groundwater Data Summary: MW-1802
Amos - LF
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
12/17/2018	Background	0.03 J1	6.08	15.5	< 0.02 U1	< 0.01 U1	0.296	0.081	0.445	4.79	0.1 J1	< 0.009 U1	< 0.002 U1	22.7	0.04 J1	< 0.1 U1
1/25/2019	Background	0.05 J1	6.00	17.1	0.03 J1	< 0.01 U1	0.497	0.219	0.522	4.82	0.214	0.03 J1	< 0.002 U1	23.1	0.05 J1	< 0.1 U1
2/21/2019	Background	0.03 J1	6.42	16.1	< 0.02 U1	< 0.01 U1	0.232	0.083	0.1739	4.87	0.08 J1	< 0.009 U1	< 0.002 U1	24.9	< 0.03 U1	< 0.1 U1
3/13/2019	Background	0.04 J1	6.28	15.2	< 0.02 U1	< 0.01 U1	0.269	0.074	0.0735	4.75	0.1 J1	< 0.009 U1	< 0.002 U1	23.9	< 0.03 U1	< 0.1 U1
4/24/2019	Background	0.08 J1	6.24	17.0	< 0.02 U1	< 0.01 U1	0.300	0.099	0.281	5.04	0.142	< 0.009 U1	< 0.002 U1	28.0	0.06 J1	< 0.1 U1
6/12/2019	Background	0.02 J1	5.66	13.6	< 0.02 U1	< 0.01 U1	0.08 J1	0.03 J1	0.418	4.54	0.04 J1	< 0.009 U1	< 0.002 U1	23.3	< 0.03 U1	< 0.1 U1
7/23/2019	Background	0.04 J1	6.43	15.5	< 0.02 U1	< 0.01 U1	0.281	0.071	0.0519	5.16	0.1 J1	< 0.02 U1	< 0.002 U1	26.9	0.05 J1	< 0.1 U1
11/5/2019	Background	0.04 J1	6.37	14.6	< 0.02 U1	< 0.01 U1	0.273	0.04 J1	0.2057	4.84	0.06 J1	0.00714	< 0.002 U1	26.8	0.05 J1	< 0.1 U1

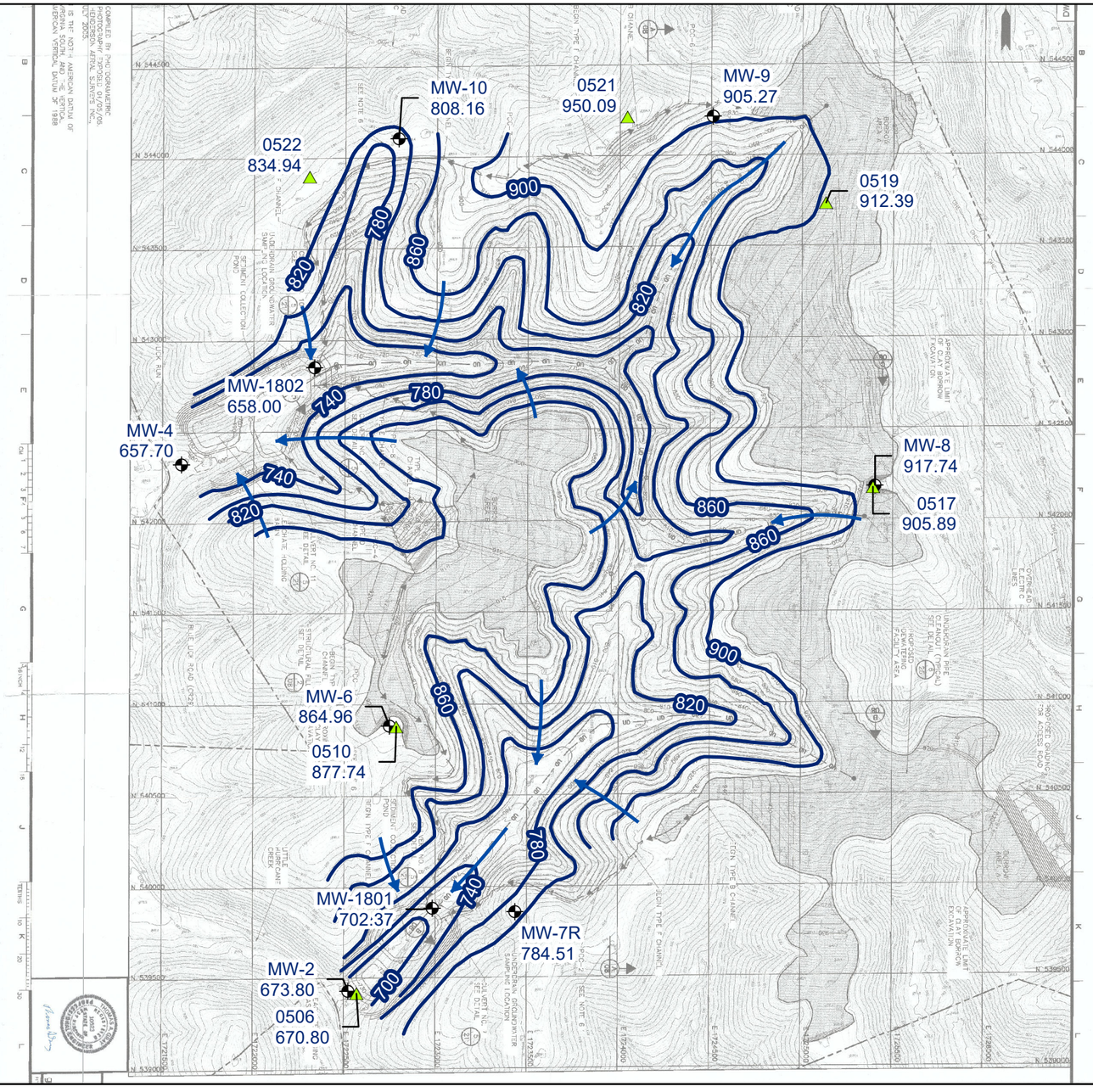
Notes:
- -: Not analyzed
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
L1: The associated laboratory control sample (LCS) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) recovery was outside acceptance limits.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
MW-1 and MW-5 were removed from the groundwater monitoring network in 2020.
mg/L: milligrams per liter
pCi/L: picocuries per liter
SU: standard unit
µg/L: micrograms per liter

Table 2: Residence Time Calculation Summary
Amos Landfill

Geosyntec Consultants, Inc.

			2023-02[3]		2023-05		2023-07[3]		2023-10	
CCR Management Unit	Monitoring Well	Well Diameter (inches)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Landfill	MW-2 [2]	2.0	2.8	21	2.6	23	2.9	21	0.6	96
	MW-4 [2]	2.0	2.0	30	2.0	30	2.1	30	0.5	132
	MW-6 [1]	2.0	0.5	124.5	0.5	120.4	0.5	129.4	0.5	133.7
	MW-7R [1]	2.0	3.9	15.6	3.8	15.9	3.9	15.7	0.8	77.7
	MW-8 [1]	2.0	0.9	70.0	0.7	92.3	0.8	77.9	0.6	108.3
	MW-9 [1]	2.0	1.0	63.2	0.9	65.9	0.9	70.1	0.8	72.8
	MW-10 [1]	2.0	0.9	69.0	1.3	47.1	0.9	70.7	2.2	28.2
	MW-1801 [2]	2.0	2.3	26	2.4	26	2.3	26	0.2	258
	MW-1802 [2]	2.0	2.9	21	2.9	21	2.9	21	0.5	111

Notes:
[1] - Background Well
[2] - Downgradient Well
[3] - Two-of-two verification sampling
NC - Not calculated



Legend

- Groundwater Monitoring Well
- Piezometer
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on May 24, 2023) provided by AEP.
- Potentiometric surface contour interval is 40 feet.
- As of 2023, a portion of the liner in Cell 4 was replaced with a riprap drainage blanket; re-lining construction is ongoing.
- Topography and drainage system basemap from AEP Drawing No. 13-30500-05-A (topographic contour interval: 10 feet).
- Groundwater elevation units are feet above mean sea level.

700 350 0 700
Feet

Potentiometric Surface Map - Uppermost Aquifer
May 2023

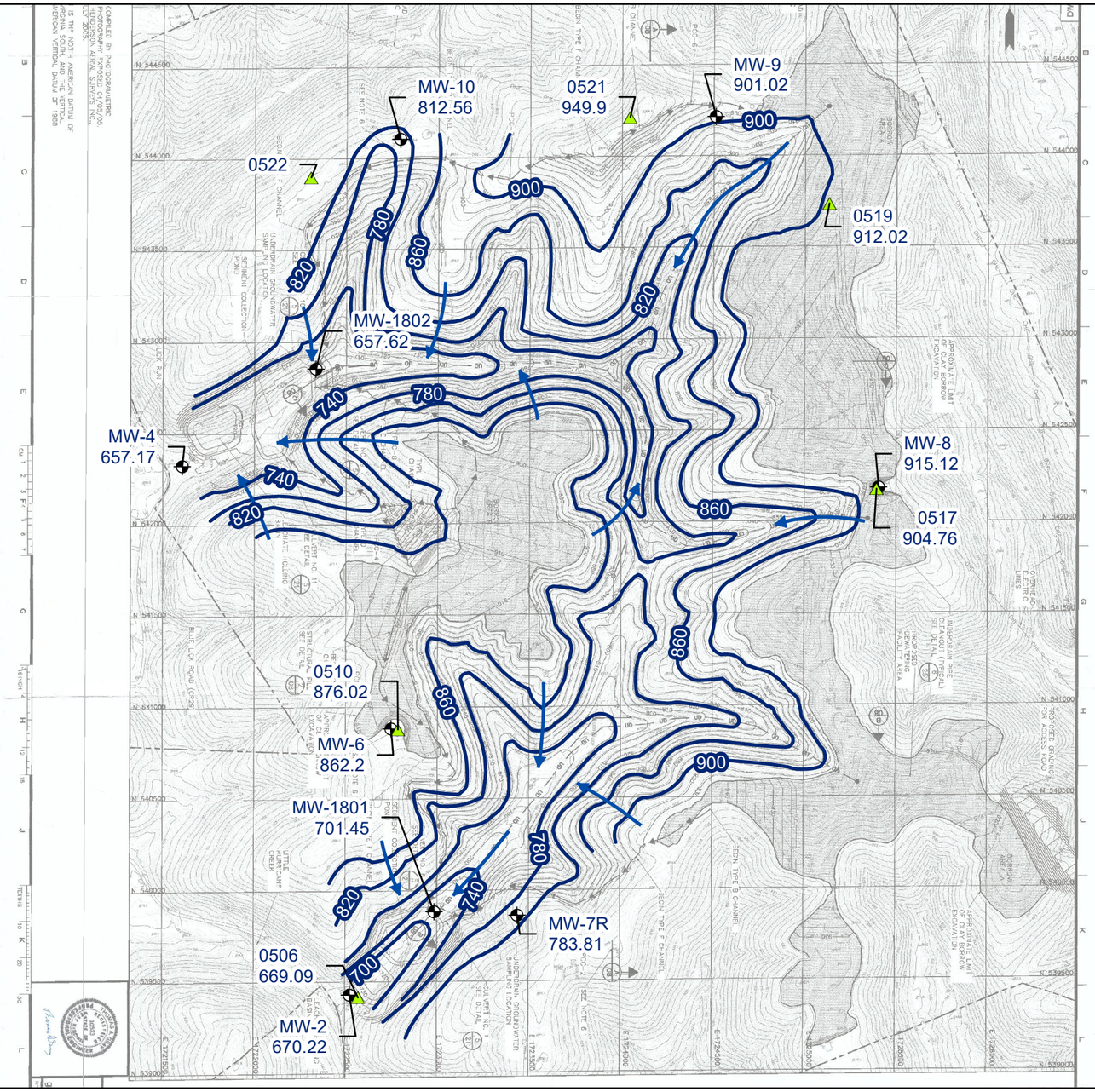
AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2023/12/13

Figure 2

\\annarbor-01\Data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\2023\AEP-Amos_Landfill_GW_2023-05.mxd. ASoltero. 12/13/2023. CHA8423/04/08.



Legend

- Groundwater Monitoring Well
- Piezometer
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on October 16, 2023) provided by AEP.
- PZ-0522 was dry during the October 2023 sampling event.
- Potentiometric surface contour interval is 40 feet.
- As of 2023, a portion of the liner in Cell 4 was replaced with a riprap drainage blanket; re-lining construction is ongoing.
- Topography and drainage system basemap from AEP Drawing No. 13-30500-05-A (topographic contour interval: 10 feet).
- Groundwater elevation units are feet above mean sea level.

700 350 0 700 Feet

Potentiometric Surface Map - Uppermost Aquifer October 2023

AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2023/12/26

Figure 3

A:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\2023\AEP-Amos_Landfill_GW_2023-10.mxd. Okiemute.Commander. 12/26/2023. CHA8423/04/08.

APPENDIX 2

The statistical analysis reports completed in 2023 follow.

Geosyntec consultants

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Memorandum

Date:	May 16, 2023
To:	David Miller (AEP)
Copies to:	Benjamin Kepchar (AEP)
From:	Allison Kreinberg (Geosyntec)
Subject:	Evaluation of Detection Monitoring Data at Amos Plant's Landfill (LF)

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257 Subpart D, "CCR rule"), the second semiannual detection monitoring event of 2022 at the Landfill (LF), an existing CCR unit at the Amos Power Plant located in Winfield, West Virginia was completed on November 1-4, 2022. Based on the results, verification sampling was completed on February 8, 2023.

Background values for the LF were previously calculated in January 2018. In May 2020, monitoring wells MW-1 and MW-5 were removed from the groundwater monitoring network and replaced with wells MW-1801 and MW-1802. Following completion of eight background monitoring events, upper prediction limits (UPLs) and lower prediction limits (LPLs) were calculated for MW-1801 and MW-1802. After a minimum of four detection monitoring events, the results of those events were compared to the existing background and the dataset was updated as appropriate for all wells in the groundwater monitoring network. Revised UPLs were calculated for each Appendix III parameter to represent background values. LPLs were also calculated for pH. Details on the calculation of these revised background values are described in Geosyntec's *Statistical Analysis Summary – Background Update Calculations* report, dated August 26, 2022.

To achieve an acceptably high statistical power while maintaining a site-wide false-positive rate (SWFPR) of 10% per year or less, prediction limits were calculated based on a one-of-two retesting procedure. With this procedure, a statistically significant increase (SSI) is concluded only if both samples in a series of two exceed the UPL (or are below the LPL for pH). In practice, if the initial result did not exceed the UPL, a second sample was not collected or analyzed.

Detection monitoring results and the relevant background values are compared in Table 1 and noted exceedances are described in the list below.

- Chloride concentrations exceeded the intrawell UPL of 25.1 milligrams per liter (mg/L) in both the initial (26.1 mg/L) and second (27.5 mg/L) samples collected at MW-4, the intrawell UPL of 14.0 mg/L in both the initial (15.0 mg/L) and second (14.2 mg/L) samples collected at MW-1801, and the intrawell UPL of 13.4 mg/L in both the initial (17.0 mg/L) and second (16.8 mg/L) samples collected at MW-1802. Thus, SSIs over background are concluded for chloride at MW-4, MW-1801, and MW-1802.

In response to the exceedances noted above, the Amos LF CCR unit will either transition to assessment monitoring or an alternative source demonstration (ASD) for chloride will be conducted in accordance with 40 CFR 257.94(e)(2). If the ASD is successful, the Amos LF will remain in detection monitoring.

The statistical analysis was conducted within 90 days of completion of sampling and analysis in accordance with 40 CFR 257.93(h)(2). A certification of these statistics by a qualified professional engineer is provided in Attachment A.

Table 1. Detection Monitoring Data Comparison
Detection Monitoring Memorandum
Amos Plant, Landfill

Geosyntec Consultants, Inc.

Analyte	Unit	Description	MW-2	MW-4		MW-1801		MW-1802	
			11/1/2022	11/1/2022	2/8/2023	11/1/2022	2/8/2023	11/4/2022	2/8/2023
Boron	mg/L	Intrawell Background Value (UPL)	0.243	0.206		0.293		0.282	
		Analytical Result	0.215	0.170	--	0.253	--	0.261	--
Calcium	mg/L	Intrawell Background Value (UPL)	3.50	0.904		1.78		1.05	
		Analytical Result	1.89	0.87	--	1.57	--	**1.13**	0.99
Chloride	mg/L	Intrawell Background Value (UPL)	5.32	25.1		14.0		13.4	
		Analytical Result	2.93	**26.1**	**27.5**	**15.0**	**14.2**	**17.0**	**16.8**
Fluoride	mg/L	Intrawell Background Value (UPL)	1.74	1.55		5.58		5.32	
		Analytical Result	1.63	1.28	--	5.38	--	4.86	--
pH	SU	Intrawell Background Value (UPL)	8.9	9.8		9.3		9.4	
		Intrawell Background Value (LPL)	8.2	8.6		8.5		8.7	
		Analytical Result	8.8	9.3	--	8.9	--	9.2	--
Sulfate	mg/L	Intrawell Background Value (UPL)	12.1	11.5		9.05		24.2	
		Analytical Result	8.31	9.39	--	5.66	--	18.2	--
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	396	419		563		527	
		Analytical Result	380	400	--	520	--	510	--

Notes:
Bold values exceed the background value.
Background values are shaded gray.
UPL: Upper prediction limit
LPL: Lower prediction limit
mg/L: milligrams per liter
SU: standard units
--: not measured

ATTACHMENT A

Certification by a Qualified Professional Engineer

CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

I certify that the selected statistical method, described above and in the August 26, 2022 *Statistical Analysis Summary* report, is appropriate for evaluating the groundwater monitoring data for the Amos LF CCR management area and that the requirements of 40 CFR 257.93(f) have been met.

