ALTERNATIVE SOURCE DEMONSTRATION REPORT

2024 2nd SEMIANNUAL EVENT
TEXAS STATE CCR RULE

H.W. Pirkey Power Plant
East Bottom Ash Pond
Registration No. CCR104
Hallsville, Texas

Prepared for

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LIST OF ACRONYMS

Å	angstrom
ASD	alternative source demonstration
bgs	below ground surface
CCR	coal combustion residuals
EBAP	East Bottom Ash Pond
EDS	energy-dispersive spectroscopy
EPRI	Electric Power Research Institute
GWPS	groundwater protection standard
LCL	lower confidence limit
mg/kg	milligram per kilogram
mg/L	milligram per liter
SEM	scanning electron microscopy
SPLP	Synthetic Precipitation Leaching Procedure
SSL	statistically significant level
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
VAP	vertical aquifer profiling
WBAP	West Bottom Ash Pond
XRD	X-ray diffraction

1. INTRODUCTION AND SUMMARY

This alternative source demonstration (ASD) report has been prepared to address statistically significant levels (SSLs) of cobalt and lithium in the groundwater monitoring network for the former East Bottom Ash Pond (EBAP), located at the H.W. Pirkey Plant in Hallsville, Texas, following the second semiannual assessment monitoring event of 2024. The H.W. Pirkey Plant has four coal combustion residuals (CCR) storage units regulated by the Texas Commission on Environmental Quality (TCEQ) under Registration No. CCR104 (**Figure 1**). Three of the units, including the former EBAP, have been closed by removal, and one unit is still active.

In September 2024, a semiannual assessment monitoring event was conducted at the former EBAP in accordance with the Texas Administrative Code (TAC) Title 30 §352.951(a) [30 TAC §352.951(a)]. The monitoring data were submitted to Groundwater Stats Consulting, LLC for statistical analysis. Confidence intervals were recalculated for the Appendix IV parameters at the compliance wells to assess whether these parameters were present at SSLs above the groundwater protection standards (GWPSs). An SSL was concluded if the lower confidence limit (LCL) of a parameter exceeded the GWPS (i.e., if the entire confidence interval exceeded the GWPS). The following SSLs were identified at the former EBAP (Geosyntec 2024a):

- The LCLs for cobalt exceeded the GWPS of 0.00939 milligrams per liter (mg/L) at AD-2 (0.0230 mg/L), AD-31 (0.00947 mg/L), and AD-32 (0.0280 mg/L).
- The LCL for lithium exceeded the GWPS of 0.0489 mg/L at AD-2 (0.0583 mg/L), AD-31 (0.0767 mg/L), and AD-32 (0.0721 mg/L).

No other SSLs were identified.

1.1 CCR Rule Requirements

TCEQ regulations regarding assessment monitoring programs for CCR landfills and surface impoundments provide owners and operators with the option to make an ASD when an SSL is identified:

> In making a demonstration under this subsection, the owner or operator must, within 90 days of detecting a statistically significant level above the groundwater protection standard of any constituent listed in Appendix IV adopted by reference in §352.1431 of this title, submit a report prepared and certified in accordance with §352.4 of this title (relating to Engineering and Geoscientific Information) to the executive director, and any local pollution agency with jurisdiction that has requested to be notified, demonstrating that a source other than a CCR unit caused the exceedance or that the exceedance resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. (30 TAC §352.951(e))

Pursuant to 30 TAC §352.951(e), Geosyntec Consultants, Inc. (Geosyntec) has prepared this ASD report to document that the SSLs identified for cobalt and lithium in the groundwater monitoring network for the EBAP are from a source other than the former EBAP.

1.2 Demonstration of Alternative Sources

An evaluation was completed to assess possible alternative sources to which the identified SSLs could be attributed. Alternative sources were categorized into the following five types, based on methodology provided by the Electric Power Research Institute (EPRI 2017):

- 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 (i.e., anthropogenic impacts)

A demonstration was conducted to show that the SSLs identified for cobalt and lithium were based on a Type IV cause and not by a release from the former Pirkey EBAP.

2. SUMMARY OF SITE CONDITIONS

The EBAP design and construction, regional geology and site hydrogeology, and groundwater monitoring system and flow conditions are described below.

2.1 EBAP Design and Construction

The EBAP was a 31.5-acre CCR surface impoundment located at the north end of the Pirkey Plant, immediately east of the West Bottom Ash Pond (WBAP) (**Figure 1**). It was constructed while the Pirkey Plant was being developed in 1983 and 1984 and placed into operation in 1985 to receive bottom ash and economizer ash sluiced from the Plant boiler (Arcadis 2016). Pirkey Power Plant placed CCR and non-CCR waste streams into the pond complex, alternating between the EBAP and WBAP. Bottom ash generated at the plant was sluiced to one of the ponds (the active pond) until it was close to full. Bottom ash in the inactive pond was drained and dewatered, and then removed from the pond. Dry ash was loaded into trucks and transported to the Landfill. It typically took approximately twelve months for the active pond to fill, at which time the second pond (which had been emptied of bottom ash) became the active pond, and the first pond was drained.

A Closure Plan was developed in October 2016 and revised in December 2021 (AEP 2021). This document detailed the closure activities which were to take place throughout the closure of the EBAP. AEP submitted a certified notification that the receipt of CCR materials had ceased as of April 25, 2023 and the closure activities had been initiated (AEP 2023a). At that time, the EBAP commenced closure by removal in accordance with the Closure Plan, with CCR material removal occurring from April to June of 2023. The final inspection for CCR material removal was completed on July 20, 2023. On October 17, 2023, the EBAP was certified closed by removal in accordance with 30 TAC §352.1221 and the most recent Closure Plan, and notification was placed in the Operating Record (AEP 2023b).

The former EBAP was developed by excavating part of its perimeter into native soils to create an embankment height of approximately 4 feet, constructing compacted clay perimeter embankments, and constructing a compacted clay liner over the base of the pond (Arcadis 2016). Multiple lithological borings advanced after the installation of the clay liner confirm that at least 6 feet of clay was present below the base of the EBAP (Arcadis 2016). The bottom elevation of the EBAP was approximately 347 feet above mean sea level, and the elevation of the top of the pond embankment was approximately 357 feet above mean sea level.

2.2 Regional Geology / Site Hydrogeology

The former EBAP was positioned on an outcrop of the Eocene-age Recklaw Formation, which consists predominantly of clay and fine-grained sand (Arcadis 2016). The Recklaw Formation is underlain by the Carrizo Sand, which crops out in the topographically lower southern portion of the plant. Regionally, the Carrizo Sand consists of fine- to medium-grained sand interbedded with silt and clay.

The very-fine- to fine-grained clayey and silty sand found beneath an upper silty to silty sandy clay layer in the vicinity of the former EBAP is considered to be the uppermost aquifer below this CCR unit (Arcadis, 2016). Here it is approximately 15-feet thick and located between an elevation of 325 and 340 feet mean sea level.

2.3 Groundwater Monitoring History and Flow Conditions

The groundwater monitoring well network for the former EBAP monitors groundwater within the uppermost aquifer. Geologic cross section A-A' from the EBAP Groundwater Monitoring Well Network Report (Arcadis 2016), provided herein as **Attachment A**, shows the subsurface geometry of the uppermost aquifer (indicated on the figure as clayey silty sand, tan to gray) underlying the former EBAP and the former WBAP and demonstrates lateral continuity of the uppermost aquifer spanning the entire length of the former EBAP.

Groundwater flow direction in the area of the former EBAP is west-southwesterly (**Figure 1**). Seasonal variability in groundwater flow has not been observed since the monitoring well network was installed. Groundwater flow velocities in the uppermost aquifer in the vicinity of the former EBAP have been reported as approximately 6 to 44 feet per year. The monitoring network for the former EBAP unit consists of upgradient monitoring wells AD-4, AD-12, and AD-18 and compliance wells AD-2, AD-3, AD-31, and AD-32, all of which are screened within the uppermost aquifer.

3. ALTERNATIVE SOURCE DEMONSTRATION

The ASD evaluation method and proposed alternative source of cobalt or lithium in AD-2, AD-31, and AD-32 are described below.

3.1 Proposed Alternative Source

An initial review of site geochemistry, site historical data, and laboratory quality assurance and quality control data did not identify alternative sources for cobalt and lithium due to Type I (sampling), Type II (laboratory), Type III (statistical evaluation), or Type V (anthropogenic impacts) issues. Groundwater sampling, laboratory analysis, and statistical evaluations were generally completed in accordance with 30 TAC §352.931 and the draft TCEQ guidance for groundwater monitoring (TCEQ 2020). As described below, the SSLs have been attributed to natural variation associated with the underlying geology, which is a Type IV (natural variation) issue.

3.1.1 Cobalt

Previous ASDs for cobalt at the former EBAP provided evidence that cobalt is present in the aquifer geologic media at the site and that the observed cobalt concentrations in groundwater were due to natural variation of native geogenic sources (Geosyntec 2019a, Geosyntec 2019b, Geosyntec 2020a, Geosyntec 2020b, Geosyntec 2021a, Geosyntec 2021b, Geosyntec 2022a, Geosyntec 2022b, Geosyntec 2023a, Geosyntec 2023b, Geosyntec 2023c, Geosyntec 2023d, Geosyntec 2024b). The previous ASDs demonstrated how the former EBAP was not a source for the elevated cobalt in downgradient groundwater, based on observed concentrations of cobalt both in the ash material and in leachate from Synthetic Precipitation Leaching Procedure (SPLP) analysis (SW-846 Test Method 1312 [United States Environmental Protection Agency 1994]) of the ash material. Cobalt was not detected in the most recent SPLP ash leachate sample, collected in 2019, above the reporting limit of 0.01 mg/L, which is lower than the average concentrations of 0.0114 to 0.0380 mg/L observed at the wells of interest (**Table 1**).