David Anthony Miller

Printed Name of Licensed Professional Engineer

Signature

22663	West Virginia	05.18.2023
License Number	Licensing State	Date

Geosyntec consultants

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Memorandum

Date:	October 5, 2023
To:	David Miller (AEP)
Copies to:	Marie Gildow (AEP)
From:	Allison Kreinberg (Geosyntec)
Subject:	Evaluation of Detection Monitoring Data at Amos Plant's Landfill (LF)

In accordance with United States Environmental Protection Agency (USEPA) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257 Subpart D, "CCR rule"), the first semiannual detection monitoring event of 2023 at the Landfill (LF), an existing CCR unit at the Amos Power Plant located in Winfield, West Virginia was completed on May 26-31, 2023. Based on the results, verification sampling was completed on July 19, 2023.

Background values for the LF were previously calculated in January 2018. In May 2020, monitoring wells MW-1 and MW-5 were removed from the groundwater monitoring network and replaced with wells MW-1801 and MW-1802. Following completion of eight background monitoring events, upper prediction limits (UPLs) and lower prediction limits (LPLs) were calculated for MW-1801 and MW-1802. After a minimum of four detection monitoring events, the results of those events were compared to the existing background and the data set was updated as appropriate for all wells in the groundwater monitoring network. Revised UPLs were calculated for each Appendix III parameter to represent background values. LPLs were also calculated for pH. Details on the calculation of these revised background values are described in Geosyntec's *Statistical Analysis Summary – Background Update Calculations* report, dated August 26, 2022.

To achieve an acceptably high statistical power while maintaining a site-wide false-positive rate (SWFPR) of 10% per year or less, prediction limits were calculated based on a one-of-two retesting procedure. With this procedure, a statistically significant increase (SSI) is concluded only if both samples in a series of two exceed the UPL (or are below the LPL for pH). In practice, if the initial result did not exceed the UPL, a second sample was not collected or analyzed.

Detection monitoring results and the relevant background values are compared in Table 1 and noted exceedances are described in the list below.

- Chloride concentrations exceeded the intrawell UPL of 14.0 mg/L in both the initial (14.9 mg/L) and second (15.3 mg/L) samples collected at MW-1801. Chloride concentrations exceeded the intrawell UPL of 13.4 mg/L in both the initial (17.2 mg/L) and second (16.3 mg/L) samples collected at MW-1802. Thus, SSIs over background are concluded for chloride at MW-1801 and MW-1802.

In response to the exceedance noted above, the Amos LF CCR unit will either transition to assessment monitoring or an alternative source demonstration (ASD) for chloride will be conducted in accordance with 40 CFR 257.94(e)(2). If the ASD is successful, the Amos LF will remain in detection monitoring.

The statistical analysis was conducted within 90 days of completion of sampling and analysis in accordance with 40 CFR 257.93(h)(2). A certification of these statistics by a qualified professional engineer is provided in Attachment A.

Table 1: Detection Monitoring Data Evaluation
Amos Plant - Landfill

Geosyntec Consultants, Inc.

Analyte	Unit	Description	MW-2	MW-4	MW-1801		MW-1802	
			5/26/2023	5/26/2023	5/31/2023	7/19/2023	5/26/2023	7/19/2023
Boron	mg/L	Intrawell Background Value (UPL)	0.243	0.206	0.293		0.282	
		Analytical Result	0.187	0.151	0.220	--	0.221	--
Calcium	mg/L	Intrawell Background Value (UPL)	3.50	0.904	1.78		1.05	
		Analytical Result	1.52	0.77	1.47	--	0.82	--
Chloride	mg/L	Intrawell Background Value (UPL)	5.32	25.1	14.0		13.4	
		Analytical Result	3.55	23.8	**14.9**	**15.3**	**17.2**	**16.3**
Fluoride	mg/L	Intrawell Background Value (UPL)	1.74	1.55	5.58		5.32	
		Analytical Result	1.68	1.39	5.32	--	4.99	--
pH	SU	Intrawell Background Value (UPL)	8.9	9.8	9.3		9.4	
		Intrawell Background Value (LPL)	8.2	8.6	8.5		8.7	
		Analytical Result	8.7	9.0	8.6	--	8.9	--
Sulfate	mg/L	Intrawell Background Value (UPL)	12.1	11.5	9.05		24.2	
		Analytical Result	9.5	9.8	4.6	--	19.3	--
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	396	419	563		527	
		Analytical Result	380	400	510	--	510	--

Notes:

Bold values exceed the background value.

Background values are shaded gray.

LPL: lower prediction limit

mg/L: milligrams per liter

SU: standard units

UPL: upper prediction limit

--: not sampled

ATTACHMENT A

Certification by a Qualified Professional Engineer

CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

I certify that the selected statistical method, described above and in the August 26, 2022 *Statistical Analysis Summary* report, is appropriate for evaluating the groundwater monitoring data for the Amos LF CCR management area and that the requirements of 40 CFR 257.93(f) have been met.

David Anthony Miller

Printed Name of Licensed Professional Engineer

David Anthony Miller

Signature

22663	West Virginia	10.13.2023
License Number	Licensing State	Date

APPENDIX 3

The alternative source demonstrations follow.

Geosyntec consultants

engineers | scientists | innovators

ALTERNATIVE SOURCE DEMONSTRATION REPORT

FEDERAL STATE CCR RULE

Amos Power Plant

Landfill

Winfield, West Virginia

Prepared for

American Electric Power
1 Riverside Plaza
Columbus, Ohio 43215-2372

Prepared by

Geosyntec Consultants, Inc.
500 West Wilson Bridge Road, Suite 250
Worthington, Ohio 43085

Project CHA8495

August 2023

Geosyntec consultants

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ACRONYMS AND ABBREVIATIONS

ASD	alternative source demonstration
CCR	coal combustion residuals
CFR	Code of Federal Regulations
ft/yr	feet per year
LPL	lower prediction limit
mg/L	milligrams per liter
SSI	statistically significant increase
UPL	upper prediction limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1. INTRODUCTION AND SUMMARY

This alternative source demonstration (ASD) report has been prepared to address statistically significant increases (SSIs) for chloride at the John E. Amos Plant Landfill (Landfill) following the second semiannual detection monitoring event of 2022.

After four detection monitoring events were completed, the previously calculated upper prediction limits (UPLs) for the Landfill were recalculated for each Appendix III parameter to represent background values (Geosyntec 2022). A lower prediction limit (LPL) was also recalculated for pH. The revised prediction limits were calculated based on a one-of-two retesting procedure in accordance with the *Unified Guidance* (United States Environmental Protection Agency [USEPA] 2009) and the statistical analysis plan developed for the site (Geosyntec 2020). With this procedure, an SSI is concluded only if both samples in a series of two are above the UPL or, in the case of pH, are below the LPL.

The second semiannual detection monitoring event of 2022 was performed in November 2022 (initial sampling event) and February 2023 (verification sampling event), and the results were compared to the recalculated prediction limits. During this detection monitoring event, SSIs were identified for chloride at MW-4, MW-1801, and MW-1802 based on intrawell comparisons. A summary of the detection monitoring analytical results for all constituents listed in the Code of Federal Regulations (CFR) Title 40, Part 257, Appendix III, and the calculated prediction limits to which they were compared is provided in **Table 1**.

1.1 CCR Rule Requirements

In accordance with the USEPA regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments, 40 CFR 257.94(e)(2) states the following:

> The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer . . . verifying the accuracy of the information in the report.

Pursuant to 40 CFR 257.94(e)(2), Geosyntec Consultants, Inc. (Geosyntec) has prepared this ASD report to identify whether the SSIs identified for chloride at MW-4, MW-1801, and MW-1802 are from a source other than the Landfill.

1.2 Demonstration of Alternative Sources

An evaluation was completed to assess possible alternative sources to which identified SSIs could be attributed. Alternative sources are classified into the following five types:

- ASD Type I: Sampling Causes
- ASD Type II: Laboratory Causes
- ASD Type III: Statistical Evaluation Causes

- ASD Type IV: Natural Variation
- ASD Type V: Alternative Sources

A demonstration was conducted to assess whether the increases in chloride at monitoring wells MW-4, MW-1801, and MW-1802 were based on a Type I, II, III, or IV cause and not by a release from the Landfill.

2. SITE SUMMARY

A brief description of the site geology and hydrology are provided below.

2.1 Site Geology Summary

The Landfill site consists of a northern valley and a southern valley, both of which are surrounded on all sides by bedrock ridges (**Figure 1**). A topographic high point separates the two valleys (Arcadis 2020), as shown in **Figure 2**. MW-4 and MW-1802 are downgradient wells in the northern valley, and MW-1801 is a downgradient well in the southern valley. The northern and southern valleys are hydrologically separated from each other.

Bedrock in the vicinity of MW-4, MW-1801, and MW-1802 consists of a combination of gray siltstone, silty shale, and red claystone. The predominant lithologies within the screened interval for MW-4, 58 to 78 feet below ground surface, were siltstone and sandstone (**Attachment A**). The boring logs for MW-1801 and MW-1802 identified predominately shale interbedded with sandstone within the screened intervals (**Attachment A**). These lithologies make up part of the Pennsylvanian Monongahela and Conemaugh Formations, which were deposited by cyclic sequences of limestone, siltstone, sandstone, red and gray shale, and coal (United States Geological Survey [USGS] n.d.).

These formations contain a system of stress-relief fractures that are associated with a regional decline in stress and erosion (Arcadis 2020). Although not represented in boring logs associated with Landfill monitoring well network construction, the sedimentary deposits associated with the Monongahela and Conemaugh Formations contains occasional thin limestone and coal beds. The Pittsburgh Coal and Pittsburgh Limestone beds serve as marker beds indicating the contact between the Monongahela and Conemaugh formations. The Pittsburgh limestone bed has been observed in boring logs at the nearby fly ash pond (Arcadis 2020).

2.2 Site Hydrogeology Summary

Groundwater flows through the stress-relief fracture formations, as illustrated in a conceptual site model provided in the *Groundwater Monitoring Network Report* (Arcadis 2020) and included here as **Attachment B**. Bedrock groundwater flow generally follows surface topography, flowing downslope of ridges toward valley floors (Arcadis 2020).

The Landfill monitoring well network monitors groundwater flow within the Uppermost Aquifer, which was defined by Arcadis (2020) as the saturated portion of the stress-relief fracturing system. This Uppermost Aquifer unit is independent of any single lithologic unit; the stress-relief fracturing system occurs in both the Conemaugh and Monongahela Formations and spans multiple lithologies comprising these formations. According to the *Groundwater Monitoring Network Report*, the stress-relief fracture system "is hydraulically connected from ridges to valleys" (Arcadis 2020), as determined by a multiple-lines-of-evidence approach discussed in Section 3.2.3 of that report. These multiple lines of evidence include evaluation of boring logs, assessment of groundwater geochemistry, hydraulic testing consisting of packer testing and pump-yield testing, and high-resolution water level monitoring using pressure transducers deployed in monitoring wells across the site.

Water level monitoring data was used to calculate groundwater velocities for MW-4 (2.0 feet per year [ft/yr]), MW-1801 (2.4 ft/yr), and MW-1802 (3.7 ft/yr). Both high-resolution water level monitoring conducted by Arcadis and seasonal water level monitoring have not identified seasonal flow-regime changes at or near the Landfill monitoring well network. The current Landfill monitoring well network consists of upgradient monitoring wells MW-6, MW-7R, MW-8, MW-9, and MW-10 and downgradient compliance wells MW-2, MW-4, MW-1801, and MW-1802. Previous Landfill monitoring network wells MW-1 and MW-5 have been removed from the monitoring network after it was determined that groundwater from those locations was representative of shallow perched groundwater zones (Arcadis 2020).

3. ALTERNATIVE SOURCE DEMONSTRATION

An initial review of site geochemistry, site historical data, and laboratory quality assurance and quality control data did not demonstrate an alternative source in Type I (sampling) or Type II (laboratory) causes. A review of the statistical methods used did not identify any Type III (statistical) causes. A preliminary review of site geochemistry did not identify any Type V (anthropogenic) causes. Therefore, natural variation, which is a Type IV cause, was examined as a potential cause of the SSIs.

3.1 Landfill Leachate Data Analysis

The concentrations of boron, major cations, and major anions known to be indicative of CCR leachate were examined in Landfill leachate samples and compared to monitoring well network groundwater to evaluate whether Landfill leachate influenced downgradient groundwater. Piper diagrams, which represent the relative concentrations of major cations and anions in the groundwater and leachate analytical samples, were created to visualize groundwater geochemistry at downgradient wells MW-4, MW-1801, and MW-1802 and leachate (**Figure 3**). The data shown in these Piper diagrams captures the background and detection monitoring periods: 2018 through 2022 for MW-1801 and MW-1802, 2017 through 2022 for MW-4, and 2020 through 2023 for leachate samples.

The groundwater geochemistry at downgradient wells MW-4, MW-1801, and MW-1802 has remained nearly unchanged throughout the monitoring period, as illustrated by the tight clustering of sample results for each well on the Piper diagrams. Groundwater compositions are distinct from leachate, particularly for the relative anion percentages; leachate samples consist predominantly of sulfate, while groundwater anion compositions are dominated by alkalinity. These results illustrate stable geochemical composition of site groundwater and a lack of influence from leachate on the groundwater composition. Considering the distinct geochemical composition of the leachate samples, variation in relative percentages of major anions would be expected if downgradient monitoring wells were impacted by Landfill leachate. No such variation is observed in downgradient monitoring well groundwater samples (**Figure 3**).

Boron and sulfate are typically considered geochemically conservative parameters due to their lack of attenuation by chemical processes in groundwater flow. They therefore function as indicators for potential CCR unit releases due to their high relative concentration in CCR. Boron concentrations in Landfill leachate samples were 24.6 milligrams per liter (mg/L) and 115 mg/L for the samples collected from the northern valley and southern valley, respectively, in January 2023. Concentrations of boron at downgradient wells MW-4, MW-1801, and MW-1802 are consistently less than 0.3 mg/L (**Figure 4**). Landfill leachate sulfate concentrations collected from the northern valley and southern valley leachate collection systems in January 2023 were 3,680 and 19,700 mg/L, respectively. The concentrations of sulfate at MW-4, MW-1801, and MW-1802 are consistently less than 25 mg/L (**Figure 5**).

If Landfill leachate, which contains concentrations of boron and sulfate several orders of magnitude higher than the wells of interest, were impacting groundwater quality at downgradient monitoring wells, an increase in boron and sulfate concentrations at downgradient wells MW-4, MW-1801, and MW-1802 would be expected. The current boron and sulfate concentrations at the downgradient monitoring wells do not display increasing trends (**Figure 4** and **Figure 5,**

respectively), which suggests that changes in chloride in groundwater at MW-4, MW-1801, and MW-1802 are not due to a release from the Landfill.

3.2 Examination of Natural Variability

Chloride has been found to be a common constituent in groundwater from the Pennsylvanian Group in West Virginia (Chambers, et al. 2012), which includes the Monongahela and Conemaugh formations. MW-4, MW-1801, and MW-1802 are screened in the Monongahela and Conemaugh formations.

Long-term groundwater quality was monitored at 300 wells in West Virginia from 1999 to 2008 (Chambers et al. 2012). Samples grouped by geologic age of the aquifer unit indicated that the highest chloride concentrations (i.e., greater than 250 mg/L) were measured at four Pennsylvanian-aged aquifers. A comparison of downgradient concentrations to the median value of Pennsylvanian-aged aquifers in West Virginia indicates that chloride concentrations at MW-4, MW-1801, and MW-1802 are similar to or lower than chloride concentrations in groundwater measured in the Pennsylvanian aquifers (**Figure 6**).

These observations suggest that chloride concentrations at the downgradient locations are attributable to natural variations within groundwater from native geologic material.

3.3 Summary of Findings

A demonstration was conducted to assess whether the SSIs for chloride at MW-4, MW-1801, and MW-1802 were based on a Type IV cause (natural variation) and not by a release from the Amos Plant Landfill. The following is concluded:

- The SSIs could not be attributed to a Type I (sampling error), Type II (laboratory), Type III (statistical), or Type V (anthropogenic) cause.
- Groundwater chemistry at MW-4, MW-1801, and MW-1802, which are the downgradient wells with chloride SSIs, is generally stable and does not show evidence of influence from Landfill leachate.
- The concentrations of boron and sulfate, which are primary indicators of CCR impacts to groundwater, at MW-4, MW-1801, and MW-1802 do not show increasing trends. If impacts from Landfill leachate to downgradient locations were occurring, increasing boron and sulfate groundwater concentrations would be expected.
- Pennsylvanian-aged aquifer data from a recent USGS report indicate that MW-4, MW-1801, and MW-1802 contain chloride concentrations that are lower than or comparable to typical values for wells screened within this geologic material across the state.

3.4 Sampling Requirements

The conclusions of this ASD support the determination that the identified SSIs are from natural variation and not due to a release from the Landfill. Therefore, the unit will remain in the detection monitoring program. Groundwater at the unit will be sampled for Appendix III parameters on a semiannual basis.

4. CONCLUSIONS AND RECOMMENDATIONS

The preceding information serves as the ASD prepared in accordance with 40 CFR 257.94(e)(2) and supports the conclusion that the SSIs for chloride at MW-4, MW-1801, and MW-1802 are attributed to variation of natural groundwater quality (Type IV). Therefore, no further action is warranted, and the Amos Plant Landfill will remain in the detection monitoring program. Certification of this ASD by a qualified professional engineer is provided in **Attachment C**.

5. REFERENCES

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Chambers, D. B., M. D. Kozar, J. S. White, and K. S. Paybins. 2012. *Groundwater Quality in West Virginia, 1993–2008*. United States Geological Survey Scientific Investigations Report 2012-5186.

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TABLES

Table 1. Detection Monitoring Data Comparison
Alternative Source Demonstration
Amos Power Plant, Landfill

Analyte	Unit	Description	MW-2	MW-4		MW-1801		MW-1802	
			11/1/2022	11/1/2022	2/8/2023	11/1/2022	2/8/2023	11/4/2022	2/8/2023
Boron	mg/L	Intrawell Background Value (UPL)	0.243	0.206		0.293		0.282	
		Analytical Result	0.215	0.170	--	0.253	--	0.261	--
Calcium	mg/L	Intrawell Background Value (UPL)	3.50	0.904		1.78		1.05	
		Analytical Result	1.89	0.87	--	1.57	--	**1.13**	0.99
Chloride	mg/L	Intrawell Background Value (UPL)	5.32	25.1		14.0		13.4	
		Analytical Result	2.93	**26.1**	**27.5**	**15.0**	**14.2**	**17.0**	**16.8**
Fluoride	mg/L	Intrawell Background Value (UPL)	1.74	1.55		5.58		5.32	
		Analytical Result	1.63	1.28	--	5.38	--	4.86	--
pH	SU	Intrawell Background Value (UPL)	8.9	9.8		9.3		9.4	
		Intrawell Background Value (LPL)	8.2	8.6		8.5		8.7	
		Analytical Result	8.8	9.3	9.2	8.9	8.8	9.2	8.8
Sulfate	mg/L	Intrawell Background Value (UPL)	12.1	11.5		9.05		24.2	
		Analytical Result	8.31	9.39	--	5.66	--	18.2	--
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	396	419		563		527	
		Analytical Result	380	400	--	520	--	510	--

Notes:
Bold values exceed the background value.
Background values are shaded gray.
--: Not measured
LPL: lower prediction limit
mg/L: milligrams per liter
SU: standard units
UPL: upper prediction limit

FIGURES

Legend

- Upgradient Sampling Location
- Downgradient Sampling Location
- FGD Landfill Permitted Limits
- Northern Valley
- Southern Valley

Notes

- Monitoring well coordinates provided by AEP.
- Aerial imagery provided by DigitalGlobe and dated 8/30/2016.

700 350 0 700 Feet

Site Layout
FGD Landfill

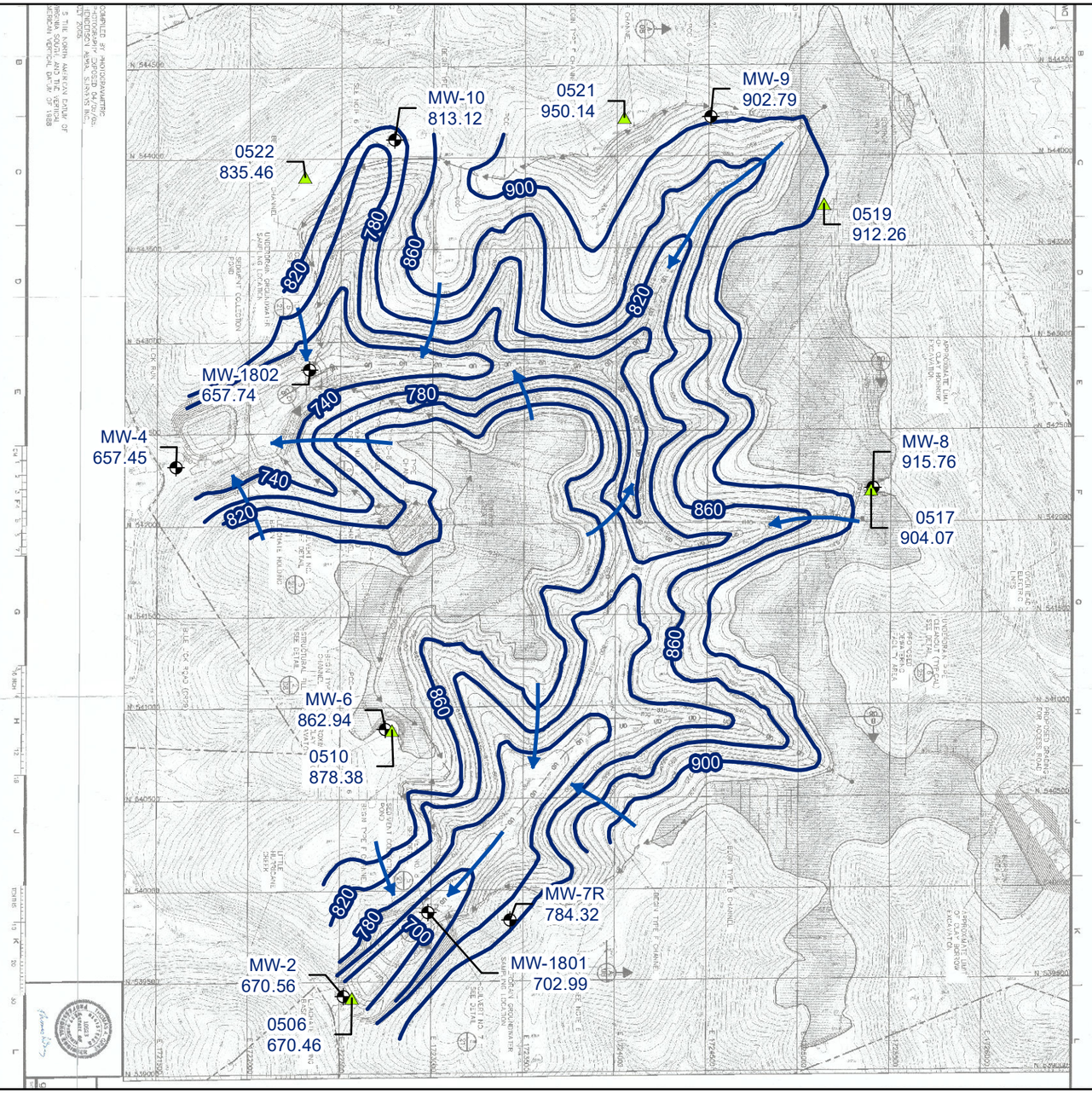
AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | Jul-2023

Figure **1**

\\annarbor-01\data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\AEP-Amos_Landfill_Site_Layout.mxd. Jennifer.Souza. 4/29/2021. CHA8423/04/08.



Legend

- Groundwater Monitoring Well
- Piezometer
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on October 24, 2022) provided by AEP.
- Potentiometric surface contour interval is 40 feet.
- Topography and drainage system basemap from AEP Drawing No. 13-30500-05-A (topographic contour interval: 10 feet).
- Groundwater elevation units are feet above mean sea level.

700 350 0 700 Feet

Potentiometric Surface Map - Uppermost Aquifer
October 2022

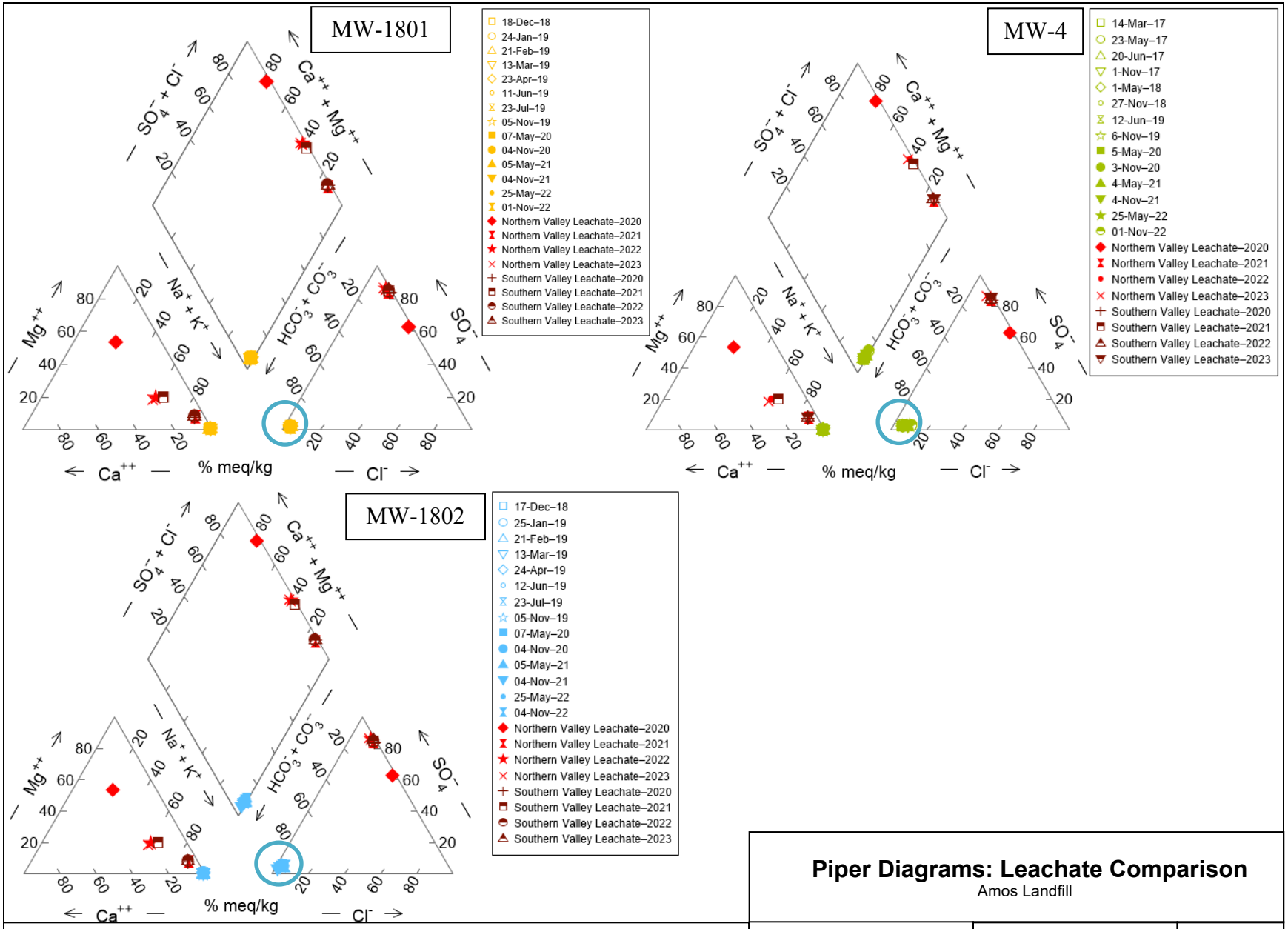
AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | Jul-2023

Figure **2**

W:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\2022\AEP-Amos_Landfill_GW_2022-10.mxd. ASoltero. 12/21/2022. CHA8423/04/08.



Piper Diagrams: Leachate Comparison

Amos Landfill

Notes: Landfill leachate samples were collected on October 7, 2021, February 15, 2022, and May 17, 2023. Leachate samples were not analyzed for potassium (K^+). All groundwater samples for each monitoring location are circled in blue on the anion distribution triangle.
% meq/kg: percent milliequivalents per kilogram

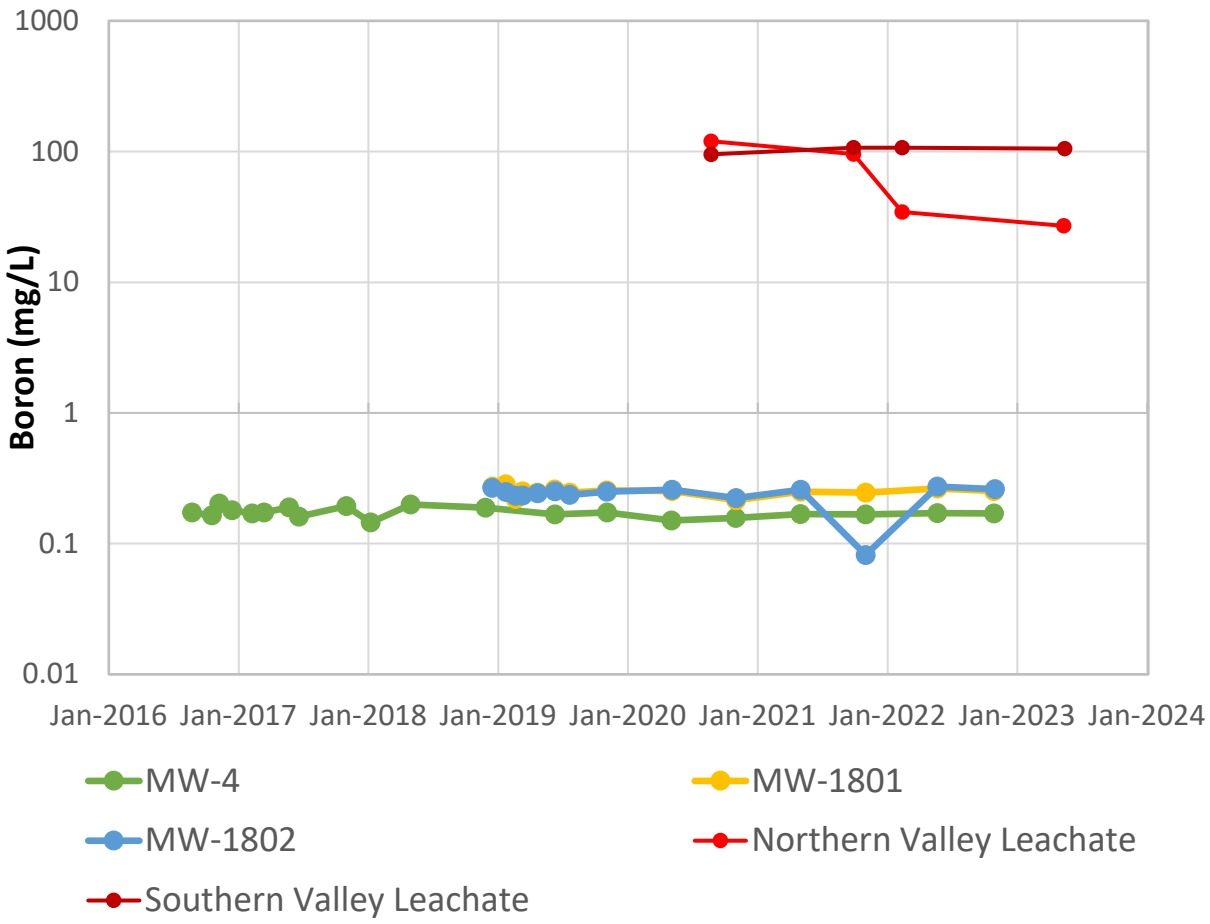
Geosyntec consultants

AMERICAN ELECTRIC POWER

Columbus, Ohio

Jul-2023

Figure 3



Notes: Data was collected under the federal coal combustion residual (CCR) rule and represents total boron in groundwater.

mg/L: milligrams per liter

Boron Time Series Graph
Amos Landfill

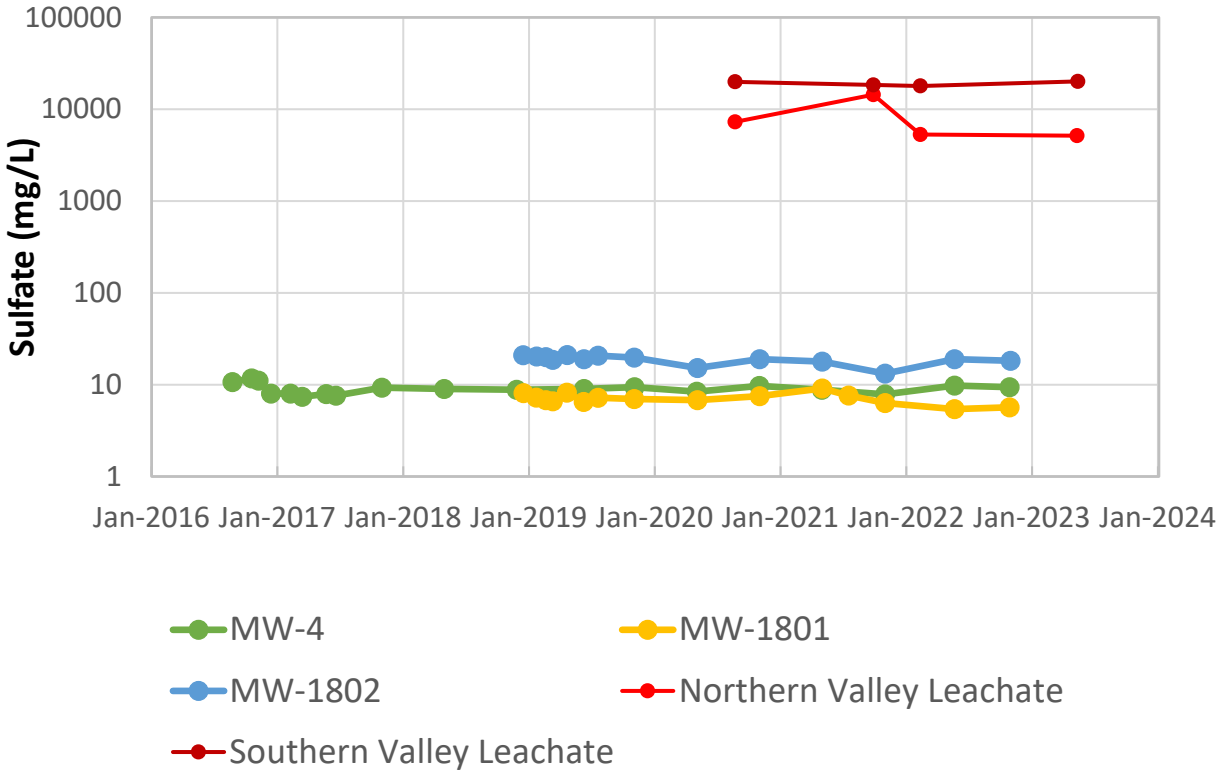
Geosyntec consultants

AMERICAN ELECTRIC POWER

Columbus, Ohio

Jul-2023

Figure **4**



Notes: Data was collected under the federal CCR rule and represents total sulfate in groundwater.