In a February 2023 surface water sample collected from the EBAP to characterize the total cobalt concentrations, cobalt was detected at a concentration of 0.00350 mg/L (**Table 1**). This concentration is lower than the reported cobalt concentrations for multiple in-network wells from the September 2024 sampling event (**Figure 2**). The cobalt concentration of the EBAP sample was also found to be approximately an order of magnitude lower than the average concentration in groundwater at the wells of interest (**Table 1**). Therefore, the former EBAP is not the likely source of cobalt at AD-2, AD-31, or AD-32.

As noted in the previous ASDs, soil samples collected across the site, including from locations near the former EBAP, identified cobalt in the aquifer solids at concentrations ranging from non-detect to 23.5 milligrams per kilogram (mg/kg), with the highest value reported at AD-41, which is upgradient of the EBAP and WBAP (**Figure 3**). SB-2 was advanced in the vicinity of AD-2 in April 2020 to re-log the geology at AD-2 and collect samples for laboratory analysis of total metals and mineralogy. The SB-2 field boring log, which was generated by Auckland Consulting LLC, is provided as **Attachment B**. Cobalt was detected at AD-2 at concentrations of 9.45 mg/kg at 25–27 feet below ground surface (bgs) and 19.2 mg/kg at 31–33 feet bgs (**Table 2**). These cobalt concentrations are greater than the concentration of cobalt present in the bottom ash (6.1 mg/kg; **Table 1**). Both samples correlate to the depth of the monitoring well screen of AD-2 (20–40 feet bgs), indicating that naturally occurring cobalt is present in aquifer solids within the AD-2 screened interval.

In addition to the analysis of total cobalt, soil samples were submitted for mineralogical analysis to determine the mineral composition of soils near the former EBAP. X-ray diffraction (XRD) analysis of soils from SB-2 identified pyrite (an iron sulfide) in samples collected at 25–27 feet bgs and 31–33 feet bgs at concentrations up to 7% by weight (**Figure 3**). Cobalt is known to undergo isomorphic substitution for iron in crystalline iron minerals such as pyrite due to their similar ionic radii of approximately 1.56 angstroms (Å) for iron and 1.52 Å for cobalt (Clementi and Raimondi 1963, Krupka and Serne 2002, Hitzman et al. 2017). The presence of iron-bearing minerals in soil near the former EBAP constitutes a potential source of naturally occurring cobalt.

The aquifer solids at SB-2 are distinctly red in color at shallow depths, as illustrated in the photolog of soil cores provided in **Attachment C**. The red color of the soil suggests the presence of iron oxide and hydroxide minerals within the shallow depth interval. While shallow samples were not collected for mineralogical analysis, red color in soils is often associated with the presence of oxidized iron-bearing minerals such as hematite and goethite. The weathering of pyrite to these iron oxide and hydroxide minerals under oxidizing conditions is also a well-understood phenomenon, including in formations in east Texas (Senkayi et al. 1986, Dixon et al. 1982). It is likely that the pyrite weathering process is resulting in the release of isomorphically substituted cobalt from the pyrite crystal structure as it undergoes oxidative transformation to iron oxide/hydroxide minerals.

As described in the previous ASDs for the former EBAP, vertical aquifer profiling (VAP) was completed in May 2019 to collect groundwater samples from upgradient locations B-2 and B-3 during the soil boring and sample collection process (Geosyntec 2019b). A groundwater sample was also collected from AD-32, one of the existing compliance wells within the EBAP groundwater monitoring network where a cobalt SSL was identified. Solid-phase materials within these groundwater samples were separated and submitted for analysis of chemical composition. For the VAP samples, because of the high abundance of suspended solids, separation was completed using a centrifuge. For the groundwater sample at AD-32, the sample was filtered using a 1.5-micron filter. Based on total metals analysis, cobalt was identified both in the centrifuged solid material collected from upgradient VAP location B-3 (VAP-B3-[40-45]) and in the material retained on the filter after processing groundwater from permanent monitoring wells B-2 and B-3 (**Table 2**). The concentrations of cobalt in the solid material retained after filtration were comparable to concentrations in the bulk soil samples collected from the same locations.

The solid sample VAP-B3-(40-45) was submitted for mineralogical analysis via XRD and scanning electron microscopy (SEM) using an energy-dispersive spectroscopy (EDS) analyzer. The XRD results identified pyrite as approximately 3% of the solid phase (**Table 3**). Pyrite was identified during SEM/EDS analysis of lignite, which is mined immediately adjacent to the site. Logging completed while the VAP boring was advanced identified coal at several intervals, including 45 and 48 feet bgs (**Figure 4**). Furthermore, SEM/EDS of both centrifuged solid samples VAP-B3-(40-45) and VAP-B3-(50-55) identified pyrite in backscattered electron micrographs by the distinctive framboidal morphology (Harris et al. 1981, Sawlowicz 2000). Major peaks representing iron and sulfur were identified in the EDS spectrum, which further support the identification of pyrite (**Attachment D**). While cobalt was not identified in the EDS spectrum, it is likely present at concentrations below the detection limit.

The former EBAP was not identified as the source of cobalt at wells in the EBAP monitoring network based on the low concentrations of cobalt in the pond itself and the ubiquity of naturally occurring cobalt, especially in soil and groundwater samples upgradient from the EBAP. Cobalt in the EBAP network groundwater is believed to be a result of natural variability within the aquifer. Naturally occurring cobalt is known to substitute for iron in iron-bearing minerals. The presence of iron sulfide (as pyrite) and iron oxides/hydroxides hematite and goethite has been confirmed at AD-2 and across the site. The weathering of pyritic minerals to iron oxide/hydroxide minerals may be resulting in the release of cobalt into groundwater from the crystal structure of these aquifer minerals.

3.1.2 Lithium

Previous ASDs for lithium at the former EBAP attributed the observed lithium exceedances at AD-2, AD-31, and AD-32 to variations in lithium associated with the suspended native aquifer solids that likely originate from naturally occurring lignite present in these soils. These native lithium-containing aquifer solids are ubiquitous in the aquifer based on the presence of both solid-phase and dissolved lithium at upgradient locations (Geosyntec 2019b, Geosyntec 2020a, Geosyntec 2020b, Geosyntec 2021a, Geosyntec 2021b, Geosyntec 2022a, Geosyntec 2022b, Geosyntec 2023a, Geosyntec 2023b, Geosyntec 2023c, Geosyntec 2023d, Geosyntec 2024b). Data gathered in support of the prior ASDs and recent results provide additional evidence that the observed lithium groundwater concentrations at AD-2, AD-31, and AD-32 are naturally occurring and are due to natural variation in the aquifer (Type IV ASD).

As discussed in Section 3.1.1, a surface water sample was collected directly from the EBAP in February 2023. Lithium was detected in the February 2023 EBAP sample at a concentration of 0.0653 mg/L (**Figure 5, Table 4**). This concentration is below the reported lithium value at AD-2 and comparable to the reported values at AD-31 and AD-32 (**Figure 5**). The labile fraction identified in the bottom ash by SPLP from a February 2019 sample was even lower, with an estimated (J-flagged) lithium concentration of 0.011 mg/L. This labile concentration is below the average lithium concentrations at AD-2 (0.0547 mg/L), AD-31 (0.0818 mg/L) and AD-32 (0.0807 mg/L) (**Table 4**). Therefore, the former EBAP is not the likely source of lithium at AD-2, AD-31 and AD-32.

Groundwater samples collected from upgradient wells B-2 and B-3 in September 2024 had total lithium concentrations of 0.0557 mg/L and 0.0839 mg/L, respectively (**Figure 5**). Because B-2 and B-3 were installed at locations upgradient to and unimpacted by site activities, these lithium concentrations suggest that aqueous lithium is naturally present at concentrations above the GWPS of 0.0489 mg/L across the site at variable concentrations and not limited to AD-2, AD-31, and AD-32.

B-2 and B-3 are not part of the monitoring network for the former EBAP, and as such the lithium concentrations in groundwater from these wells were not considered in calculating the GWPS for the CCR unit. The addition of B-2 and B-3 as background locations to the monitoring network would result in a site-specific GWPS of 0.1231 mg/L (**Attachment E**). This is higher than the lower confidence limits at the wells of concern (Section 1), suggesting that concentrations of lithium within the observed ranges at AD-2, AD-31, and AD-32 are naturally occurring across the site.

As described in Section 3.1.1, groundwater samples were collected from B-2, B-3, and AD-32 in 2019 and filtered to separate solids. Groundwater was also collected from a VAP boring (VAP-B3-[40-45]) and centrifuged to separate solids. Lithium was detected in the solid material separated from these groundwater samples at concentrations comparable to bulk soil at all locations, providing evidence that the particulates captured during groundwater sampling contain lithium (**Table 5**).

3.1.2.1 Calculated Partition Coefficients

A previous ASD for lithium at the former EBAP discussed lithium mobility in groundwater due to desorption from cation exchange complexes associated with clay minerals within naturally occurring lignite material. This mechanism was posited as the source of lithium in both upgradient and downgradient wells at the former EBAP (Geosyntec 2019b). Previously completed XRD analysis of centrifuged solid material samples (VAP-B3-[40-45]) found that clay minerals, including kaolinite, smectite, and illite/mica, made up at least 60% of the aquifer solid (**Table 3**). SEM/EDS analysis also identified the presence of silicon, aluminum, and oxygen, all of which are components of clay minerals (**Attachment D**). The backscattered electron micrographs of these samples also identified clay particles by morphology. The largest clay particles (≥ 5 micrometers) are likely kaolinite, while smectite and illite dominate the smaller fraction. These clay minerals, particularly smectite and illite, are known to retain cations such as lithium via incorporation into the octahedral layer of the mineral structure and through cation exchange processes.

Partition coefficients values (K_d) for lithium, potassium, and sodium were calculated using mass measurements and total metal concentrations in the solid materials separated from the groundwater samples during filtration and the filtered groundwater concentrations. Details about the K_d calculation are provided in the previous ASD (Geosyntec 2019b). K_d values for groundwater and particulates collected from wells B-2, B-3, and AD-32 were comparable to literature K_d values reported for organic-rich media such as bogs and peat beds (Sheppard et al. 2009, Sheppard et al. 2011), providing further evidence that lithium mobility in site groundwater is similar to other sites with organic-rich soils (**Table 6**). Additionally, the calculated K_d values for Pirkey soils were consistent with the literature, with potassium having the highest K_d (greatest affinity for sorption) and sodium the lowest K_d (least affinity for sorption). Furthermore, the values are similar for groundwater from all three wells, suggesting a universal mechanism controlling lithium, sodium, and potassium mobility in groundwater.