mg/L: milligrams per liter

Sulfate Time Series Graph
Amos Landfill

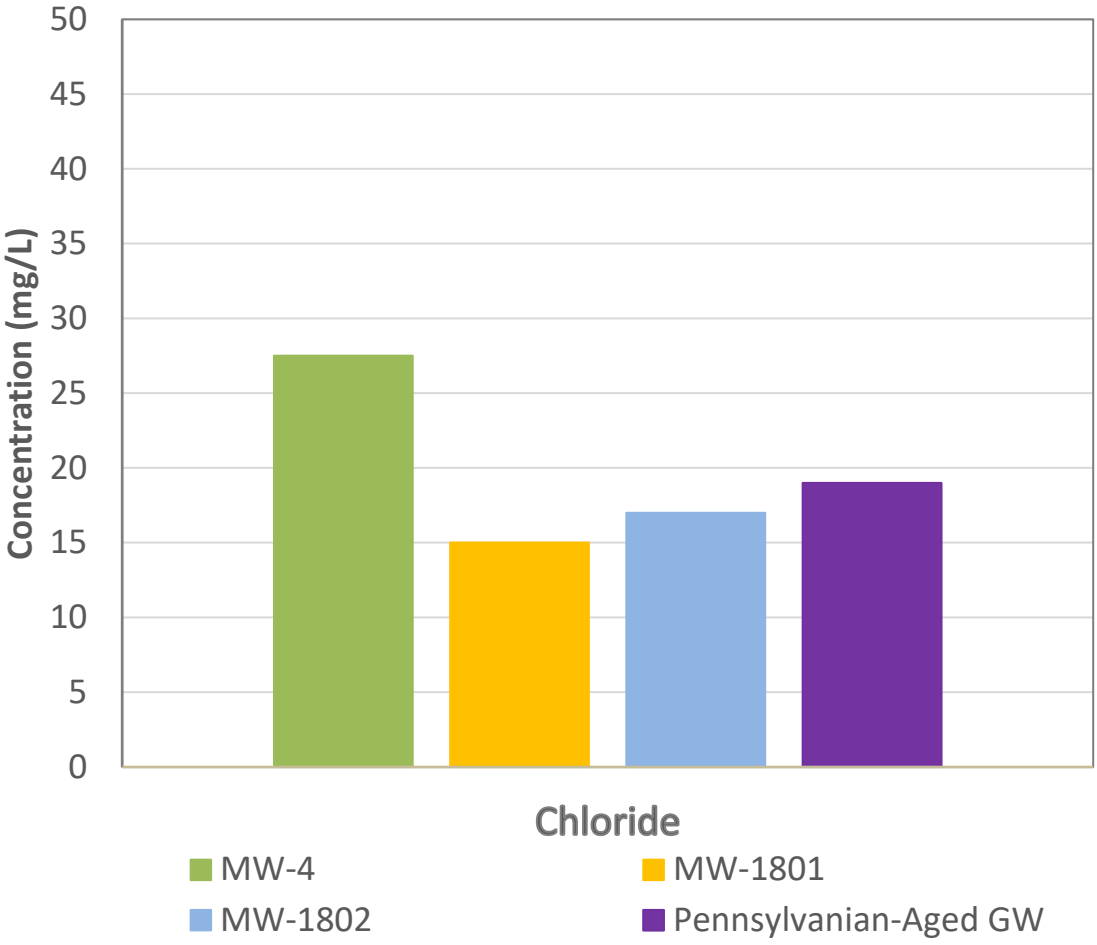
Geosyntec consultants

AMERICAN ELECTRIC POWER

Figure **5**

Columbus, Ohio

Jul-2023



Notes: MW-4, MW-1801, and MW-1802 show the maximum chloride concentration from all past collected data. 'Pennsylvanian-Aged GW', shown in purple, represents median Pennsylvanian-aged aquifer data from Chambers et al., 2012. Data for all monitoring wells were collected under the federal CCR rule and represents total chloride in groundwater.

mg/L: milligrams per liter

Chloride Bar Graph
Amos Landfill

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AMERICAN ELECTRIC POWER

Columbus, Ohio

Jul-2023

Figure **6**

ATTACHMENT A

MW-4, MW-1801, MW-1802 Boring Logs and Well Construction Diagrams

N 542305.16
E 1753086.04 Grade El. 674.76 Top of PVC Riser El. 676.36

gai consultants
transforming ideas into reality

PROJECT Area 2/3 John E Amos Power Plant BORING NO. 0532 (mw-4)

ELEVATION _____ GWL 0 HRS 19.2' PROJECT NO. C040384.40.01

24 HRS 17.9'

DATE 7-7-05 CLASSIFIED BY T R Gower PAGE 1 of 1

DEPTH (FT.)	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%) OR TORVANE	DESCRIPTION: PROFILE	DESCRIPTION: SOIL DENSITY - CONSISTENCY OR ROCK HARDNESS	DESCRIPTION: COLOR	DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
				2.0		BR	Sandy Silt		Damp, start 9:45
						BR	Sand and Rock Fragments		Damp
				6.0		↓	of shale		
						BR	Sandy Clay - some Rock		RF < 2" ϕ, moist
				9.0		↓	Fragments of Sandstone		Auger to 10.0' refusal
						Red	Decomposed claystone		Damp, TOR 10.0'
						↓	weathered to claystone		
				12.5		↓	↓		
						Gray	Siltstone Interbedded with		
						Red	Claystone/clayshale		
				41.0		↓	↓		
						Gray	Silt shale/Siltstone - trace		
				49.0		↓	Red seams of claystone		
					Soft	Red	Claystone		
				53.0		↓	↓		
						Gray	Interbedded Silt-shale &		
				58.0		Red	claystone		
						Gray	Siltstone		Wet cuttings last
				70.0		↓	↓		dust @ 58.0', water
						Gray	Sandstone		from hole by 62.0'
				78.5		↓	↓		more water @ 71.0'
							Bottom @ 78.5'		
							Installation		Materials
							Sand 78.5 to 78.0', 20'		4 Bags Sand
							Screen 78.0 to 58.0', Sand		½ bucket pellets
							78.0 to 53', Bentonite to		2 bags Volclay grout
							49.0', Volclay grout to 3'		10 Bags Concrete Mix
							Concrete to 0.0, 6'ϕ Pad		6"x5' Steel Casing
							PVC stickup 1.6', Steel 2.1'		

REMARKS** 4¼" ID HSA to 10.0', 4" ϕ Air Rotary 10.0' to 78.5', Simco 4000-TZ Track Rig
Doug Novotny Driller, Terra Testing.

* POCKET PENETROMETER READINGS

** METHOD OF ADVANCING AND CLEANING BORING

BORING NO. 0532 (mw-4)

TERRA TESTING

WELL / PIEZOMETER SCHEMATIC

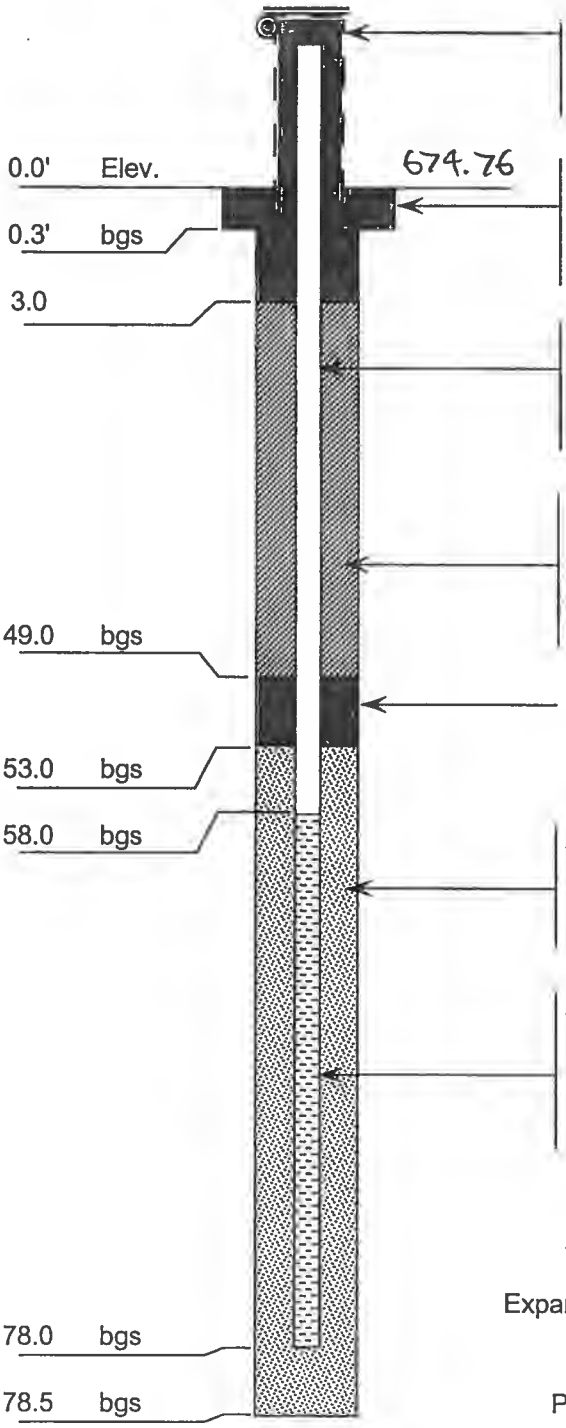
Geotechnical & Environmental Drilling

Well No: 05-32/MW-4 **Project:** John E. Amos Power Plant

Well Tag: 0275-27-05 **TTI Proj. No:** 05639

Date Installed: 07/07/05 **Client:** GAI Consultants, Inc.

GPS Location: **Latitude:** N 38° 29' 10.03" **Longitude:** W 081° 51' 45.0"



STEEL PROTECTIVE COVER (Stick-up)

Size:	6" x 5'
Riser Stick-up:	2'

CONCRETE PAD

Size:	6' diameter
No. of Bags:	10
Bags Size:	80

Riser:

Type:	Sch. 40 PVC	
Size:	2	inches I.D.
Length	60	feet

Grout Backfill

Cement:	N/A	No. of Bags
Bags Size:	N/A	lbs.
Gran. Bentonite	N/A	lbs.
Volclay	100	lbs.

Bentonite 50 lbs.

Sand Pack

Type:	Best #430	
Bags Size:	50	lbs.
No. of Bags	4	

Screen

Type:	Sch. 40 PVC	
Size:	2	inches I.D.
Slot Size:	0.01	inches
Length:	20	feet

Additional Well Supplies

Expanding Locking Cap	Y
Locks	
PVC Slip Cap	
PVC Threaded Cap	
PVC Bottom Plug	Y
Auger Plugs	
No. of 55-gallon Drums Used	
No of Guard Posts Used	

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos - FGD Landfill**

COORDINATES **N 38.5 E 81.6**

GROUND ELEVATION **735.6** SYSTEM **NAVD88**

Water Level, ft	▽ 21.0	▼	▼
TIME			
DATE	8/15/2018		

BORING NO. **MW-1801** DATE **5/3/19** SHEET **1** OF **5**

BORING START **8/7/18** BORING FINISH **8/8/18**

PIEZOMETER TYPE **PVC** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.8** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **50.4** BOTTOM **114.4**

WELL DEVELOPMENT **Surge/Purge** BACKFILL **Bentonite Grout**

FIELD PARTY **Zachary Racer (AEP)** RIG **Direct Circulation - Wireline Core**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
									CL ML	0-5': SILTY CLAY; 2.5YR 5/6 (red); moist; backfill material.		0-49': Riser
		5.0	6.5	50/4	3.6		5			5-6': SANDSTONE.		
		6.5	8.0	48-23-15	3.6				CL ML	6-6.3': SHALE; GLEY1 5/N (gray); dry; thin bedded; hard.		
									ML	6.3-6.5': SILTY CLAY; red; moist; hard		
		8.0	9.5	11-3-5	7.2				MH	6.5-8': SILT; 10YR 6/2 (tan); with sandstone and shale fragments; compacted fill material. 8-9.5': CLAYEY SILT; 5YR 4/2 (brown); firm; moist; fill material.		
		9.5	11.0	4-4-7	10.8		10		CL ML	9.5-11': SILTY CLAY; 10YR 6/3 (brown) to brown clayey silt; dry; crumbly; fill material.		
		11.0	12.5	4-8-50/3	10.8				CL ML	11-12.5': SILTY CLAY; 5YR 4/2 (brown); moist; firm.		
		12.5	14.0	50/3					ML	Note: Sandstone at 12-12.3'. 12.5-14': SILT, compacted; 10YR 7/4 (tan); very hard; dry; fill material.		
		14.0	15.5	50/4						14-14.5': SILTY SHALE material, weathered; mottled tan and dark brown; dry; very hard.		
		14.9	19.9		51		15			14.5-14.9': SANDSTONE; strong field strength; 2.5Y 6/2; fine-grained texture; massive structure; slightly to moderately decomposed; moderately disintegrated with Fe staining; fracture at 14.3-14.5'. 14.9-19.9': SHALE; moderate field strength; GLEY1 5/GY; fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintegrated along bedding planes and fracture; vertical fracture with Fe staining at 15.5-16.5'.		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
NA	6" x 3.25 HSA	
NA	9" x 6.25 HSA	
NA	HW CASING ADVANCER	4"
NA	NW CASING	3"
NA	SW CASING	6"
NA	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **A. Gillespie**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **2** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		19.9	24.9	8-7-6	55					19.9-24.9': SHALE; moderate field strength; GLEY1 5/GY; fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintegrated; moderately to intensely fractured. Transition to strong field strength, 2.5YR 4/4; fine-grained texture; massive structure to thinly bedded; slightly decomposed; slightly disintegrated; slightly to moderately fractured.		
		24.9	34.9	4-4-13	72		25			24.9-25.2': SHALE; strong field strength; fine-grained structure; massive structure to thinly bedded; slightly decomposed; slightly disintegrated; slightly to moderately fractured. 25.2-30.7': CLAYSTONE/MUDSTONE, highly weathered; very weak field strength; 10YR 5/3; very fine-grained texture with sandstone fragments; massive structure; highly decomposed; intensely disintegrated; unfractured.		
		34.9	38.3	4-5-8	36		30			30.7-32.5': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed; slightly to moderately disintegrated; slightly to moderately fractured. 32.5-34.9': CLAYSTONE/MUDSTONE; moderate field strength; GLEY1 4/104; fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately to intensely fractured.		
		38.3	44.9	5-7-13-9-6-6	70		35			34.9-38.3': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; moderately to highly decomposed; intensely disintegrated, mottling tan and gray; moderately to intensely fractured. 38.3-44.9': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; highly decomposed; intensely disintegrated; intensely fractured.		
		44.9	50.0	4-4-7-8	50		40					
							45			44.9-50': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **3** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		44.9	50.0	4-4-7-8	50					tan, black, and gray; fine-grained texture; massive structure; highly decomposed; intensely disintegrated; intensely fractured.		49-52': Bentonite Pellets
		50.0	55.0	4-4-5-4	50		50			50-56.7': CLAYSTONE/MUDSTONE; moderate field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; moderately to highly decomposed, becomes less weathered at 50.3'; highly disintegrated, highly mottled; moderately to intensely fractured.		52-53': Secondary Filter Pack 53-75': Primary Filter Pack
		55.0	59.8	5-7-5-36	52		55					55-75': Screen
		59.8	64.8	8-5-4-4-7-5-5-4	60		60			56.7-58': SANDSTONE, interbedded; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture; moderately fractured at 56.7' and 57.1-57.5'. 58-58.8': SHALE, interbedded; strong field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture. 58.8-59.2': SANDSTONE, interbedded; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture. 59.2-59.8': SHALE, interbedded; strong field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture.		
		64.8	74.8	4-5-4-6	76		65			59.8-60.7': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; unfractured. 60.7-63.9': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintigrated with silt filled fractures; moderately fractured. 63.9-64.3': SANDSTONE; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; unfractured.		
							70			64.3-64.8': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed; moderately		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **4** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		64.8	74.8	4-5-4-6	76					disintigrated; moderately fractured.		
										64.8-74.8': SHALE, highly weathered at base; moderate to weak field strength along some bedding planes; 2.5YR 3/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintigrated, becomes more limestone fragments last 1 ft, 3-5 cm; moderately to intensely fractured.		
		74.8	85.0				75			74.8-85': SHALE, highly weathered; weak field strength; 2.5YR 4/4 (red) with tan and gray mottling; fine-grained texture; massive structure; highly decomposed; highly disintigrated, mottled; intensely fractured.		75-105': Bentonite
		85.0	95.0	5-4-4	120		80			85-92.7': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated, calcite in light colored beds/thin; slightly fractured.		
							85					
							90			92.7-94.6': SHALE; moderate field strength; fine-grained texture; massive structure; slightly decomposed; slightly disintigrated, some mottling; moderately fractured.		
		95.0	105.0	7-4-4	120		95			94.6-95': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated, calcite in light colored beds/thin; slightly fractured at 94.6-95'.		
										95-100.1': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated; slightly fractured at 95-95.2'.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **5** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		95.0	105.0	7-4-4	120		100			100.1-101.5': SHALE and sandstone interbedded; moderate field strength; fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; slightly fractured at 100.2-100.5'. 101.5-105': SHALE; moderate to weak field strength; fine-grained texture; massive structure; highly decomposed; moderately to highly disintigrated mottling with silt filled fractures; highly fractured.		
							105					
							110					
							115					
							120					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos - FGD Landfill**

COORDINATES **N 38.5 E 81.9**

GROUND ELEVATION **709.8** SYSTEM **NAVD88**

Water Level, ft	▽ 35.0	▼	▼
TIME			
DATE	8/21/2019		

BORING NO. **MW-1802** DATE **5/3/19** SHEET **1** OF **5**

BORING START **8/20/18** BORING FINISH **8/21/18**

PIEZOMETER TYPE **NA** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.91** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **50** BOTTOM **114.4**

WELL DEVELOPMENT **Surge/Purge** BACKFILL **Bentonite Grout**

FIELD PARTY **Zachary Racer (AEP)** RIG **Direct Circulation - Wireline Core**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
									GW	0-3.5': GRAVEL backfill; large rip-rap and smaller compacted gravels.		0-41': Bentonite Grout
									CL	3.5-4.5': SILTY CLAY; brown; moist; soft; backfill material.		
		4.5	6.0	6-4-5	0		5			4.5-6': NO RECOVERY, due to gravel blocking cutting shoe.		
		6.0	7.5	4-3-4	3.6				CL	6-17': SILTY CLAY; 7.5YR 4/3 (brown); moist; firm; compacted backfill material; becomes wet at 12.5'.		
		7.5	9.0	3-4-5	7.2							
		9.0	10.5	4-4-6	18		10					
		10.5	12.0	5-4-5	13.2							
		12.0	13.5	3-4-6	15.6							
		13.5	15.0	3-5-8	14.4							
		15.0	16.5	4-7-9	15.6		15					
		16.5	18.0	6-25-8	16.8					17-17.5': SANDSTONE, weathered; GLEY1 7/N (gray); dry.		
		18.0	19.5	7-23-15	14.4				CL	17.5-19.5': SILTY CLAY; GLEY1 6/N (gray) mottled with brown, red, tan; moist; soft; crumbles easily.		
		19.5	21.0	20->50/4	10.8				CL			

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
NA	6" x 3.25 HSA	
NA	9" x 6.25 HSA	
NA	HW CASING ADVANCER	4"
NA	NW CASING	3"
NA	SW CASING	6"
NA	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **A. Gillespie**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **2** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		19.5	21.0	20->50/4	10.8					19.5-22.5': SILTY CLAY; GLEY1 6/N (gray) mottled with brown, tan; dry; soft; crumbles easily.		
		21.0	22.5	27-50/5	9.6							
		22.5	24.4	4	23					22.5-24': SILTSTONE; moderate to weak field strength; GLEY1 6/N; fine-grained texture; massive structure; highly decomposed; moderately to highly disintegrated with tan/brown mottling; moderately to intensely fractured.		
		24.4	29.4		22		25			24-24.4': SILTSTONE; weak field strength; 10R 4/4 (red) mottled; fine-grained texture; massive structure; highly decomposed; moderately to intensely fractured.		
										24.4-29.4': SILTSTONE; weak field strength; 10R 4/4 (red) mottled with tan, gray, and black; fine-grained texture; massive structure; highly decomposed; highly disintegrated, highly mottled; moderately fractured.		
		29.4	33.7	5-11-6	40		30			29.4-32.8': SHALE, weathered; moderate field strength; 10YR 4/4 (red) mottled; fine-grained texture; massive structure; moderately decomposed; moderately to intensely disintegrated; moderately fractured.		
		33.7	39.4	5-4-4-7-5	59		35			32.8-33.7': SHALE; moderate field strength; 5YR 5/4 (tan) mottled; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; moderately to intensely fractured.		
										33.7-39.4': SHALE; moderate field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; intensely fractured.		
		39.4	44.4	4-6-4-4	57		40			39.4-44.4': SHALE; moderate field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; intensely fractured.		41-44': Bentonite Pellets
		44.4	54.4	7-8-7-5-5-24-5	120		45			44.4-47.8': SHALE, highly weathered; weak field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure;		44-45': Secondary Filter Pack 45-71': Primary Filter Pack

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **3** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		44.4	54.4	7-8-7-5-5-24-5	120					highly decomposed; intensely disintegrated; intensely fractured.		
										47.8-49.9': SHALE, less weathered; moderate field strength; 10R 3/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately fractured.		
							50			49.9-50.8': SHALE, interbedded with sandstone; moderate field strength; GLEY1 4/N; fine-grained texture; thinly bedded; moderately decomposed; slightly disintegrated; moderately fractured.		50-70': Screen
										50.8-52.8': SHALE; moderate to strong field strength; 10R 4/3 (red); fine-grained texture; massive structure; slightly decomposed; moderately disintegrated; slightly fractured.		
										52.8-53.1': SHALE, interbedded with sandstone; strong field strength; GLEY1 4/5GY; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; unfractured.		
		54.4	64.4	8-12-5-6-7-4-4-4	114		55			53.1-54.4': SHALE; moderate field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately fractured.		
										54.4-55.4': SANDSTONE, interbedded with shale; moderate field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; slightly to moderately fractured.		
							60			55.4-57.1': SHALE, interbedded with sandstone; moderate field strength; GLEY1 4/3, 10R 4/3; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
										57.1-64.4': SHALE, weathered; moderate to weak field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated with intense gray mottling; intensely fractured.		
		64.4	74.4	4-6-8-6-4-5-4-4-5	117		65			64.4-70.5': SHALE, highly weathered; moderate to weak field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately to intensely disintegrated with gray mottling; intensely fractured.		
							70			70.5-74.4': SHALE, interbedded with sandstone; strong field strength; 10R 4/3 (red) interbedded with GLEY1 4/N (gray-green); fine-grained		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **4** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		64.4	74.4	4-6-8-6-4-5-4-4-5	117					texture; thinly bedded; slightly to moderately decomposed along some bedding planes; moderately disintegrated with silt filled fractures; moderately fractured.		
		74.4	84.4	8-7-5-5-14-8-7-22-12	120		75			74.4-77.1': SHALE, with some interbedded sandstone lenses; moderate field strength; 10R 4/3 (red); fine-grained texture; thinly bedded; slightly to moderately decomposed at some bedding planes; slightly disintegrated; moderately fractured.		
							80			77.1-82.7': SANDSTONE, with some red shale lenses; strong field strength; GLEY1 4/N; fine-grained texture; thinly bedded; fresh; moderately disintegrated, calcite reacts to HCl in light colored bands within 0.5' of surrounding contact lines, no HCl/calcite in fractures, no Fe staining; moderately fractured.		
										82.7-84.4': SHALE, with some interbedded sandstone lenses; moderate field strength; 10R 4/3 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
		84.4	94.4	10-11-6-7-7-8-9-8-7-6-6-7-10	120		85			84.4-86.7': SHALE, with sandstone lenses; moderate field strength; 10R 4/2 (red) with GLEY1 4/N lenses; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
										86.7-89.2': SANDSTONE, with shale lenses; moderate field strength; GLEY1 4/N with 10R 4/2 lenses; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
							90			89.2-94.4': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded, micaceous; fresh; slightly disintegrated, some calcite in light bands, no staining, no calcite in fractures; slightly to moderately fractured along bedding planes; fracture at 92.8'.		
		94.4	104.4	7-4-5-4-9-9-8-5-11-5-6-10-19	120		95			94.4-104.4': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded, micaceous, cross-bedding at 94.4-94.8; fresh; slightly disintegrated, calcite in some light bedded planes, no calcite or Fe staining noted in fractures; slightly to moderately fractured along bedding planes.		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **5** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		94.4	104.4	7-4-5-4-9-9-8-5-11-5-6-10-19	120		100					
		104.4	114.4	15-6-21-6-4-4-8-8-6-4-13-5-7	120		105			104.4-108': SANDSTONE; strong field strength; GLEY1 6/N; fine to medium-grained texture; thinly bedded, micaceous, shale fragments; fresh; moderately disintegrated, calcite along entire sandstone void and shale fragments at base, calcite in void; slightly fractured.		
										108-108.9': SHALE, with interbedded sandstone; moderate field strength; GLEY1 4/N, 10R 4/3 bands; thinly bedded; moderately decomposed between bedding planes; moderately disintegrated along bedding planes; moderately fractured.		
							110			108.9-114.4': SHALE; moderate field strength; 10R 4/3 (red) with GLEY1 4/N mottling; fine-grained texture; massive structure; moderately decomposed; moderately to intensely disintegrated, mottling; moderately fractured.		
							115					
							120					

AEP - AEP.GDT - 5/3/19 11:49 - S:\KNOXVILLE-TN\FOR NICOLE AEP LOG EDIT FILES\GINT LOGS OUTPUT\AEP MOUNTAINEER\AEP MOUNTAINEER.GPJ

ATTACHMENT B
Stress-Relief Fracture Conceptual Site Model

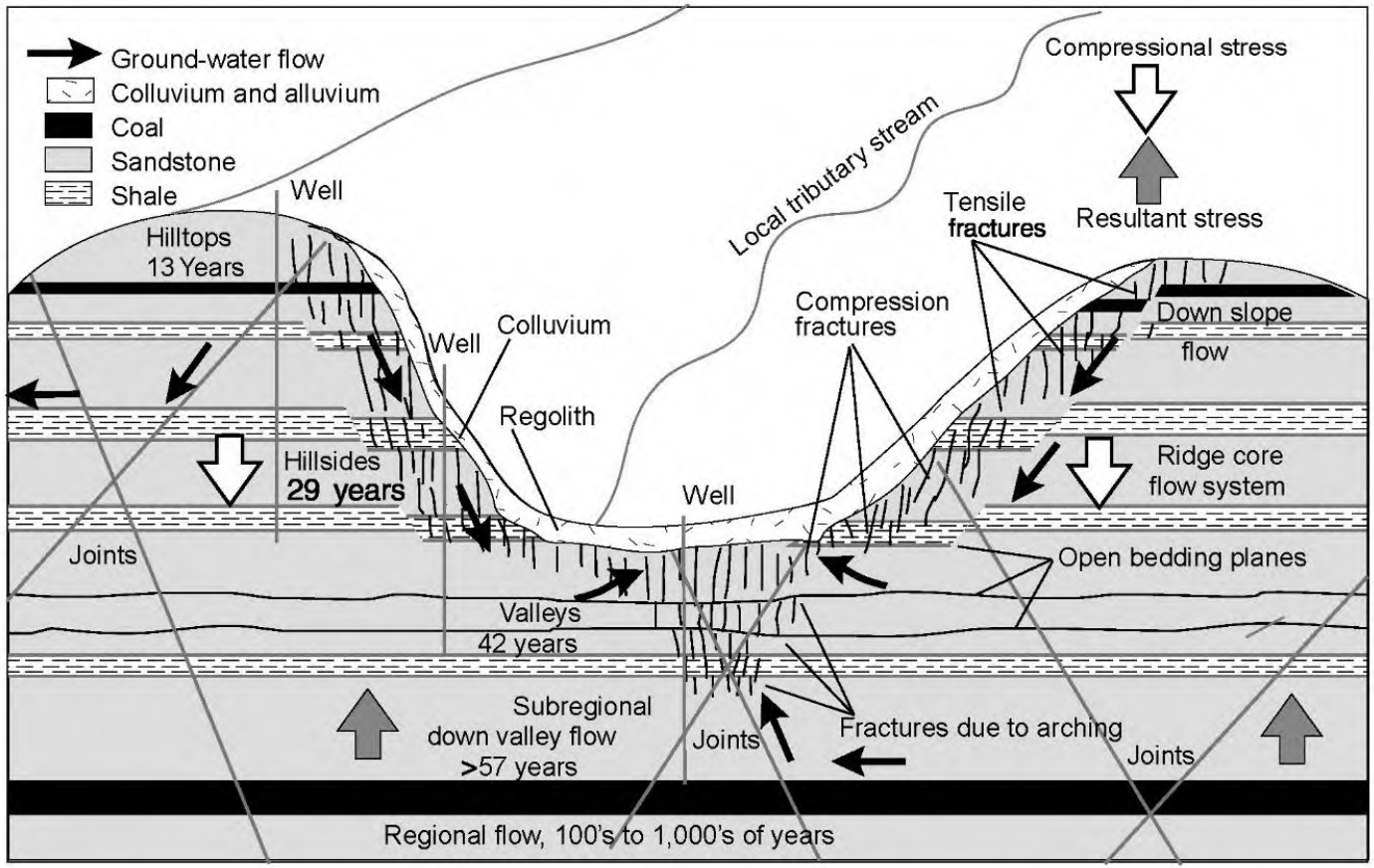


Figure 3. Revised conceptual model of ground-water flow in an Appalachian Plateaus fractured-bedrock aquifer including apparent age of ground water (Modified from Wyrick and Borchers, fig. 3.2-1, 1981 and Kozar, 1998).

References:

- United States Geological Survey (USGS), Wyrick, G.D. and J.W. Borchers, 1981. Hydrologic Effects of Stress-Relief Fracturing in an Appalachian Valley. Water-Supply Paper 2177.

AEP AMOS GENERATING PLANT - FGD LANDFILL
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

STRESS RELIEF FRACTURE SYSTEM CONCEPTUAL SITE MODEL

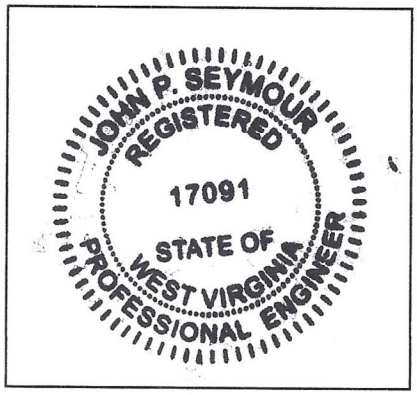
ARCADIS Design & Consultancy for natural and built assets

FIGURE
4

ATTACHMENT C
Certification by a Qualified Professional Engineer

CERTIFICATION BY A QUALIFIED PROFESSIONAL ENGINEER

I certify that the above described alternative source demonstration is appropriate for evaluating the groundwater monitoring data for the Amos Plant Landfill CCR management area and that the requirements of 40 CFR 257.94(e)(2) have been met.



John Seymour
Printed Name of Licensed Professional Engineer

Signature

017091	West Virginia	8/9/2023
License Number	Licensing State	Date

Geosyntec consultants

engineers | scientists | innovators

ALTERNATIVE SOURCE DEMONSTRATION REPORT – FIRST SEMIANNUAL DETECTION EVENT 2023

FEDERAL CCR RULE

Amos Power Plant

Landfill

Winfield, West Virginia

Prepared for

American Electric Power
1 Riverside Plaza
Columbus, Ohio 43215-2372

Prepared by

Geosyntec Consultants, Inc.
500 West Wilson Bridge Road, Suite 250
Worthington, Ohio 43085

Project CHA8495

January 2024

Geosyntec consultants

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ACRONYMS AND ABBREVIATIONS

ASD	alternative source demonstration
CCR	coal combustion residuals
CFR	Code of Federal Regulations
ft/yr	feet per year
LPL	lower prediction limit
mg/L	milligrams per liter
SSI	statistically significant increase
UPL	upper prediction limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1. INTRODUCTION AND SUMMARY

This alternative source demonstration (ASD) report has been prepared to address statistically significant increases (SSIs) for chloride at the John E. Amos Plant Landfill (Landfill) following the first semiannual detection monitoring event of 2023.

The previously calculated upper prediction limits (UPLs) for the Landfill were recalculated for each Appendix III parameter to represent background values (Geosyntec 2022) after four detection monitoring events were completed. A lower prediction limit (LPL) was also recalculated for pH. The revised prediction limits were calculated based on a one-of-two retesting procedure in accordance with the *Unified Guidance* (United States Environmental Protection Agency [USEPA] 2009) and the statistical analysis plan developed for the site (Geosyntec 2020). With this procedure, an SSI is concluded only if both samples in a series of two are above the UPL or, in the case of pH, are below the LPL.

The first semiannual detection monitoring event of 2023 was performed in May 2023 (initial sampling event) and July 2023 (verification sampling event), and the results were compared to the recalculated prediction limits. During this detection monitoring event, SSIs were identified for chloride at MW-1801 and MW-1802 based on intrawell comparisons. A summary of the detection monitoring analytical results for all constituents listed in the Code of Federal Regulations (CFR) Title 40, Part 257, Appendix III, and the calculated prediction limits to which they were compared is provided in **Table 1**.

1.1 CCR Rule Requirements

In accordance with the USEPA regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments, 40 CFR 257.94(e)(2) states the following:

> The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer . . . verifying the accuracy of the information in the report.

Pursuant to 40 CFR 257.94(e)(2), Geosyntec Consultants, Inc. (Geosyntec) has prepared this ASD report to identify whether the SSIs identified for chloride at MW-1801 and MW-1802 are from a source other than the Landfill.

1.2 Demonstration of Alternative Sources

An evaluation was completed to assess possible alternative sources to which identified SSIs could be attributed. Alternative sources are classified into the following five types:

- ASD Type I: Sampling Causes
- ASD Type II: Laboratory Causes
- ASD Type III: Statistical Evaluation Causes

- ASD Type IV: Natural Variation
- ASD Type V: Alternative Sources

A demonstration was conducted to assess whether the increases in chloride at monitoring wells MW-1801 and MW-1802 were based on a Type I, II, III, or IV cause, or whether they should be attributed to a release from the Landfill.

2. SITE SUMMARY

A brief description of the site geology and hydrology are provided below.

2.1 Site Geology Summary

The Landfill site consists of a northern valley and a southern valley, both of which are surrounded on all sides by bedrock ridges (**Figure 1**). A topographic high point separates the two valleys (Arcadis 2020), as shown in **Figure 2**. MW-1802 is a downgradient well in the northern valley, and MW-1801 is a downgradient well in the southern valley. The groundwater flow patterns in the northern and southern valleys are hydrologically separated from each other.

Bedrock in the vicinity of MW-1801 and MW-1802 consists of a combination of gray siltstone, silty shale, and red claystone. The boring logs for MW-1801 and MW-1802 identified predominately shale interbedded with sandstone within the screened intervals (**Attachment A**). These lithologies make up part of the Pennsylvanian Monongahela and Conemaugh Formations, which were deposited by cyclic sequences of limestone, siltstone, sandstone, red and gray shale, and coal (United States Geological Survey [USGS] n.d.).

These formations contain a system of stress-relief fractures that are associated with a regional decline in stress and erosion (Arcadis 2020). Although not represented in boring logs associated with Landfill monitoring well network construction, the sedimentary deposits associated with the Monongahela and Conemaugh Formations contains occasional thin limestone and coal beds. The Pittsburgh Coal and Pittsburgh Limestone beds serve as marker beds indicating the contact between the Monongahela and Conemaugh formations. The Pittsburgh limestone bed has been observed in boring logs at the nearby fly ash pond (Arcadis 2020).