These multiple lines of evidence show that elevated lithium concentrations at AD-2, AD-31, and AD-32 are likely not due to a release from the former EBAP and can instead be attributed to natural variation (Type IV ASD). This variation appears related to the distribution of clay fractions associated with lignite materials in the soil aquifer material.

4. CONCLUSIONS AND RECOMMENDATIONS

The preceding information serves as the ASD prepared in accordance with 30 TAC §352.951(e) and supports the position that the SSLs for cobalt and lithium identified during assessment monitoring in September 2024 were not due to a release from the former EBAP. The identified SSLs should instead be attributed to natural variation in the underlying geology. Therefore, no further action is warranted. Certification of this ASD by a qualified professional engineer is provided in **Attachment F.**

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TABLES

Table 1. Summary of Key Cobalt Analytical Data
Alternative Source Demonstration Report
East Bottom Ash Pond - H.W. Pirkey Plant

Sample	Sample Date	Unit	Cobalt Concentration
Bottom Ash (Solid Material)	2/11/2019	mg/kg	6.1
Texas-Specific Soil Background Concentration			7.0
SPLP Leachate of Bottom Ash	2/11/2019	mg/L	<0.01
EBAP Pond Water	2/28/2023	mg/L	0.0035
AD-2 - Average	May 2016 - September 2024	mg/L	0.0182
AD-31 - Average	May 2016 - September 2024	mg/L	0.0114
AD-32 - Average	May 2016 - September 2024	mg/L	0.0380
Site-Specific Groundwater Protection Standard		mg/L	0.00939

Notes:

1. Texas-specific soil background concentration from TCEQ Chapter 350 (Texas Risk Reduction Program).
2. Average values were calculated using all cobalt data collected under 40 CFR 257 Subpart D, excluding any identified outliers.
3. Site-specific Groundwater Protection Standard from "Statistical Analysis Summary - 2024 2nd Semiannual Event. East Bottom Ash Pond. H.W. Pirkey Plant." (Geosyntec 2024a).

EBAP: East Bottom Ash Pond

mg/kg: milligrams per kilogram

mg/L: milligrams per liter

SPLP: synthetic precipitation leaching procedure

Table 2. Soil Cobalt Data
Alternative Source Demonstration Report
East Bottom Ash Pond - H.W. Pirkey Plant

Location ID	**Location**	**Sample Depth (ft bgs)**	**Cobalt (mg/kg)**
Bulk Soil Samples			
AD-2	EBAP Network	25-27	9.45
		31-33	19.2
AD-18	EBAP Network	8	3.60
		22	2.90
AD-31	EBAP Network	12	1.90
		26	0.83
AD-32	EBAP Network	11	1.70
		20-25	9.10
AD-41	Upgradient	15	< 1.0
		35	23.5
		95	1.90
B-2	Upgradient	10	2.36
		16	3.62
		71	10.30
		82	7.21
		87	3.11
B-3	Upgradient	10	1.30
		20	0.59
		97	1.11
Solid Material Retained After Filtration			
AD-32	EBAP Network	13-33	5.4
B-2	Upgradient	38-48	4.3
B-3	Upgradient	29-34	12.0
		VAP 40-45	18.0

Notes:

1. For AD-XX locations, samples were collected from additional boreholes advanced in the immediate area of the location identified by the well ID. Samples were not collected from the cuttings of the borings advanced for well installation. Samples for B-2 and B-3 locations were collected from cores removed from the borehole during well lithology logging.

2. Depths for samples collected after filtration represent the screened interval for the permanent well where the sample was collected.

EBAP: East Bottom Ash Pond
ft bgs: feet below ground surface
mg/kg: milligram per kilogram
VAP: vertical aquifer profiling

Table 3. B-3 X-Ray Diffraction Results
Alternative Source Demonstration Report
East Bottom Ash Pond - H. W. Pirkey Plant

Constituent	VAP-B3-(40-45)
Quartz	15
Plagioclase Feldspar	0.5
Orthoclase	ND
Calcite	ND
Dolomite	ND
Siderite	0.5
Goethite	ND
Hematite	2
Pyrite	3
Kaolinite	42
Chlorite	4
Illite/Mica	6
Smectite	12
Amorphous	15

Notes:

1. Results given in units of relative % abundance
2. VAP-B3-(40-45) is the centrifuged solid material from the groundwater sample collected at that interval.

ND: not detected

VAP: vertical aquifer profiling

Table 4. Summary of Key Lithium Analytical Data
East Bottom Ash Pond - H.W. Pirkey Plant

Sample	Sample Date	Unit	Lithium Concentration
Bottom Ash (Solid Material)	2/11/2019	mg/kg	0.82 J
SPLP Leachate of Bottom Ash	2/11/2019	mg/L	0.011 J
EBAP Pond Water	2/28/2023	mg/L	0.0653
AD-2 - Average	May 2016 - September 2024	mg/L	0.0547
AD-31 - Average	May 2016 - September 2024	mg/L	0.0818
AD-32 - Average	May 2016 - September 2024	mg/L	0.0807

Notes:

1. Average lithium values for monitoring wells AD-2, AD-31, and AD-32 were calculated using all lithium data collected under 40 CFR 257 Subpart D, excluding statistically identified outliers.

EBAP: East Bottom Ash Pond

J: Estimated value. Result is less than the reporting limit but greater than or equal to the method detection limit.

mg/kg: milligram per kilogram

mg/L: milligram per liter

SPLP: synthetic precipitation leaching procedure

Table 5. Soil Lithium Data
Alternative Source Demonstration Report
East Bottom Ash Pond - H.W. Pirkey Plant

Location ID	Sample Depth (ft bgs)	Lithium (mg/kg)
Bulk Soil Sample		
AD-32*	11	0.53
	20-25	1.60
B-2	10	5.30
	16	3.97
	71	7.42
	87	13.10
B-3	10	3.64
	20	2.59
	97	11.10
Lignite	N/A	2.9 J
Solid Material Retained After Filtration		
AD-32*	13-33	9.8 J
B-2	38-48	6.5 J
B-3	29-34	7.8 J
	VAP 40-45	13.0

Notes:

1. Depths for samples collected after filtration represent the screened interval for the permanent well where the sample was collected.

*: AD-32 samples were collected from a separate borehole advanced near monitoring well AD-32

ft bgs: feet below ground surface
J: Estimated value. Result is less than the reporting limit but greater than or equal to the method detection limit.
mg/kg: milligram per kilogram
VAP: vertical aquifer profiling

Table 6. Calculated Site-Specific Partition Coefficients
Alternative Source Demonstration Report
Pirkey Plant - East Bottom Ash Pond

Source	B-2			Literature Value
Unit	mg/L	mg/kg	L/kg	L/kg
Element	**Aqueous Phase**	**Adsorbed**	**Kd**	**Kd**
Lithium	0.081	6.5	80	43-370
Potassium	2.6	1100	423	42-1200
Sodium	14	130	9	5.2-82

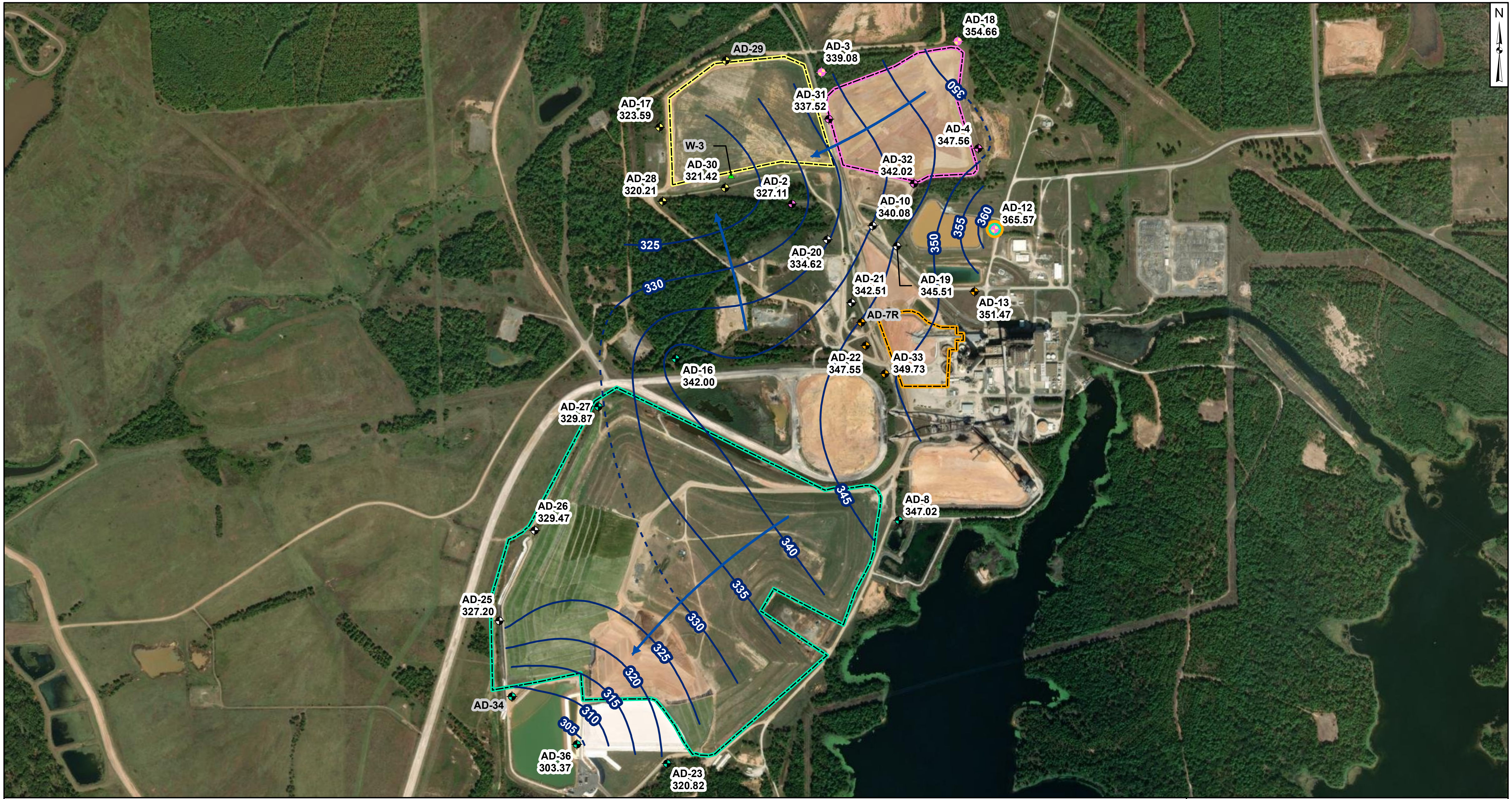
Source	B-3			Literature Value
Unit	mg/L	mg/kg	L/kg	L/kg
Element	**Aqueous Phase**	**Adsorbed**	**Kd**	**Kd**
Lithium	0.097	7.8	80	43-370
Potassium	2.9	1100	379	42-1200
Sodium	32	240	8	5.2-82