2.2 Site Hydrogeology Summary

Groundwater flows through the stress-relief fracture formations, as illustrated in a conceptual site model provided in the *Groundwater Monitoring Network Report* (Arcadis 2020) and included here as **Attachment B**. Bedrock groundwater flow generally follows surface topography, flowing downslope of ridges toward valley floors (Arcadis 2020).

The Landfill monitoring well network monitors groundwater flow within the Uppermost Aquifer, which was defined by Arcadis (2020) as the saturated portion of the stress-relief fracturing system. This Uppermost Aquifer unit is independent of any single lithologic unit; the stress-relief fracturing system occurs in both the Conemaugh and Monongahela Formations and spans multiple lithologies comprising these formations. According to the *Groundwater Monitoring Network Report*, the stress-relief fracture system "is hydraulically connected from ridges to valleys" (Arcadis 2020), as determined by a multiple-lines-of-evidence approach discussed in Section 3.2.3 of that report. These multiple lines of evidence include evaluation of boring logs, assessment of groundwater geochemistry, hydraulic testing consisting of borehole packer testing and pump-yield testing, and high-resolution water level monitoring using pressure transducers deployed in monitoring wells across the site.

Water level monitoring data was used to calculate groundwater velocities for MW-1801 (2.4 ft/yr) and MW-1802 (3.7 ft/yr). Both high-resolution water level monitoring conducted by Arcadis and seasonal water level monitoring have not identified seasonal flow-regime changes at or near the

Landfill monitoring well network. The current Landfill monitoring well network consists of upgradient monitoring wells MW-6, MW-7R, MW-8, MW-9, and MW-10 and downgradient compliance wells MW-2, MW-4, MW-1801, and MW-1802. Previous Landfill monitoring network wells MW-1 and MW-5 were removed from the monitoring network after it was determined that groundwater from those locations was representative of shallow perched groundwater zones (Arcadis 2020) and not a part of the Uppermost Aquifer.

3. ALTERNATIVE SOURCE DEMONSTRATION

An initial review of site geochemistry, site historical data, and laboratory quality assurance and quality control data did not demonstrate an alternative source in Type I (sampling) or Type II (laboratory) causes. A review of the statistical methods used did not identify any Type III (statistical) causes. A preliminary review of site geochemistry did not identify any Type V (anthropogenic) causes. Therefore, natural variation, which is a Type IV cause, was examined as a potential cause of the SSIs.

3.1 Landfill Leachate Data Analysis

The concentrations of boron, major cations, and major anions known to be indicative of CCR leachate were examined in Landfill leachate samples and compared to monitoring well network groundwater to evaluate whether Landfill leachate influenced downgradient groundwater. Piper diagrams, which represent the relative concentrations of major cations and anions in the groundwater and leachate analytical samples, were created to visualize aqueous geochemistry at Landfill leachate and downgradient wells MW-1801 and MW-1802 (**Figure 3**). The data shown in these Piper diagrams captures the background and detection monitoring periods: 2018 through 2023 for MW-1801 and MW-1802, and 2020 through 2023 for leachate samples.

The groundwater geochemistry at downgradient wells MW-1801 and MW-1802 has remained nearly unchanged throughout the monitoring period, as illustrated by the tight clustering of sample results for each well on the Piper diagrams. Groundwater compositions are distinct from leachate, particularly for the relative anion percentages; leachate samples consist predominantly of sulfate, while groundwater anion compositions are dominated by carbonate alkalinity. These results illustrate stable geochemical composition of site groundwater and a lack of influence from leachate on the groundwater composition. Considering the distinct geochemical composition of the leachate samples, variation in relative percentages of major anions would be expected if downgradient monitoring wells were impacted by Landfill leachate. No such variation is observed in downgradient monitoring well groundwater samples (**Figure 3**).

Boron and sulfate are typically considered geochemically conservative parameters due to their minimal attenuation by chemical processes in groundwater flow. They therefore function as indicators for potential CCR unit releases due to their high relative concentration in CCR. The following was observed:

- Boron concentrations in Landfill leachate samples were 27.0 milligrams per liter (mg/L) and 105 mg/L for the samples collected from the northern valley and southern valley, respectively, in May 2023. Concentrations of boron at downgradient wells MW-1801 and MW-1802 are consistently less than 0.3 mg/L (**Figure 4**).
- Landfill leachate sulfate concentrations collected from the northern valley and southern valley leachate collection systems in May 2023 were 5,150 and 20,100 mg/L, respectively. The concentrations of sulfate at MW-1801 and MW-1802 are consistently less than 25 mg/L (**Figure 5**).

If Landfill leachate, which contains concentrations of boron and sulfate several orders of magnitude higher than the wells of interest, were impacting groundwater quality at downgradient monitoring wells, an increase in boron and sulfate concentrations at downgradient wells MW-1801

and MW-1802 would be expected. The current boron and sulfate concentrations at the downgradient monitoring wells do not display increasing trends (**Figure 4** and **Figure 5,** respectively), which suggests that changes in chloride in groundwater at MW-1801 and MW-1802 are not due to a release from the Landfill.

3.2 Examination of Natural Variability

Chloride has been found to be a common constituent in groundwater from the Pennsylvanian Group in West Virginia (Chambers, et al. 2012), which includes the Monongahela and Conemaugh formations. MW-1801 and MW-1802 are screened in the Monongahela and Conemaugh formations.

Long-term groundwater quality was monitored at 300 wells in West Virginia from 1999 to 2008 (Chambers et al. 2012). Samples grouped by geologic age of the aquifer unit indicated that the highest chloride concentrations (i.e., greater than 250 mg/L) were measured at four Pennsylvanian-aged aquifers. A comparison of downgradient concentrations to the median value of Pennsylvanian-aged aquifers in West Virginia indicates that chloride concentrations at MW-1801 and MW-1802 are similar to or lower than chloride concentrations in groundwater measured in the Pennsylvanian aquifers (**Figure 6**).

These observations suggest that chloride concentrations at the downgradient locations are attributable to natural variations within groundwater from native geologic material, as documented by academic studies.

3.3 Summary of Findings

A demonstration was conducted to assess whether the SSIs for chloride at MW-1801 and MW-1802 were based on a Type IV cause (natural variation) and not by a release from the Amos Plant Landfill. The following is concluded:

- The SSIs could not be attributed to a Type I (sampling error), Type II (laboratory), Type III (statistical), or Type V (anthropogenic) cause.
- Groundwater chemistry at MW-1801 and MW-1802, which are the downgradient wells with chloride SSIs, is generally stable and does not show evidence of influence from Landfill leachate.
- The concentrations of boron and sulfate, which are primary indicators of CCR impacts to groundwater, at MW-1801 and MW-1802 do not show increasing trends. If impacts from Landfill leachate to downgradient locations were occurring, increasing boron and sulfate groundwater concentrations would be expected.
- Pennsylvanian-aged aquifer data from a recent USGS report indicate that MW-1801 and MW-1802 contain chloride concentrations that are lower than or comparable to typical values for wells screened within this geologic material across the state.

3.4 Sampling Requirements

The conclusions of this ASD support the determination that the identified SSIs are from natural variation and not due to a release from the Landfill. Therefore, the unit will remain in the detection

monitoring program. Groundwater at the unit will be sampled for Appendix III parameters on a semiannual basis.

4. CONCLUSIONS AND RECOMMENDATIONS

The preceding information serves as the ASD prepared in accordance with 40 CFR 257.94(e)(2) and supports the conclusion that the SSIs for chloride at MW-1801 and MW-1802 are attributed to variation of natural groundwater quality (Type IV). Therefore, no further action is warranted, and the Amos Plant Landfill will remain in the detection monitoring program. Certification of this ASD by a qualified professional engineer is provided in **Attachment C**.

5. REFERENCES

Arcadis. 2020. *FGD Landfill – CCR Revised Groundwater Monitoring Well Network Evaluation*. *John E. Amos Plant. Winfield, West Virginia* May.

Chambers, D. B., M. D. Kozar, J. S. White, and K. S. Paybins. 2012. *Groundwater Quality in West Virginia, 1993–2008*. United States Geological Survey Scientific Investigations Report 2012-5186.

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USGS. n.d. "Monongahela and Conemaugh Formations, undivided." Mineral Resources Online Spatial Data. United States Geological Survey. Accessed July 25, 2023. https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=KYPAmc%3B0.

USEPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*. United States Environmental Protection Agency. EPA 530/R-09-007. March

TABLES

Table 1: Detection Monitoring Data Comparison
Alternative Source Demonstration
Amos Power Plant, Landfill

Geosyntec Consultants, Inc.

Analyte	Unit	Description	MW-2	MW-4	MW-1801		MW-1802	
			5/26/2023	5/26/2023	5/31/2023	7/19/2023	5/26/2023	7/19/2023
Boron	mg/L	Intrawell Background Value (UPL)	0.243	0.206	0.293		0.282	
		Analytical Result	0.187	0.151	0.220	--	0.221	--
Calcium	mg/L	Intrawell Background Value (UPL)	3.50	0.904	1.78		1.05	
		Analytical Result	1.52	0.77	1.47	--	0.82	--
Chloride	mg/L	Intrawell Background Value (UPL)	5.32	25.1	14.0		13.4	
		Analytical Result	3.55	23.8	**14.9**	**15.3**	**17.2**	**16.3**
Fluoride	mg/L	Intrawell Background Value (UPL)	1.74	1.55	5.58		5.32	
		Analytical Result	1.68	1.39	5.32	--	4.99	--
pH	SU	Intrawell Background Value (UPL)	8.9	9.8	9.3		9.4	
		Intrawell Background Value (LPL)	8.2	8.6	8.5		8.7	
		Analytical Result	8.7	9.0	8.6	--	8.9	--
Sulfate	mg/L	Intrawell Background Value (UPL)	12.1	11.5	9.05		24.2	
		Analytical Result	9.5	9.8	4.6	--	19.3	--
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	396	419	563		527	
		Analytical Result	380	400	510	--	510	--

Notes:

Bold values exceed the background value.

Background values are shaded gray.

LPL: lower prediction limit

mg/L: milligrams per liter

SU: standard units

UPL: upper prediction limit

--: not sampled

FIGURES

Legend

- Upgradient Sampling Location
- Downgradient Sampling Location
- FGD Landfill Permitted Limits
- Northern Valley
- Southern Valley

Notes

- Monitoring well coordinates provided by AEP.
- Aerial imagery provided by ESRI and dated 12/07/2023.

700 350 0 700 Feet

Site Layout
FGD Landfill

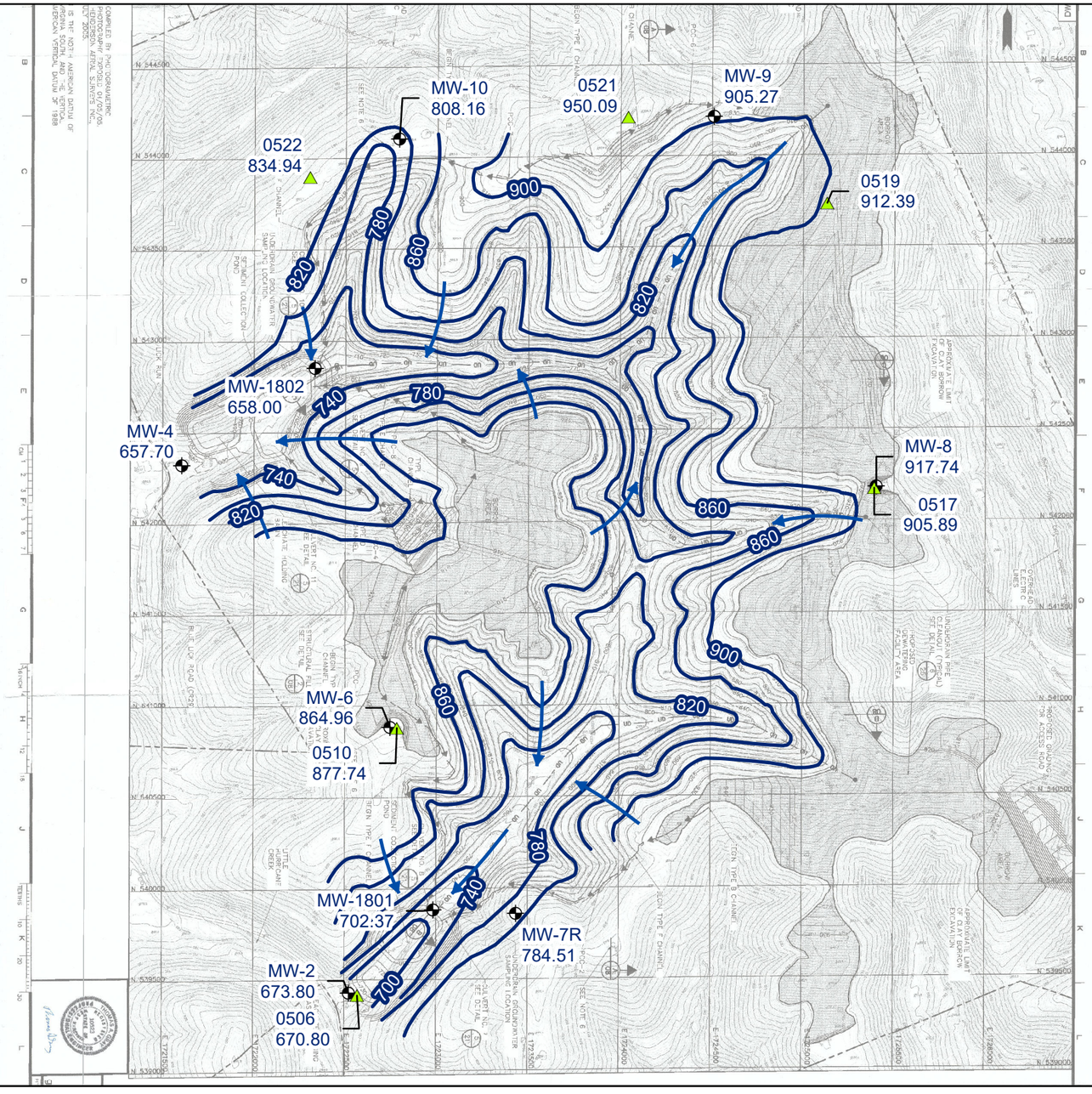
AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2023/12/15

Figure **1**

\\annarbor-01\Data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\AEP-Amos_Landfill_Site_Layout.mxd. ASoltero. 12/15/2023. CHA8423/04/08.



Legend

- Groundwater Monitoring Well
- Piezometer
- Groundwater Elevation Contour
- Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on May 24, 2023) provided by AEP.
- Potentiometric surface contour interval is 40 feet.
- Topography and drainage system basemap from AEP Drawing No. 13-30500-05-A (topographic contour interval: 10 feet).
- Groundwater elevation units are feet above mean sea level.
- AEP - American Electric Power

700 350 0 700 Feet

Potentiometric Surface Map - Uppermost Aquifer
May 2023

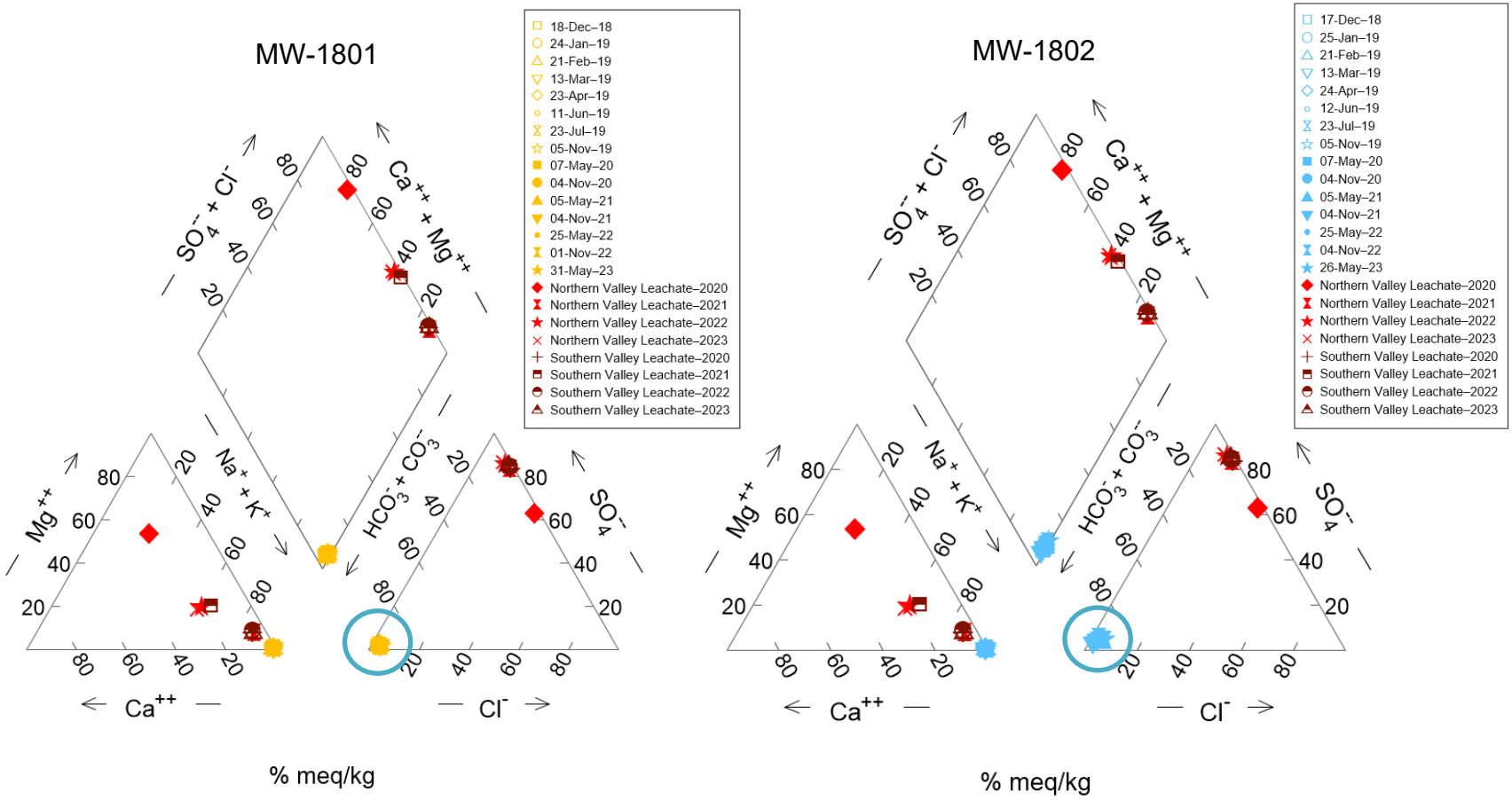
AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | December 2023

Figure **2**

\\annarbor-01\Data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\2023\AEP-Amos_Landfill_GW_2023-05.mxd. ASoltero. 12/11/2023. CHA8423/04/08.