Source	AD-32*			Literature Value
Unit	mg/L	mg/kg	L/kg	L/kg
Element	**Aqueous Phase**	**Adsorbed**	**Kd**	**Kd**
Lithium	0.11	9.8	89	43-370
Potassium	3.9	1800	462	42-1200
Sodium	57	220	4	5.2-82

Notes:
1. Adsorbed values are total metals concentrations reported by USEPA Method 6010B.
2. Literature values represent maximum and minimum values for the parameter as reported in Sheppard et al, 2009 (Table 4-1, all sites) and Sheppard et al, 2011 (Table 3-3 cultivated peat and wetland peat only).

*: AD-32 samples were collected from a separate borehole advanced near monitoring well AD-32
Kd: partition coefficient
L/kg: liters per kilogram
mg/kg: milligrams per kilogram
mg/L: milligrams per liter

FIGURES



Legend

Groundwater Monitoring Wells

- ⊕ Out of Network
- ⊕ East Bottom Ash Pond (EBAP)
- ⊕ West Bottom Ash Pond (WBAP)
- ⊕ Landfill
- ⊕ Flue Gas Desulfurization Stackout Area (FGDSA)
- ⊕ EBAP and WBAP
- ◎ All CCR Unit Networks
- ▲ Piezometer
- ─ Groundwater Elevation Contour
- - - Groundwater Elevation Contour (Inferred)
- → Approximate Groundwater Flow Direction

Notes

1. Monitoring well coordinates and water levels (collected on September 16, 17, and 18, 2024) provided by AEP.
2. Site features based on information available in coal combustion residuals (CCR) Groundwater Monitoring Well Network Evaluation Update (Arcadis 2022) provided by AEP.
3. Groundwater elevation units are feet above mean sea level (ft msl).
4. Wells AD-29 and W-3 were not gauged during the September 2024 event.
5. AD-7R replaced AD-7, which was abandoned on September 12, 2023.
6. Wells shaded in gray were not used for contouring.
7. Well AD-34 had artesian characteristics during this event and was not used for contouring.
8. AD-35 was abandoned on November 13, 2018 and is not shown on the map.
9. Removal of CCR plus one foot of material for the WBAP was completed for on July 26, 2022.
10. Removal of CCR plus one foot of material for the EBAP was completed on July 20, 2023, for the East Pond.
11. Removal of CCR plus one foot of material for the FGDSA was completed on September 18, 2023.
12. Map is updated to incorporate Landfill survey data collected on May 1, 2024.
13. Aerial imagery provided by ESRI, dated September 19, 2023.

1,000 500 0 1,000
Feet

Beth Ann Gross
January 10, 2025
Geosyntec Consultants, Inc.
Texas Firm Registration
No. 1182

BETH ANN GROSS
79864

Potentiometric Contours: Uppermost Aquifer
September 2024

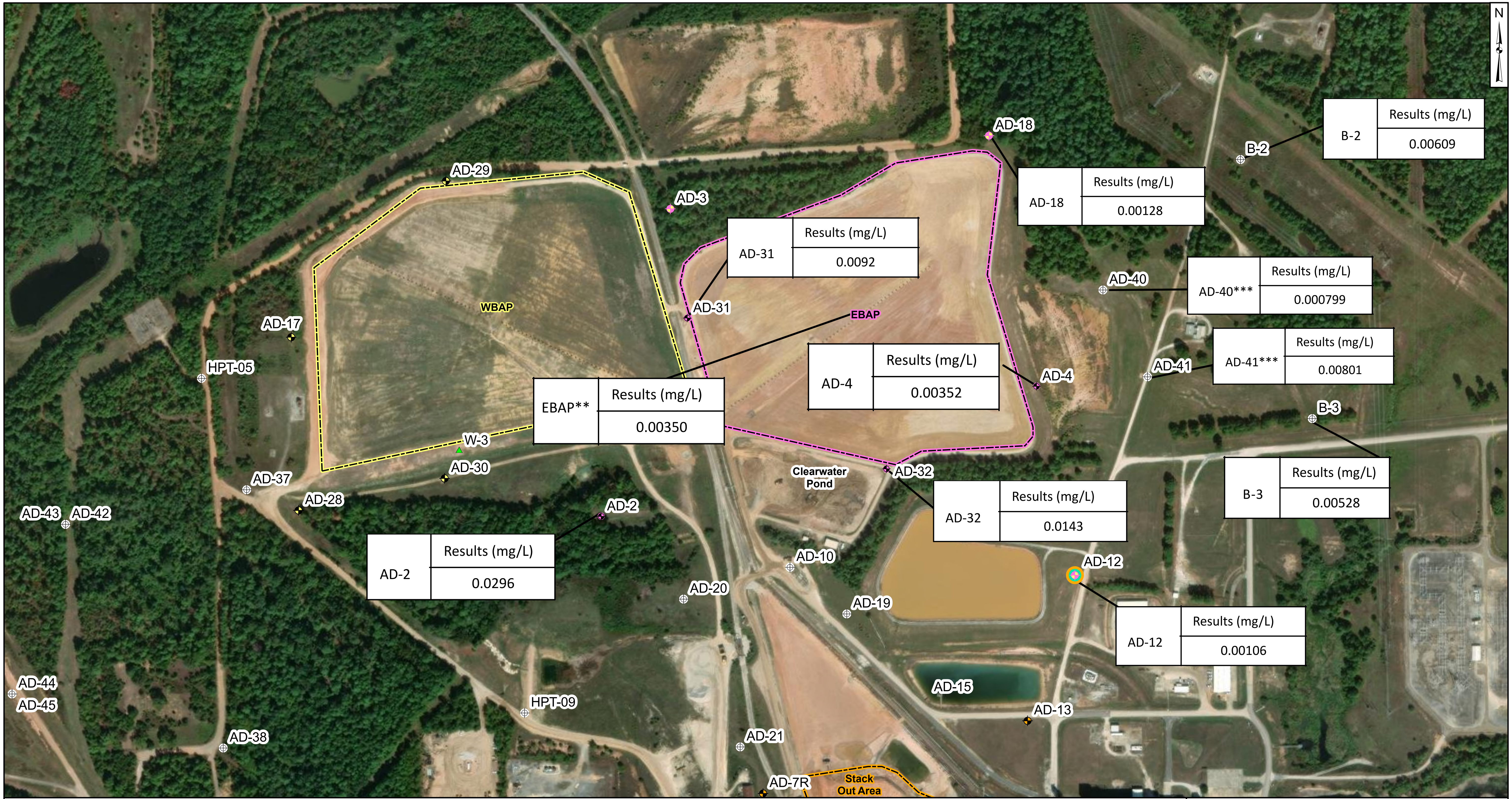
AEP Pirkey Power Plant
Hallsville, Texas

Geosyntec
consultants

Columbus, Ohio
2024/12/24

Figure
1

A:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Pirkey\2024\AEP-Pirkey_GW_2024-09Pirkey.mxd. Okiemute.Commander. 12/24/2024. Project/Phase/Task.



Legend

- ⌖ Out of Network
- ● EBAP
- ● WBAP
- ● Landfill
- ● Stackout Area
- ⌖ EBAP and WBAP
- ◎ All CCR Unit Networks
- ▲ Piezometer
- ▭ EBAP
- ▭ WBAP

Notes

1. Monitoring well coordinates, site features, and data provided by AEP.
2. AD-15 location is approximated
3. Samples collected in March 2021
4. ** - Porewater sample from East Bottom Ash Pond (EBAP) was collected in February 2023
5. *** - Well most recently sampled August 2019.
6. Results shown in milligrams per liter (mg/L).
7. Aerial imagery provided by ESRI, dated September 19, 2023.

400 200 0 400
Feet

AEP: American Electric Power
CCR: coal combustion residuals
EBAP: East Bottom Ash Pond
mg/L: milligrams per liter
WBAP: West Bottom Ash Pond

Cobalt Distribution in Groundwater

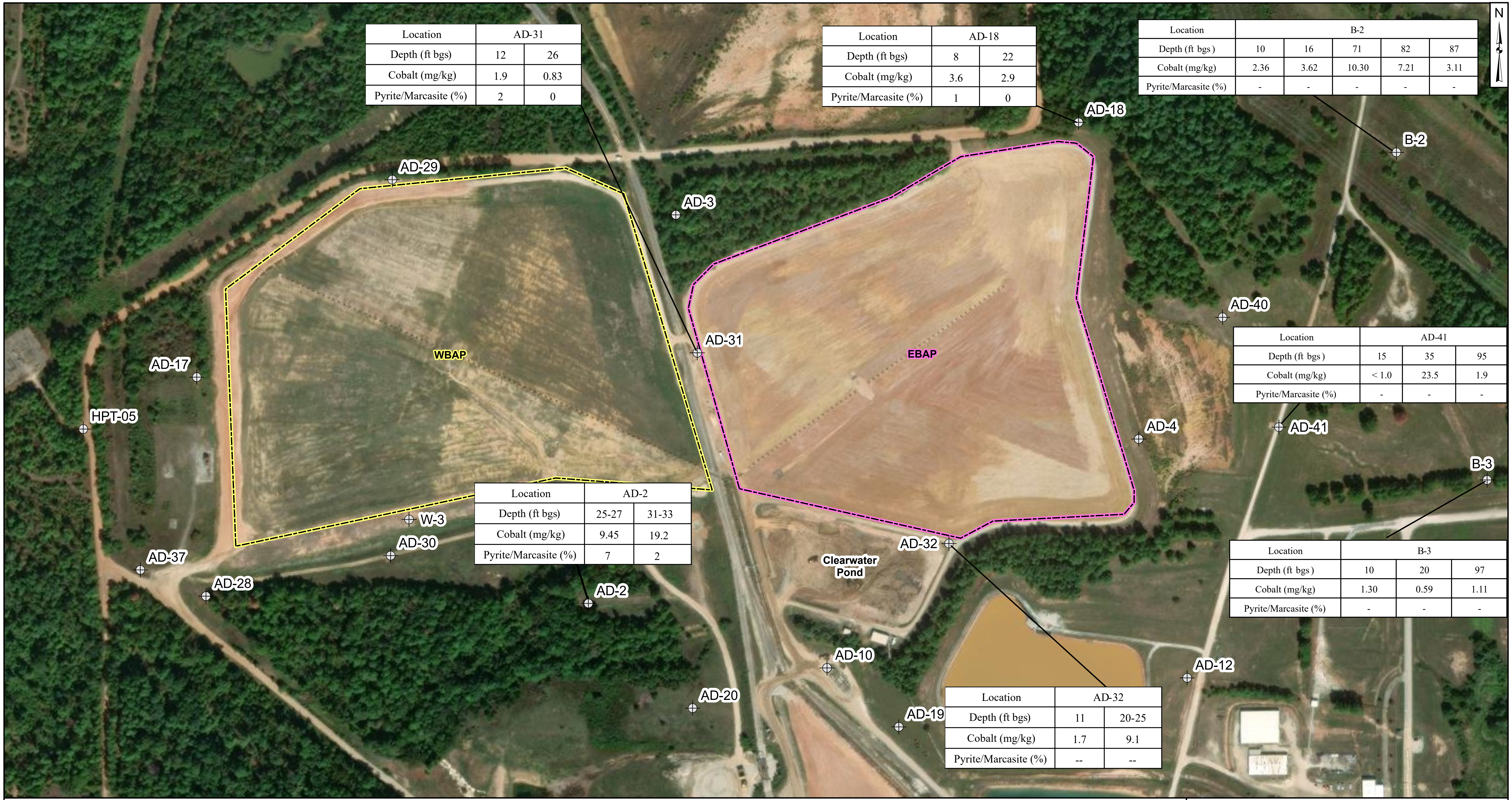
AEP Pirkey Power Plant
Hallsville, Texas

Geosyntec consultants

Columbus, Ohio | March 2025

Figure
2

\\annarbor-01\data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Pirkey\AEP_Pirkey_Cobalt_GW_20250308.aprx. OAdeyemo. 03/08/2025.



Location	AD-31	
Depth (ft bgs)	12	26
Cobalt (mg/kg)	1.9	0.83
Pyrite/Marcasite (%)	2	0

Location	AD-18	
Depth (ft bgs)	8	22
Cobalt (mg/kg)	3.6	2.9
Pyrite/Marcasite (%)	1	0

Location	B-2				
Depth (ft bgs)	10	16	71	82	87
Cobalt (mg/kg)	2.36	3.62	10.30	7.21	3.11
Pyrite/Marcasite (%)	-	-	-	-	-

Location	AD-41		
Depth (ft bgs)	15	35	95
Cobalt (mg/kg)	< 1.0	23.5	1.9
Pyrite/Marcasite (%)	-	-	-

Location	AD-2	
Depth (ft bgs)	25-27	31-33
Cobalt (mg/kg)	9.45	19.2
Pyrite/Marcasite (%)	7	2

Location	B-3		
Depth (ft bgs)	10	20	97
Cobalt (mg/kg)	1.30	0.59	1.11
Pyrite/Marcasite (%)	-	-	-

Location	AD-32	
Depth (ft bgs)	11	20-25
Cobalt (mg/kg)	1.7	9.1
Pyrite/Marcasite (%)	--	--

Legend

⌖	Monitoring Wells
▭	EBAP
▭	WBAP

Notes

1. Monitoring well coordinates provided by AEP.
2. AD-2 sample collected on April 20, 2020
3. All other data provided by AEP, 2019.
4. Aerial imagery provided by ESRI, dated September 19, 2023.

--: not analyzed.
AEP: American Electric Power
EBAP: East Bottom Ash Pond
ft bgs: feet below ground surface.
mg/kg: milligrams per kilogram.
WBAP: West Bottom Ash Pond.

Cobalt Distribution in Soil

AEP Pirkey Power Plant
Hallsville, Texas

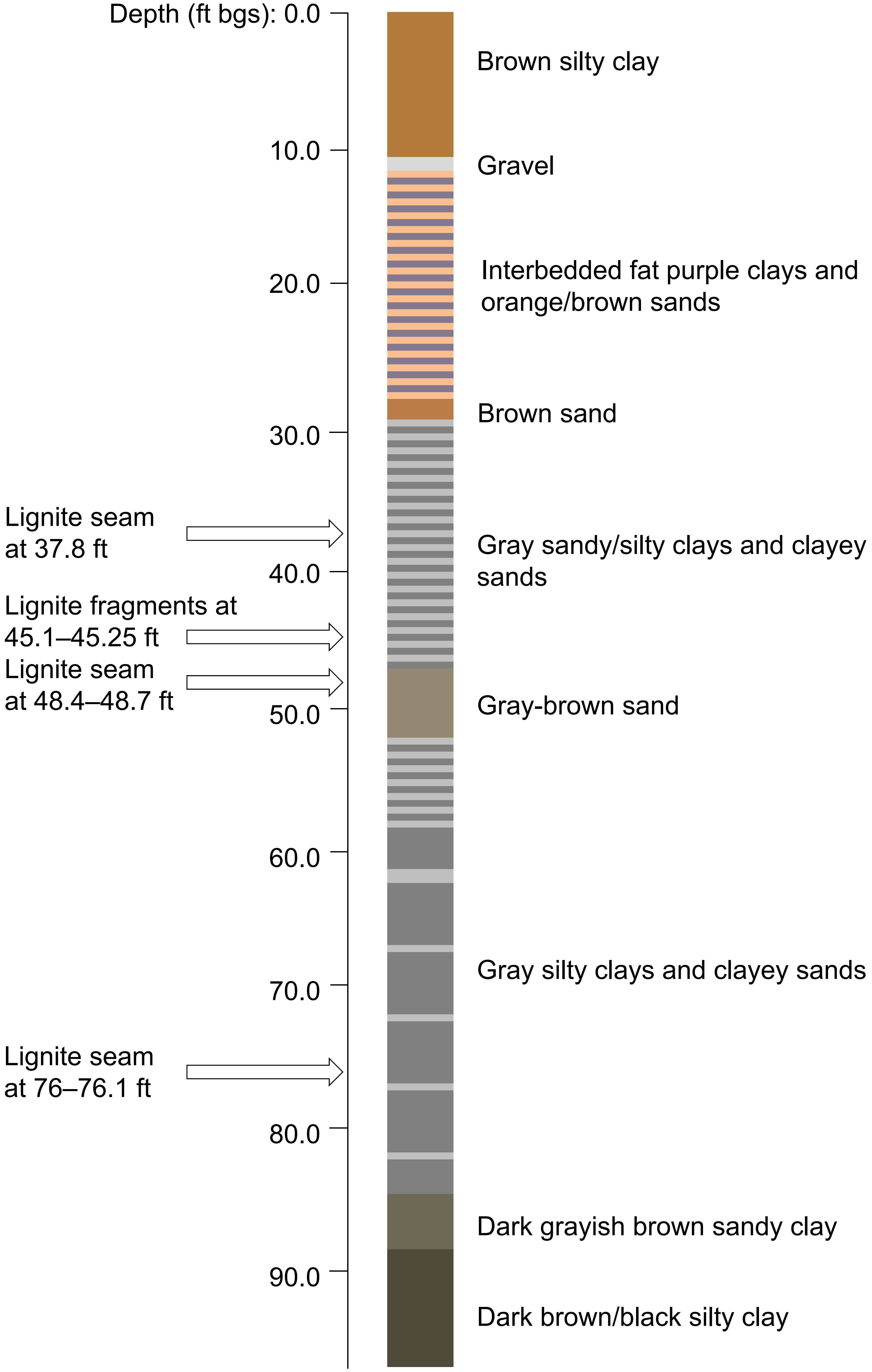
Geosyntec consultants

Columbus, Ohio

March 2025

Figure
3

\\annarbor-01\data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Pirkey\AEP_Pirkey_SoilChem_minerals_March2019aprx. OAdeyemo. 03/10/2025.