Notes: Landfill leachate samples were collected on August 25, 2020, October 7, 2021, February 15, 2022, and May 17, 2023. Leachate samples were not analyzed for potassium (K^+). All groundwater samples for each monitoring location are circled in blue on the anion distribution triangle.
% meq/kg: percent milliequivalents per kilogram

Piper Diagrams: Leachate Comparison
Amos Landfill

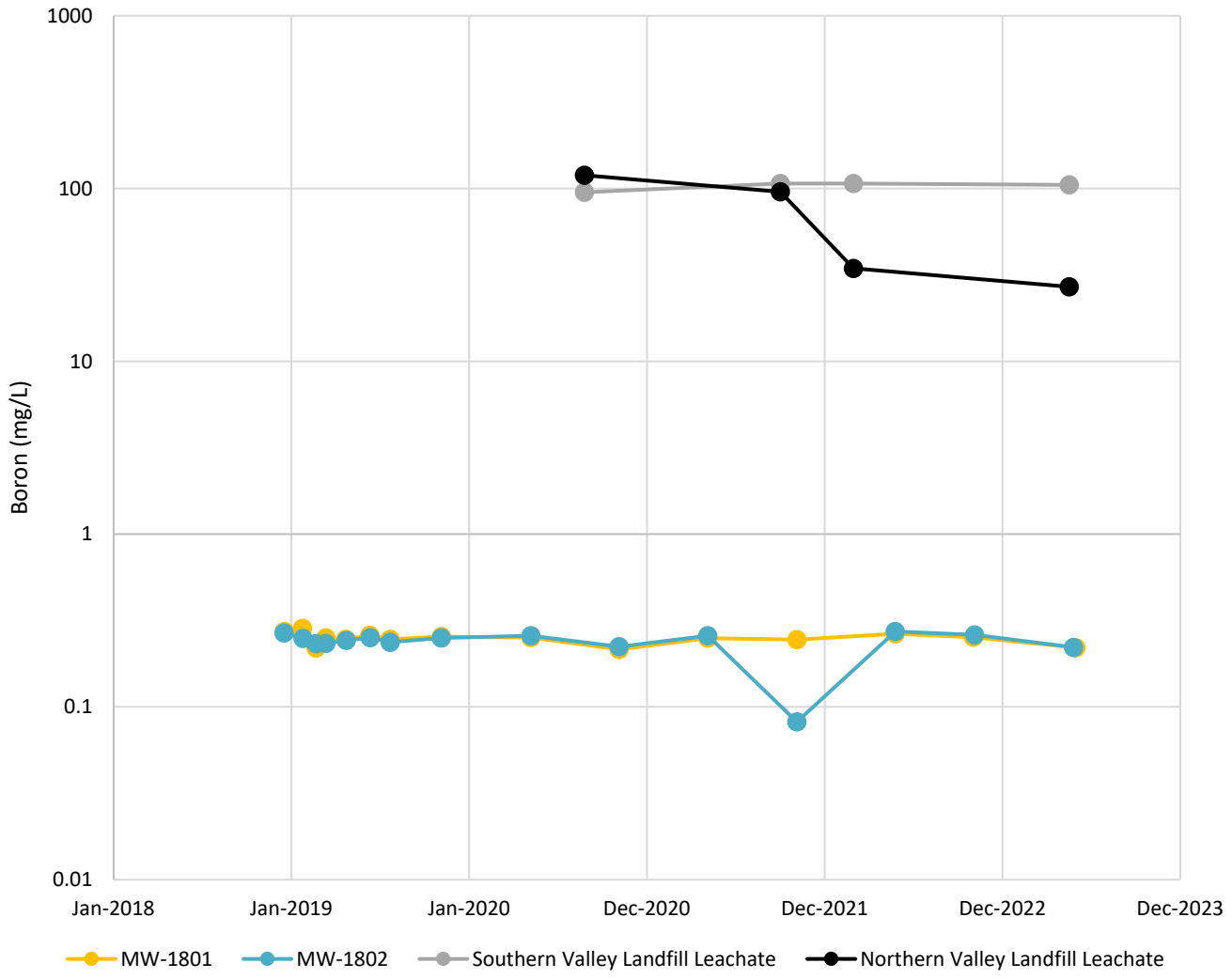
Geosyntec consultants

AMERICAN ELECTRIC POWER

Columbus, Ohio

December 2023

Figure 3



Notes: Data were collected under the federal coal combustion residual (CCR) rule requirements and represents total boron in groundwater.

mg/L: milligrams per liter

Boron Time Series Graph
Amos Landfill

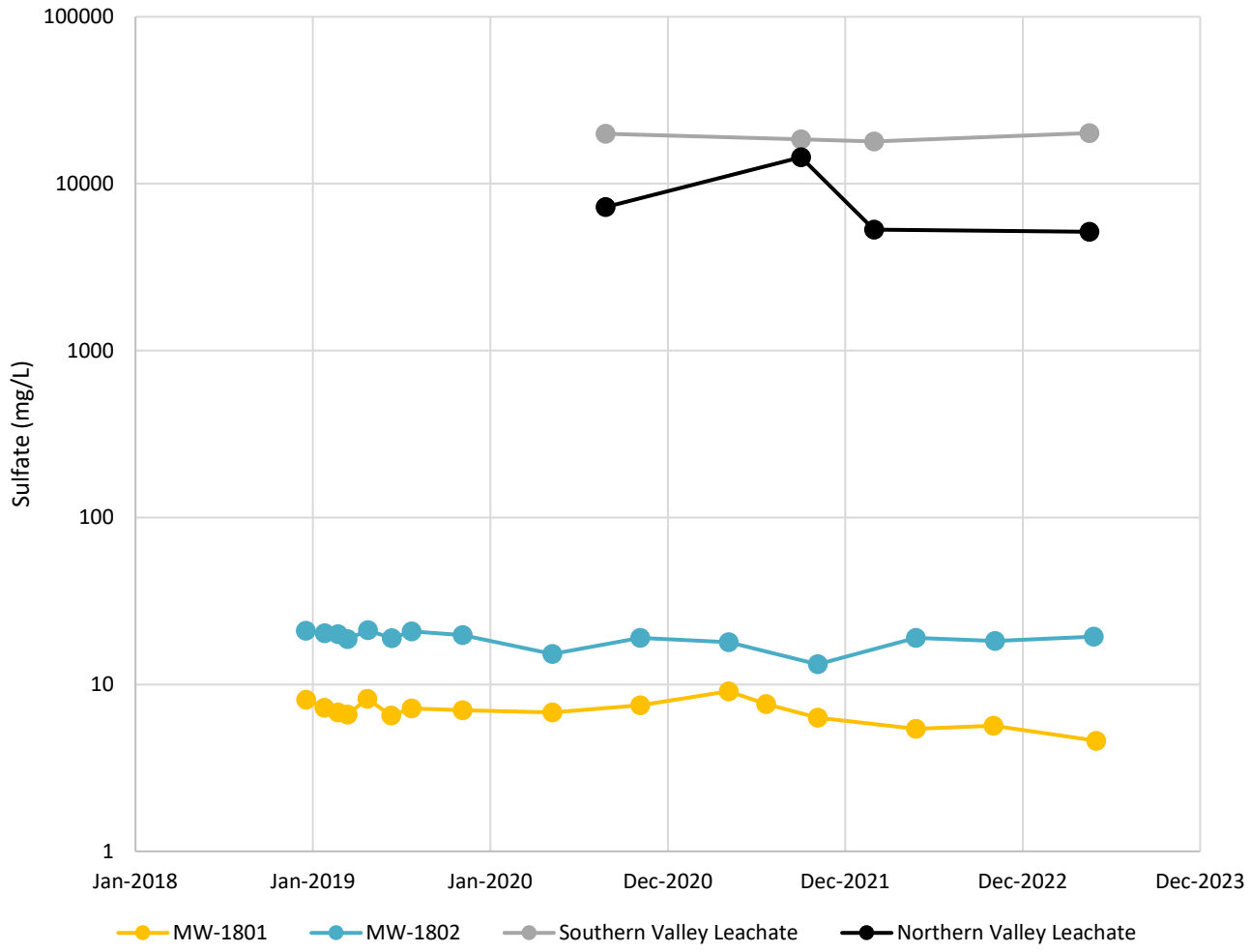
Geosyntec consultants

AMERICAN ELECTRIC POWER

Figure **4**

Columbus, Ohio

December 2023



Notes: Data was collected under the federal CCR rule and represents total sulfate in groundwater.

mg/L: milligrams per liter

Sulfate Time Series Graph
Amos Landfill

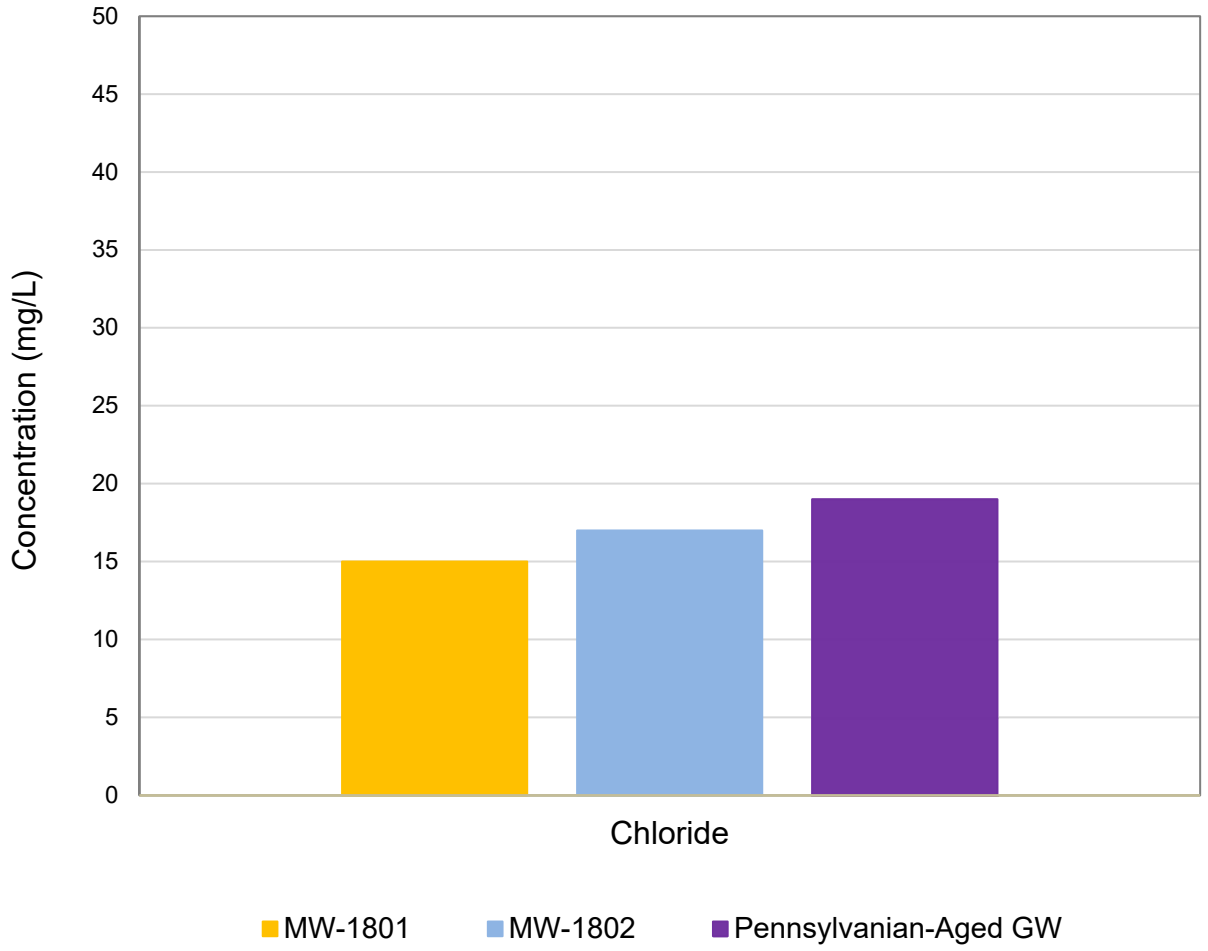
Geosyntec consultants

AMERICAN ELECTRIC POWER

Figure **5**

Columbus, Ohio

December 2023



Notes: MW-1801 and MW-1802 show the maximum chloride concentration from all past collected data at each monitoring well. 'Pennsylvanian-Aged GW', shown in purple, represents median Pennsylvanian-aged aquifer data from Chambers et al., 2012. Data for Amos monitoring wells were collected under the federal CCR rule and represents total chloride in groundwater.

mg/L: milligrams per liter

Chloride Concentration Bar Graph
Amos Landfill

Geosyntec consultants

AMERICAN ELECTRIC POWER

Columbus, Ohio

December 2023

Figure **6**

ATTACHMENT A

MW-1801 and MW-1802 Boring Logs and Well Construction Diagrams

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos - FGD Landfill**

COORDINATES **N 38.5 E 81.6**

GROUND ELEVATION **735.6** SYSTEM **NAVD88**

Water Level, ft	▽ 21.0	▼	▼
TIME			
DATE	8/15/2018		

BORING NO. **MW-1801** DATE **5/3/19** SHEET **1** OF **5**

BORING START **8/7/18** BORING FINISH **8/8/18**

PIEZOMETER TYPE **PVC** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.8** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **50.4** BOTTOM **114.4**

WELL DEVELOPMENT **Surge/Purge** BACKFILL **Bentonite Grout**

FIELD PARTY **Zachary Racer (AEP)** RIG **Direct Circulation - Wireline Core**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
									CL ML	0-5': SILTY CLAY; 2.5YR 5/6 (red); moist; backfill material.		0-49': Riser
		5.0	6.5	50/4	3.6		5			5-6': SANDSTONE.		
		6.5	8.0	48-23-15	3.6				CL ML	6-6.3': SHALE; GLEY1 5/N (gray); dry; thin bedded; hard.		
									ML	6.3-6.5': SILTY CLAY; red; moist; hard		
		8.0	9.5	11-3-5	7.2				MH	6.5-8': SILT; 10YR 6/2 (tan); with sandstone and shale fragments; compacted fill material. 8-9.5': CLAYEY SILT; 5YR 4/2 (brown); firm; moist; fill material.		
		9.5	11.0	4-4-7	10.8		10		CL ML	9.5-11': SILTY CLAY; 10YR 6/3 (brown) to brown clayey silt; dry; crumbly; fill material.		
		11.0	12.5	4-8-50/3	10.8				CL ML	11-12.5': SILTY CLAY; 5YR 4/2 (brown); moist; firm.		
		12.5	14.0	50/3					ML	Note: Sandstone at 12-12.3'. 12.5-14': SILT, compacted; 10YR 7/4 (tan); very hard; dry; fill material.		
		14.0	15.5	50/4						14-14.5': SILTY SHALE material, weathered; mottled tan and dark brown; dry; very hard.		
		14.9	19.9		51		15			14.5-14.9': SANDSTONE; strong field strength; 2.5Y 6/2; fine-grained texture; massive structure; slightly to moderately decomposed; moderately disintegrated with Fe staining; fracture at 14.3-14.5'. 14.9-19.9': SHALE; moderate field strength; GLEY1 5/GY; fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintegrated along bedding planes and fracture; vertical fracture with Fe staining at 15.5-16.5'.		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
NA	6" x 3.25 HSA	
NA	9" x 6.25 HSA	
NA	HW CASING ADVANCER	4"
NA	NW CASING	3"
NA	SW CASING	6"
NA	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **A. Gillespie**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **2** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		19.9	24.9	8-7-6	55					19.9-24.9': SHALE; moderate field strength; GLEY1 5/GY; fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintegrated; moderately to intensely fractured. Transition to strong field strength, 2.5YR 4/4; fine-grained texture; massive structure to thinly bedded; slightly decomposed; slightly disintegrated; slightly to moderately fractured.		
		24.9	34.9	4-4-13	72		25			24.9-25.2': SHALE; strong field strength; fine-grained structure; massive structure to thinly bedded; slightly decomposed; slightly disintegrated; slightly to moderately fractured. 25.2-30.7': CLAYSTONE/MUDSTONE, highly weathered; very weak field strength; 10YR 5/3; very fine-grained texture with sandstone fragments; massive structure; highly decomposed; intensely disintegrated; unfractured.		
		34.9	38.3	4-5-8	36		30			30.7-32.5': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed; slightly to moderately disintegrated; slightly to moderately fractured. 32.5-34.9': CLAYSTONE/MUDSTONE; moderate field strength; GLEY1 4/104; fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately to intensely fractured.		
		38.3	44.9	5-7-13-9-6-6	70		35			34.9-38.3': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; moderately to highly decomposed; intensely disintegrated, mottling tan and gray; moderately to intensely fractured. 38.3-44.9': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; highly decomposed; intensely disintegrated; intensely fractured.		
		44.9	50.0	4-4-7-8	50		40					
							45			44.9-50': CLAYSTONE/MUDSTONE; moderate to weak field strength; 2.5YR 4/4 (red) mottled with		

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COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **3** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		44.9	50.0	4-4-7-8	50					tan, black, and gray; fine-grained texture; massive structure; highly decomposed; intensely disintegrated; intensely fractured.		49-52': Bentonite Pellets
		50.0	55.0	4-4-5-4	50		50			50-56.7': CLAYSTONE/MUDSTONE; moderate field strength; 2.5YR 4/4 (red) mottled with tan, black, and gray; fine-grained texture; massive structure; moderately to highly decomposed, becomes less weathered at 50.3'; highly disintegrated, highly mottled; moderately to intensely fractured.		52-53': Secondary Filter Pack 53-75': Primary Filter Pack
		55.0	59.8	5-7-5-36	52		55					55-75': Screen
		59.8	64.8	8-5-4-4-7-5-5-4	60		60			56.7-58': SANDSTONE, interbedded; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture; moderately fractured at 56.7' and 57.1-57.5'. 58-58.8': SHALE, interbedded; strong field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture. 58.8-59.2': SANDSTONE, interbedded; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture. 59.2-59.8': SHALE, interbedded; strong field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated along fracture.		
		64.8	74.8	4-5-4-6	76		65			59.8-60.7': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; unfractured. 60.7-63.9': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed along bedding planes; moderately disintigrated with silt filled fractures; moderately fractured. 63.9-64.3': SANDSTONE; strong field strength; GLEY1 6/N (gray-green); fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; unfractured.		
							70			64.3-64.8': SHALE; moderate field strength; 2.5YR 4/4 (red); fine-grained texture; thinly bedded; moderately decomposed; moderately		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **4** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		64.8	74.8	4-5-4-6	76					disintigrated; moderately fractured.		
										64.8-74.8': SHALE, highly weathered at base; moderate to weak field strength along some bedding planes; 2.5YR 3/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintigrated, becomes more limestone fragments last 1 ft, 3-5 cm; moderately to intensely fractured.		
		74.8	85.0				75			74.8-85': SHALE, highly weathered; weak field strength; 2.5YR 4/4 (red) with tan and gray mottling; fine-grained texture; massive structure; highly decomposed; highly disintigrated, mottled; intensely fractured.		75-105': Bentonite
		85.0	95.0	5-4-4	120		80			85-92.7': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated, calcite in light colored beds/thin; slightly fractured.		
							85					
							90			92.7-94.6': SHALE; moderate field strength; fine-grained texture; massive structure; slightly decomposed; slightly disintigrated, some mottling; moderately fractured.		
		95.0	105.0	7-4-4	120		95			94.6-95': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated, calcite in light colored beds/thin; slightly fractured at 94.6-95'.		
										95-100.1': SANDSTONE; strong field strength; fine-grained texture; thinly bedded; fresh; slightly disintigrated; slightly fractured at 95-95.2'.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1801** DATE **5/3/19** SHEET **5** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/7/18** BORING FINISH **8/8/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		95.0	105.0	7-4-4	120		100			100.1-101.5': SHALE and sandstone interbedded; moderate field strength; fine-grained texture; thinly bedded; slightly decomposed; slightly disintigrated; slightly fractured at 100.2-100.5'. 101.5-105': SHALE; moderate to weak field strength; fine-grained texture; massive structure; highly decomposed; moderately to highly disintigrated mottling with silt filled fractures; highly fractured.		
							105					
							110					
							115					
							120					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos - FGD Landfill**

COORDINATES **N 38.5 E 81.9**

GROUND ELEVATION **709.8** SYSTEM **NAVD88**

Water Level, ft	▽ 35.0	▼	▼
TIME			
DATE	8/21/2019		

BORING NO. **MW-1802** DATE **5/3/19** SHEET **1** OF **5**

BORING START **8/20/18** BORING FINISH **8/21/18**

PIEZOMETER TYPE **NA** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.91** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **50** BOTTOM **114.4**

WELL DEVELOPMENT **Surge/Purge** BACKFILL **Bentonite Grout**

FIELD PARTY **Zachary Racer (AEP)** RIG **Direct Circulation - Wireline Core**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
									GW	0-3.5': GRAVEL backfill; large rip-rap and smaller compacted gravels.		0-41': Bentonite Grout
									CL	3.5-4.5': SILTY CLAY; brown; moist; soft; backfill material.		
		4.5	6.0	6-4-5	0		5			4.5-6': NO RECOVERY, due to gravel blocking cutting shoe.		
		6.0	7.5	4-3-4	3.6				CL	6-17': SILTY CLAY; 7.5YR 4/3 (brown); moist; firm; compacted backfill material; becomes wet at 12.5'.		
		7.5	9.0	3-4-5	7.2							
		9.0	10.5	4-4-6	18		10					
		10.5	12.0	5-4-5	13.2							
		12.0	13.5	3-4-6	15.6							
		13.5	15.0	3-5-8	14.4							
		15.0	16.5	4-7-9	15.6		15					
		16.5	18.0	6-25-8	16.8					17-17.5': SANDSTONE, weathered; GLEY1 7/N (gray); dry.		
		18.0	19.5	7-23-15	14.4				CL	17.5-19.5': SILTY CLAY; GLEY1 6/N (gray) mottled with brown, red, tan; moist; soft; crumbles easily.		
		19.5	21.0	20->50/4	10.8				CL			

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
NA	6" x 3.25 HSA	
NA	9" x 6.25 HSA	
NA	HW CASING ADVANCER	4"
NA	NW CASING	3"
NA	SW CASING	6"
NA	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **A. Gillespie**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

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LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **2** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		19.5	21.0	20->50/4	10.8					19.5-22.5': SILTY CLAY; GLEY1 6/N (gray) mottled with brown, tan; dry; soft; crumbles easily.		
		21.0	22.5	27-50/5	9.6							
		22.5	24.4	4	23					22.5-24': SILTSTONE; moderate to weak field strength; GLEY1 6/N; fine-grained texture; massive structure; highly decomposed; moderately to highly disintegrated with tan/brown mottling; moderately to intensely fractured.		
		24.4	29.4		22		25			24-24.4': SILTSTONE; weak field strength; 10R 4/4 (red) mottled; fine-grained texture; massive structure; highly decomposed; moderately to intensely fractured.		
										24.4-29.4': SILTSTONE; weak field strength; 10R 4/4 (red) mottled with tan, gray, and black; fine-grained texture; massive structure; highly decomposed; highly disintegrated, highly mottled; moderately fractured.		
		29.4	33.7	5-11-6	40		30			29.4-32.8': SHALE, weathered; moderate field strength; 10YR 4/4 (red) mottled; fine-grained texture; massive structure; moderately decomposed; moderately to intensely disintegrated; moderately fractured.		
		33.7	39.4	5-4-4-7-5	59		35			32.8-33.7': SHALE; moderate field strength; 5YR 5/4 (tan) mottled; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; moderately to intensely fractured.		
										33.7-39.4': SHALE; moderate field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; intensely fractured.		
		39.4	44.4	4-6-4-4	57		40			39.4-44.4': SHALE; moderate field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated; intensely fractured.		41-44': Bentonite Pellets
		44.4	54.4	7-8-7-5-5-24-5	120		45			44.4-47.8': SHALE, highly weathered; weak field strength; 10YR 4/4 (red) with gray, tan, and black mottling; fine-grained texture; massive structure;		44-45': Secondary Filter Pack 45-71': Primary Filter Pack

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PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		44.4	54.4	7-8-7-5-5-24-5	120					highly decomposed; intensely disintegrated; intensely fractured.		
										47.8-49.9': SHALE, less weathered; moderate field strength; 10R 3/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately fractured.		
							50			49.9-50.8': SHALE, interbedded with sandstone; moderate field strength; GLEY1 4/N; fine-grained texture; thinly bedded; moderately decomposed; slightly disintegrated; moderately fractured.		50-70': Screen
										50.8-52.8': SHALE; moderate to strong field strength; 10R 4/3 (red); fine-grained texture; massive structure; slightly decomposed; moderately disintegrated; slightly fractured.		
										52.8-53.1': SHALE, interbedded with sandstone; strong field strength; GLEY1 4/5GY; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; unfractured.		
		54.4	64.4	8-12-5-6-7-4-4-4	114		55			53.1-54.4': SHALE; moderate field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; moderately fractured.		
										54.4-55.4': SANDSTONE, interbedded with shale; moderate field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately decomposed; moderately disintegrated; slightly to moderately fractured.		
							60			55.4-57.1': SHALE, interbedded with sandstone; moderate field strength; GLEY1 4/3, 10R 4/3; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
										57.1-64.4': SHALE, weathered; moderate to weak field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately to highly decomposed; moderately to intensely disintegrated with intense gray mottling; intensely fractured.		
		64.4	74.4	4-6-8-6-4-5-4-4-5	117		65			64.4-70.5': SHALE, highly weathered; moderate to weak field strength; 10R 4/3 (red); fine-grained texture; massive structure; moderately to intensely disintegrated with gray mottling; intensely fractured.		
							70			70.5-74.4': SHALE, interbedded with sandstone; strong field strength; 10R 4/3 (red) interbedded with GLEY1 4/N (gray-green); fine-grained		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

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COMPANY **American Electric Power** BORING NO. **MW-1802** DATE **5/3/19** SHEET **4** OF **5**

PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		64.4	74.4	4-6-8-6-4-5-4-4-5	117					texture; thinly bedded; slightly to moderately decomposed along some bedding planes; moderately disintegrated with silt filled fractures; moderately fractured.		
		74.4	84.4	8-7-5-5-14-8-7-22-12	120		75			74.4-77.1': SHALE, with some interbedded sandstone lenses; moderate field strength; 10R 4/3 (red); fine-grained texture; thinly bedded; slightly to moderately decomposed at some bedding planes; slightly disintegrated; moderately fractured.		
							80			77.1-82.7': SANDSTONE, with some red shale lenses; strong field strength; GLEY1 4/N; fine-grained texture; thinly bedded; fresh; moderately disintegrated, calcite reacts to HCl in light colored bands within 0.5' of surrounding contact lines, no HCl/calcite in fractures, no Fe staining; moderately fractured.		
										82.7-84.4': SHALE, with some interbedded sandstone lenses; moderate field strength; 10R 4/3 (red); fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
		84.4	94.4	10-11-6-7-7-8-9-8-7-6-6-7-10	120		85			84.4-86.7': SHALE, with sandstone lenses; moderate field strength; 10R 4/2 (red) with GLEY1 4/N lenses; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
										86.7-89.2': SANDSTONE, with shale lenses; moderate field strength; GLEY1 4/N with 10R 4/2 lenses; fine-grained texture; thinly bedded; slightly decomposed; slightly disintegrated; moderately fractured.		
							90			89.2-94.4': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded, micaceous; fresh; slightly disintegrated, some calcite in light bands, no staining, no calcite in fractures; slightly to moderately fractured along bedding planes; fracture at 92.8'.		
		94.4	104.4	7-4-5-4-9-9-8-5-11-5-6-10-19	120		95			94.4-104.4': SANDSTONE; strong field strength; GLEY1 6/N; fine-grained texture; thinly bedded, micaceous, cross-bedding at 94.4-94.8; fresh; slightly disintegrated, calcite in some light bedded planes, no calcite or Fe staining noted in fractures; slightly to moderately fractured along bedding planes.		

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PROJECT **Amos - FGD Landfill** BORING START **8/20/18** BORING FINISH **8/21/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		94.4	104.4	7-4-5-4-9-9-8-5-11-5-6-10-19	120		100					
		104.4	114.4	15-6-21-6-4-4-8-8-6-4-13-5-7	120		105			104.4-108': SANDSTONE; strong field strength; GLEY1 6/N; fine to medium-grained texture; thinly bedded, micaceous, shale fragments; fresh; moderately disintegrated, calcite along entire sandstone void and shale fragments at base, calcite in void; slightly fractured.		
										108-108.9': SHALE, with interbedded sandstone; moderate field strength; GLEY1 4/N, 10R 4/3 bands; thinly bedded; moderately decomposed between bedding planes; moderately disintegrated along bedding planes; moderately fractured.		
							110			108.9-114.4': SHALE; moderate field strength; 10R 4/3 (red) with GLEY1 4/N mottling; fine-grained texture; massive structure; moderately decomposed; moderately to intensely disintegrated, mottling; moderately fractured.		
							115					
							120					

AEP - AEP.GDT - 5/3/19 11:49 - S:\KNOXVILLE-TN\FOR NICOLE AEP LOG EDIT FILES\GINT LOGS OUTPUT\AEP MOUNTAINEER\AEP MOUNTAINEER.GPJ

ATTACHMENT B
Stress-Relief Fracture Conceptual Site Model

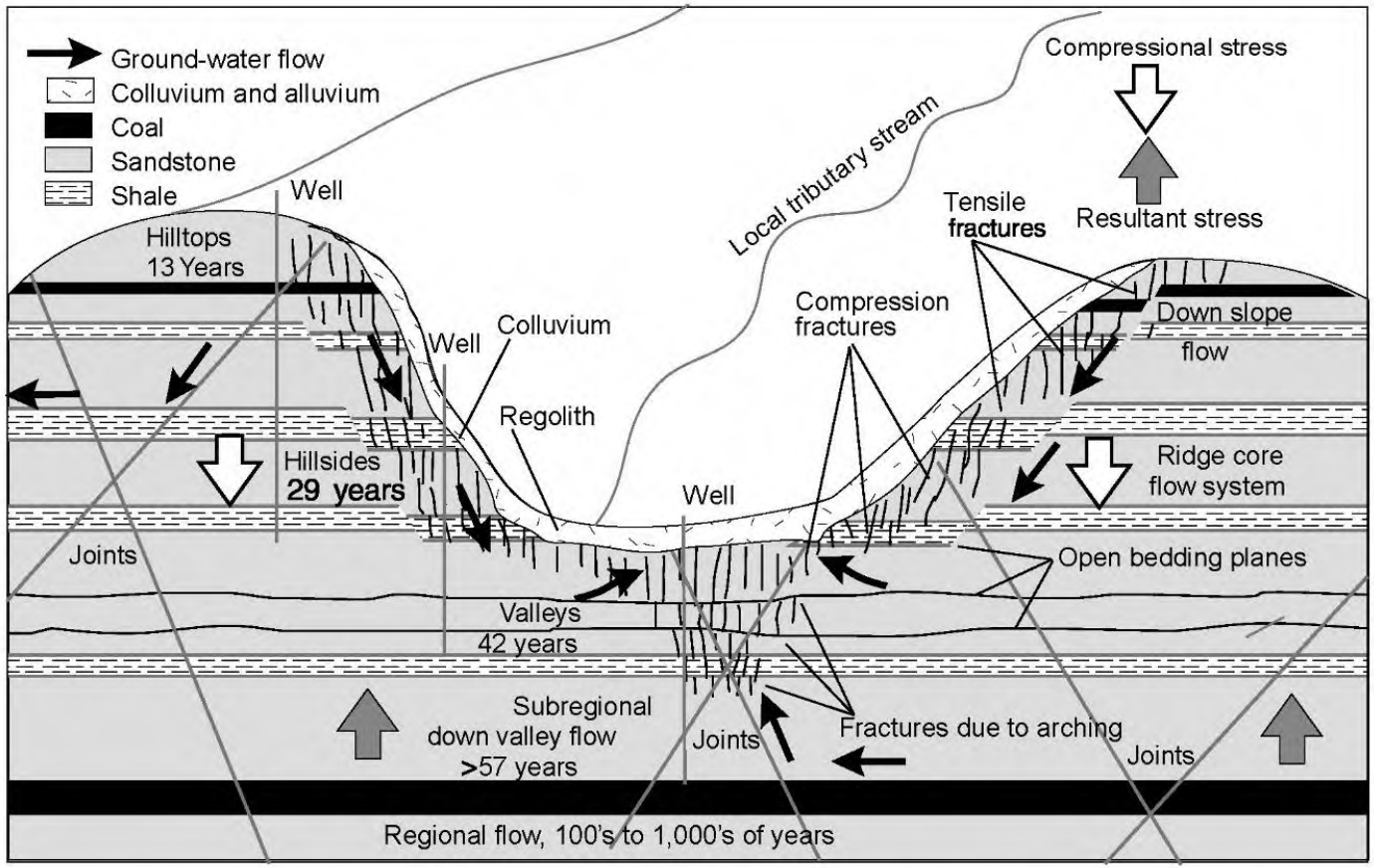


Figure 3. Revised conceptual model of ground-water flow in an Appalachian Plateaus fractured-bedrock aquifer including apparent age of ground water (Modified from Wyrick and Borchers, fig. 3.2-1, 1981 and Kozar, 1998).

References:

- United States Geological Survey (USGS), Wyrick, G.D. and J.W. Borchers, 1981. Hydrologic Effects of Stress-Relief Fracturing in an Appalachian Valley. Water-Supply Paper 2177.

AEP AMOS GENERATING PLANT - FGD LANDFILL
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

STRESS RELIEF FRACTURE SYSTEM CONCEPTUAL SITE MODEL

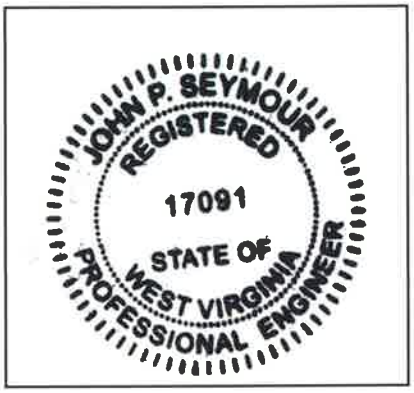
ARCADIS Design & Consultancy for natural and built assets

FIGURE
4

ATTACHMENT C
Certification by a Qualified Professional Engineer

CERTIFICATION BY A QUALIFIED PROFESSIONAL ENGINEER

I certify that the above described alternative source demonstration is appropriate for evaluating the groundwater monitoring data for the Amos Plant Landfill CCR management area and that the requirements of 40 CFR 257.94(e)(2) have been met.



John Seymour
Printed Name of Licensed Professional Engineer

Signature

017091	West Virginia	1/3/2024
License Number	Licensing State	Date

APPENDIX 4

Not applicable.

APPENDIX 5

Not applicable.