Notes:
1. Well installed in offset boring screened at 29-34 ft bgs
2. Boring completed May 2019
3. Total depth of 97.5 ft bgs

AEP: American Electric Power
bgs: below ground surface
ft: feet

B-3 Visual Boring Log

AEP Pirkey Powerplant
Hallsville, Texas

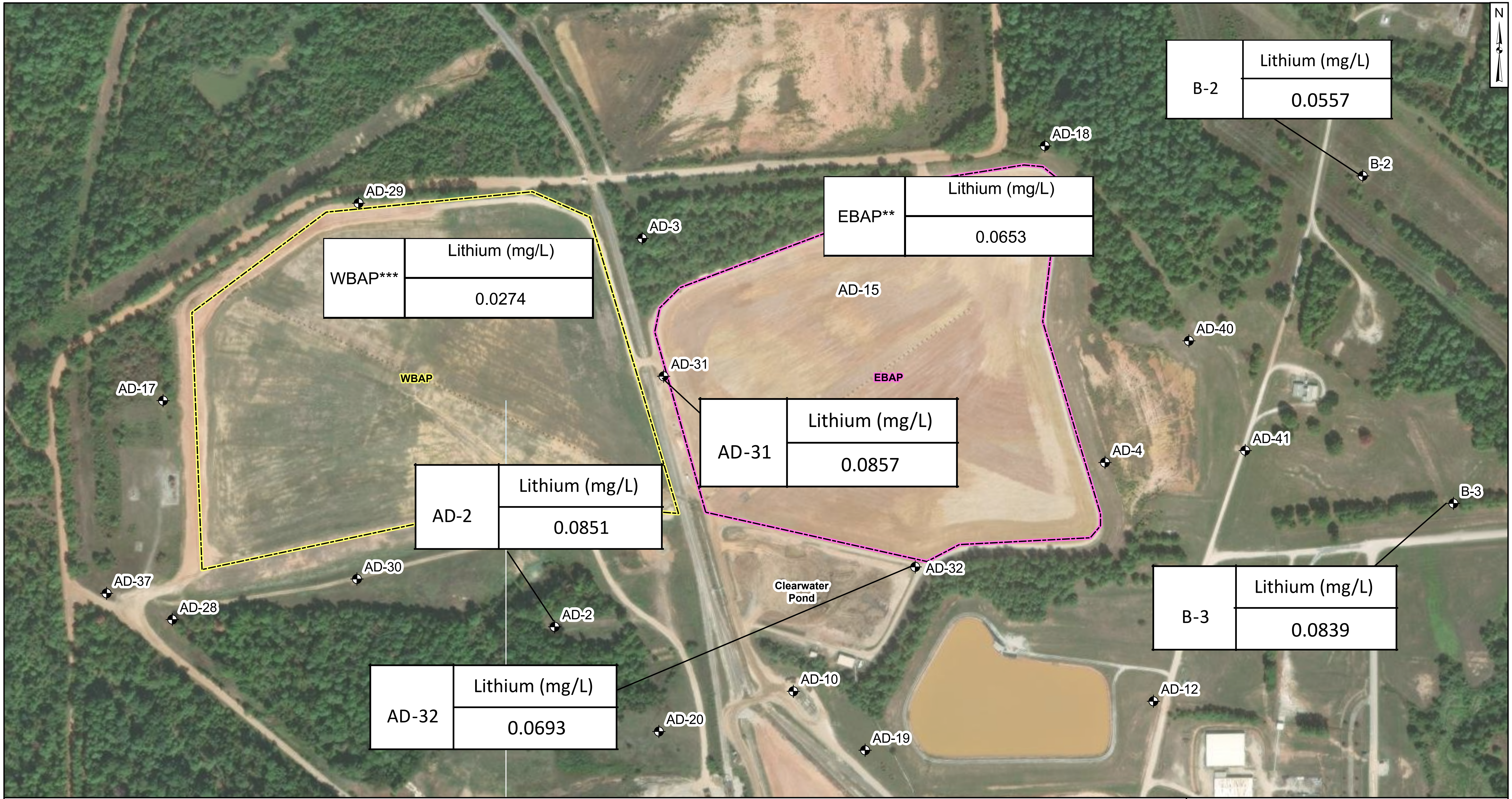
Geosyntec consultants

Columbus, Ohio | March 2025

Figure

4

\\annarbor-01\data\Projects\AEP\Legal Department - ASD Review\Pirkey\2019-05 Field Investigation\Field Forms\Compiled Boring Logs\Visual boring logs



Legend

⊕ Monitoring Well

▭ EBAP

▭ WBAP

Notes

1. Lithium concentrations in milligrams per liter mg/L.
2. Monitoring well coordinates, site features, and data provided by AEP.
3. Groundwater samples were collected in September 2024.
4. **: Porewater samples from East Bottom Ash Ponds was collected in February 2023.
5. ***: Porewater sample from West Bottom Ash Pond (WBAP) was collected in 2022.
6. Aerial imagery provided by ESRI, dated September 19, 2023.

AEP: American Electric Power

300 150 0 300
Feet

Aqueous Lithium Distribution

AEP Pirkey Power Plant
Hallsville, Texas

Geosyntec consultants

Columbus, Ohio

March 2025

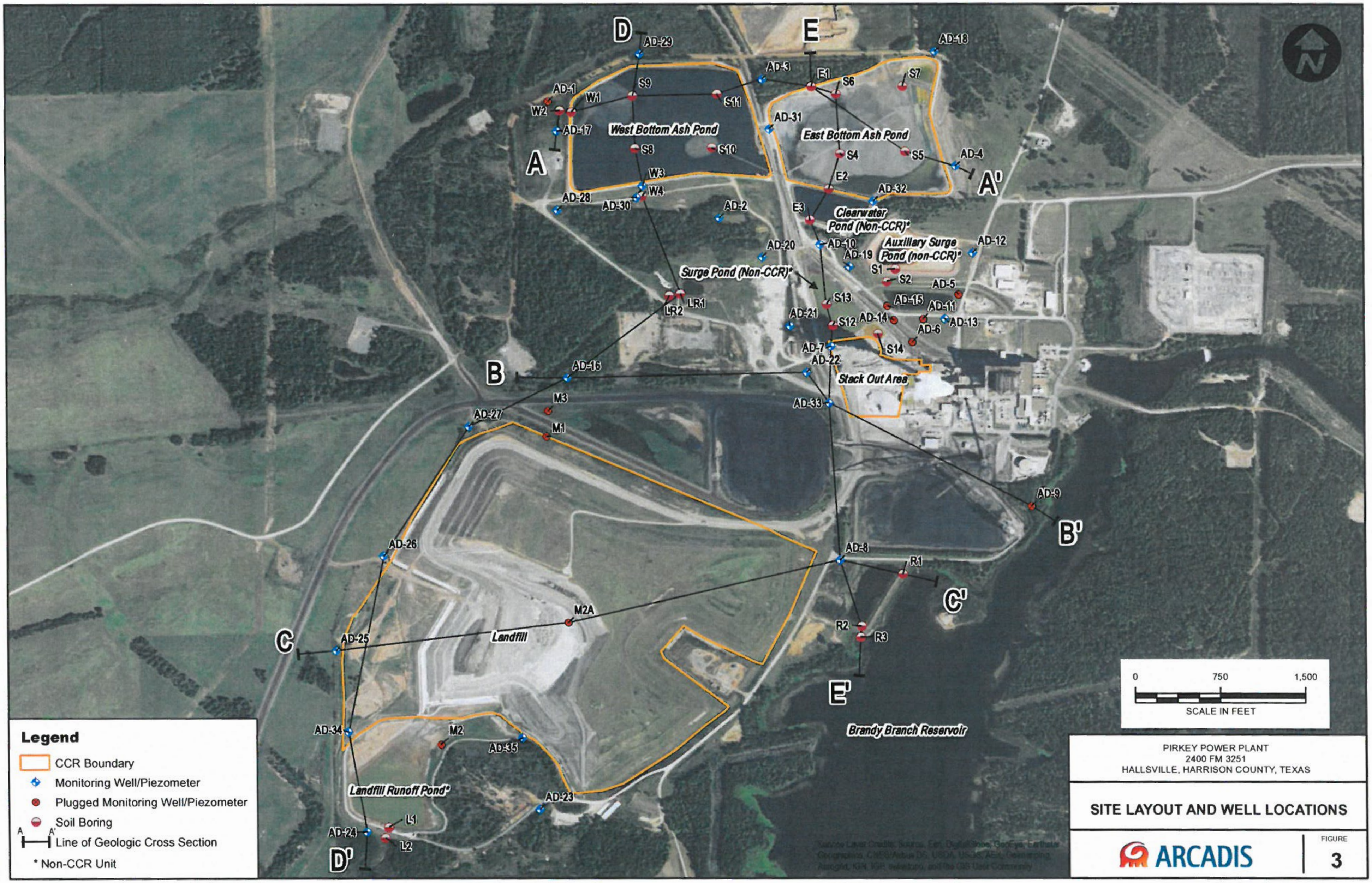
Figure
5

\\annarbor-01\data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Pirkey\AEP_Pirkey_ASD_Li.aprx. OAdeyemo. 03/10/2025.

ATTACHMENT A

Geologic Cross Section A-A’

Document Path: Z:\GISPROJECTS_ENV\AEP\Pirkey Plant\MXD\Figure 3 - Site Layout and Well Locations.mxd



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

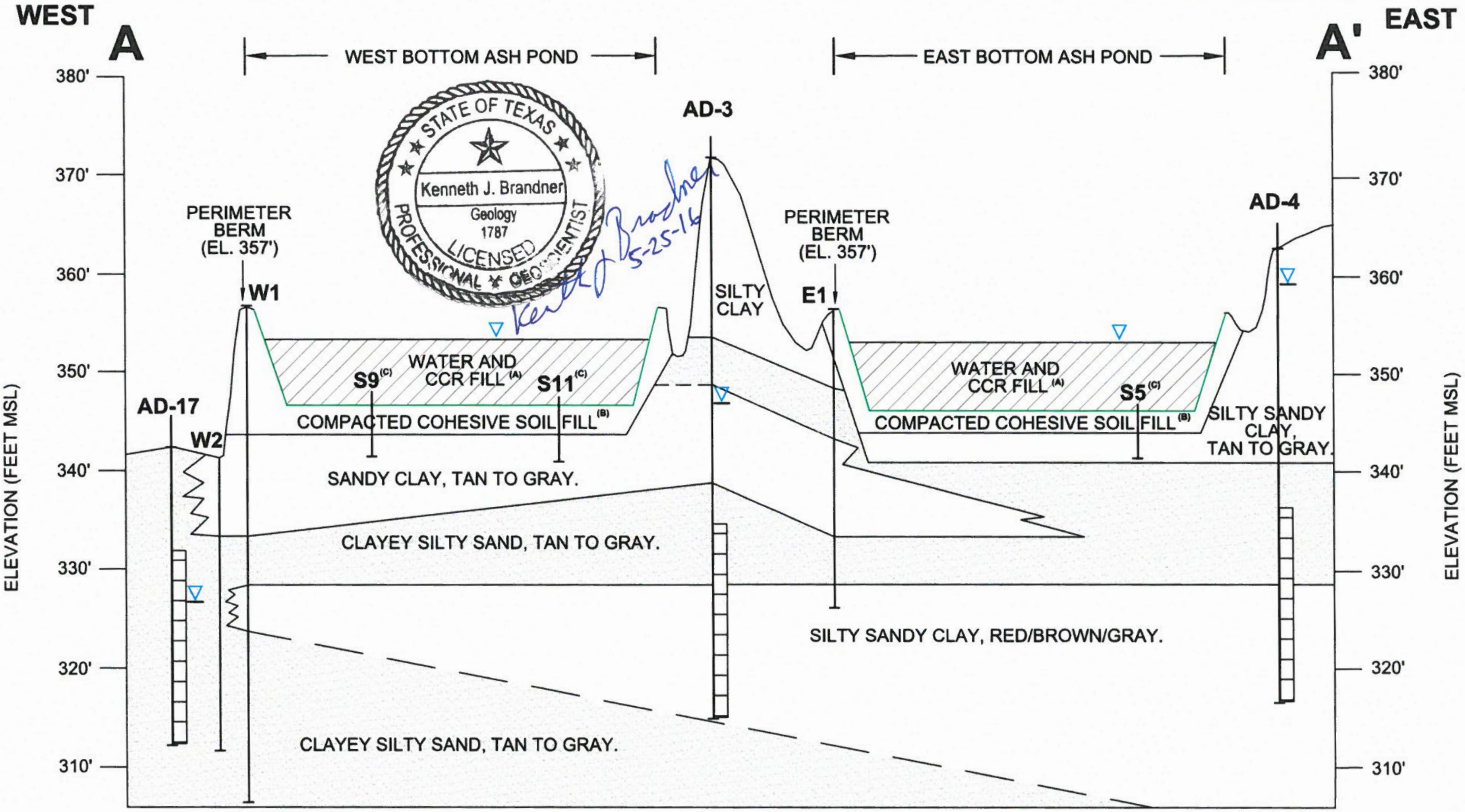
- ▭ CCR Boundary
- ◆ Monitoring Well/Piezometer
- ● Plugged Monitoring Well/Piezometer
- ◓ Soil Boring
- A ├─┤ A' Line of Geologic Cross Section
- * Non-CCR Unit

PIRKEY POWER PLANT
2400 FM 3251
HALLSVILLE, HARRISON COUNTY, TEXAS

SITE LAYOUT AND WELL LOCATIONS

ARCADIS

FIGURE
3



STATE OF TEXAS
Kenneth J. Brandner
Geology
1787
LICENSED PROFESSIONAL GEOSCIENTIST

Kenneth J. Brandner
5-25-16

0 300'
HORIZONTAL SCALE

LEGEND

▯	MONITORING WELL SCREENED INTERVAL
▽	WATER LEVEL IN MONITORING WELL (1/20/16)
—	BASE OF CCR UNIT

NOTES:

A) TOP OF WEST BOTTOM ASH POND AND EAST BOTTOM ASH POND PERIMETER BERM ELEVATION IS 357', OPERATING ELEVATION IS 354'(JOHNSON & PACE, MAY 2011). BASE ELEVATION OF WEST BOTTOM ASH POND AND EAST BOTTOM ASH POND IS 347' (SARGENT & LUNDY, JANUARY 1983).

B) COMPACTED COHESIVE SOIL FROM ELEVATION 344' TO 347' (SARGENT & LUNDY, SEPTEMBER 1984;AMEC, AUGUST 2011).

C) SOIL BORING INSTALLED BY SOUTHWESTERN LABORATORIES DURING ASH POND CONSTRUCTION IN 1983.

PIRKEY POWER PLANT
2400 FM 3251
HALLSVILLE, HARRISON COUNTY, TEXAS

CROSS SECTION
A - A'

ARCADIS

FIGURE
4

ATTACHMENT B

SB-2 Boring Log

PROJECT NO. ____________ PROJ. ____________ BOR. NO. SB-2

LOCATION AD-2/MW-2- Pirkey Power Plant ELEV. ____________ DATE 4/20/20

SILTS & SANDS

CONDITION

VLo ...... Very Loose	0- 4
Lo .... Loose	4-10
MDe ..... Med. Dense	10-30
De .... Dense	30-50
VDe ...... Very Dense	>50

COHESIVE SOILS - CLAYS

CONSISTENCY	PENETROMETER	N - VALUE
Vso.. Very Soft	0 - 0.25	<2
So.... Soft	0.25 - 0. 5	2 - 4
Mst.. Stiff	0.5 - 1.0	4 - 8
St.... Stiff	1.0 - 2.0	8 - 15
VSt.. Very Stiff	2.0 - 4.0	15 - 30
H..... Hard	> 4.0	>30

COLORS

Li .... Light .....Br ....Brown
Dk ... Dark .....Bk ....Black
G ..... Grey ....Bl ....Blue
T ...... Tan ....Gr .....Grenn
R ...... Red ......Y ......Yellow
Rdish.Reddish.Wh ...White

MATERIALS

Cl ..... Clay, Clayer
Si ..... Silt, Silty
Sa .... Sand, Sandy
Ls .... Limestone
Gr .... Gravel
SiS .... Siltstone
SS .... Sandstone
Sh..... Shale, Shaley

SAND ADJ.

F.......Fine
M ....Medium
Co....Coarse
Si.....Silty

CHARACTERTICS

Calc ..... Calcareous
Lig .... Lignite
Org .... Organic
Lam ...... Laminate
Sls .... Slickensided
SL .... Slightly
Sm(s) ... Seam (s)
Nod ...... Nodules

STRATUM DESCRIPTION

	Sample Interval ~~TEST ASSIGNMENT~~	~~SAMPLE NO.~~ Recovery	DEPTH FT.	SAMPLES	CONDITION OR CONSISTENCY	COLOR	MINOR MATERIALS OR ADJECTIVES	PREDOMINATE MATERIAL	CHARACTERISTICS OR MODIFICATIONS	STANDARD PENETROMETER SEAT - 6"	1st - 6"	2nd - 6"	UNIFIED SOIL CLASSIFICATION	N - VALUE OR HAND PENETROMETER
	0-5	2' Rec	0		0-8'	Br, Lt. Rd Br	Si	Sa	Silty Sand- trace clay,					
SM									trace root hairs, moist,				moist	(0-5)
	5-10	2.5' Rec				Lt. Rd Br			- thin lenses (less than 1/4")				moist	(5-10')
8'									at 7.5', trace iron staining					
Cl	10-15	4' Rec	8		8-14.5'	Lt. Rd Br, Rd Br, Gray	Sa, Si	Cl	Clay - some silty sand and silty				moist	(10-15')
									clayey sand in interbeds					
									to 14.5', trace iron ore gravel					
14.5'									in sand seams @ 10.5, 12', 12.5'					
	15-20	2' Rec	14.5		14.5-39'	Rd Br, Yllw. Br, Gray	Si, Cl	Sa	silty clayey sand - some sandy clay;				v. moist to	
									iron cemented sand @ 16.5'				moist	(15-20
									and ironstone → (~1.5")					
	20-25'	* No Rec.						(?	- cemented sand seams in silty				v. moist	(20-25'?)
SC									sand @ 20-25'					
	25-30'	2.5' Rec				Gray - DkGray			- gravel & cemented sand seam @ 25' (6")				sat. @	25'-25.5'
						Dk. Br			- cemented and partially cemented @					
						(25-39')			clayey silty sand @ 25.5				moist	25.5-27
									- dark gray silty sat. sand seam (2")				sat. @	27.0 (2")
									@ 27"					
	30-35	3' Rec							- sat. silty sand seam @ 30.5 (1")				sat. @	30.5 (1")
									- sat. silty sand seam @ 32' (3")					32.0 (3")
39'									* some v.f. gypsum crystals in clayey sand					
									between sat. sand seams (25-40')				v. moist	(to 39')
ML	35-40	4' Rec	39		39-40	Lt. Gray, Gray (39-40)	Cl, Sa	Si	Clayey sandy silt,					
									- interbedded silt & clay @ 39' to 40'				moist	(39-40')
									B.T. @ 40'					
									*25-27' collected @ 1015					
									*31-33' collected @ 1035					

Type Boring HSA Dry Auger ☒ Rotary Wash ☐

SEEPAGE @ 25' FT. WHILE DRILLING, W.L. @ ___ FT. ON COMPL.
(OR) BAILED TO ___ FT. UPON COMPLETION.
W.L. @ ___ FT AND CAVED TO ___ FT. ON ________.

* GPS: 32.46522, -94.49032 (12' E, 3.5' N of AD-2/MW-2)

ATTACHMENT C

SB-2 Boring Photographic Log

GEOSYNTEC CONSULTANTS
Photographic Record

Client: AEP

Project Number: CHA8495

Site Name: Pirkey East Bottom Ash Pond

Site Location: Hallsville, Texas

Photograph 1

Date: 4/21/2020

Direction: N/A

Comments:
0-5 foot interval of SB-2.

Photograph 2

Date: 4/21/2020

Direction: N/A

Comments:
5-10 foot interval of SB-2.

GEOSYNTEC CONSULTANTS
Photographic Record

Client: AEP

Project Number: CHA8495

Site Name: Pirkey East Bottom Ash Pond

Site Location: Hallsville, Texas

Photograph 3

Date: 4/21/2020

Direction: N/A

Comments:
10-15 foot interval of SB-2.

Photograph 4

Date: 4/21/2020

Direction: N/A

Comments:
15-20 foot interval of SB-2. Recovery of this interval was limited.

GEOSYNTEC CONSULTANTS
Photographic Record

Client: AEP **Project Number:** CHA8495

Site Name: Pirkey East Bottom Ash Pond **Site Location:** Hallsville, Texas

Photograph 5

Date: 4/21/2020

Direction: N/A

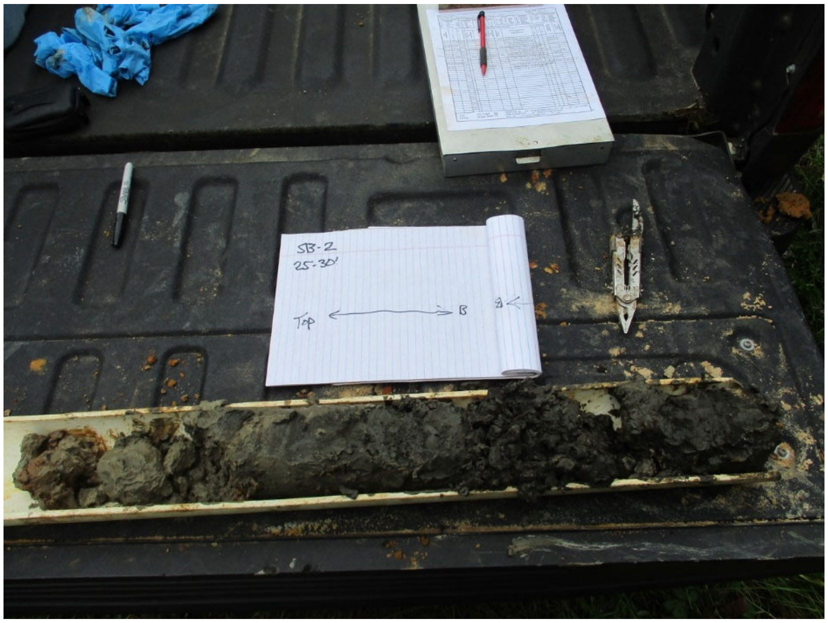
Comments:
20-25 foot interval of SB-2. Recovery of this interval was limited.

Photograph 6

Date: 4/21/2020

Direction: N/A

Comments:
25-30 foot interval of SB-2. Very little of this interval was recovered. A color change was observed from red to dark brown/black. A sample was collected from this interval.



GEOSYNTEC CONSULTANTS
Photographic Record

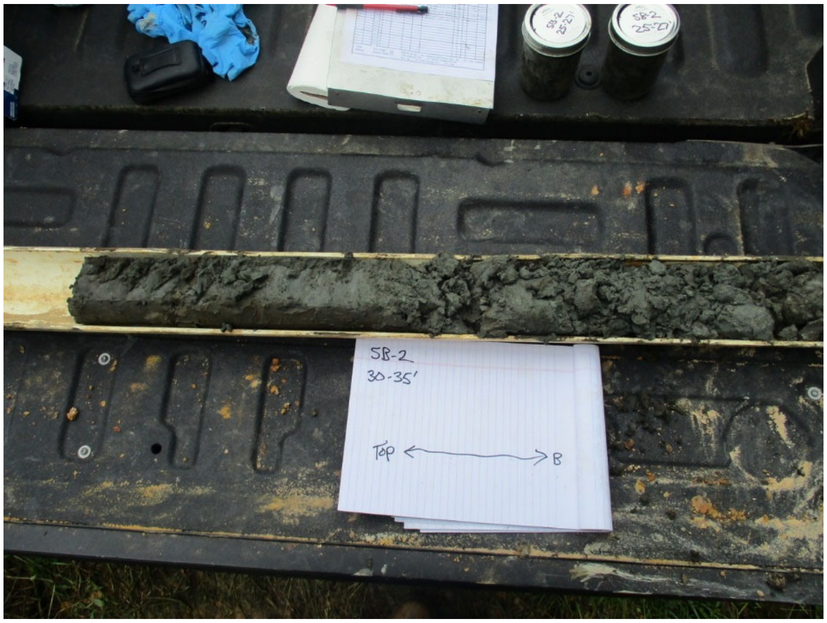
Client: AEP	**Project Number:** CHA8495
Site Name: Pirkey East Bottom Ash Pond	**Site Location:** Hallsville, Texas

Photograph 9

Date: 4/21/2020

Direction: N/A

Comments:
30-35 foot interval of SB-2. Very little of this interval was recovered.. A sample was collected from this interval.



Photograph 10

Date: 4/21/2020

Direction: N/A

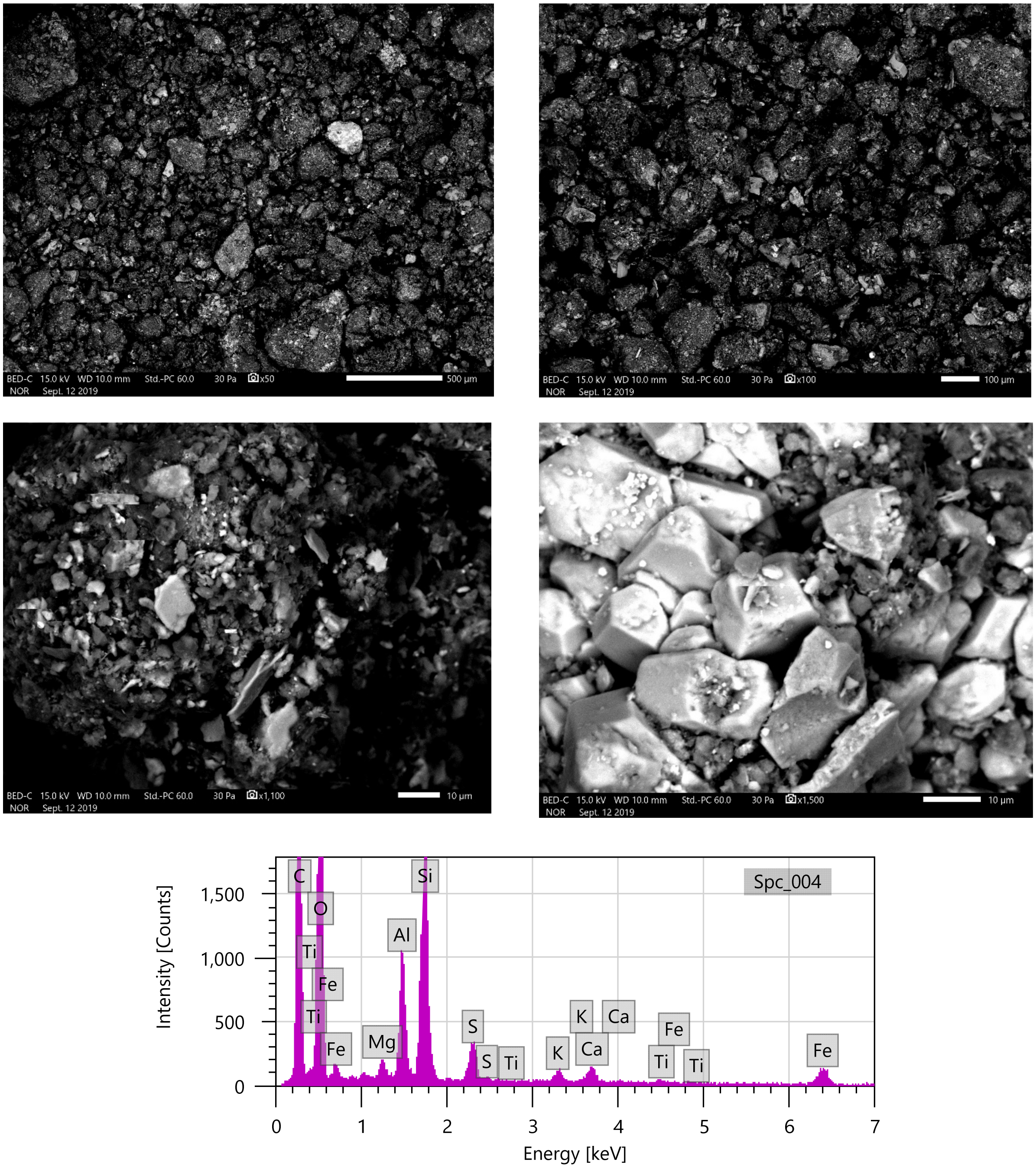
Comments:
35-40 foot interval of SB-2

ATTACHMENT D
SEM/EDS Analysis

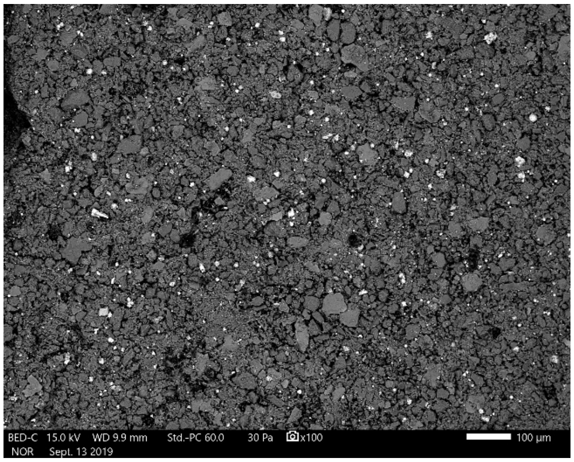
September 16, 2019

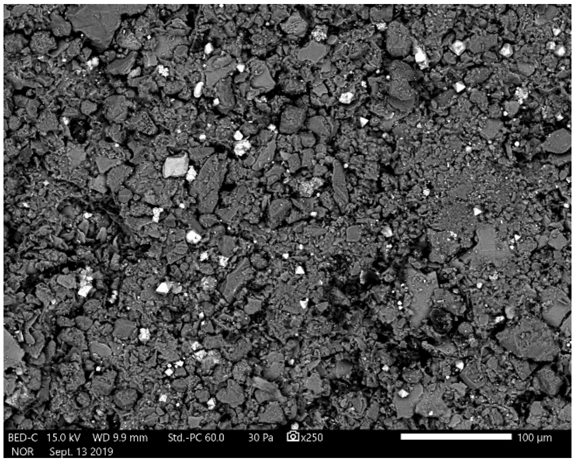
Dr. Bruce Sass
941 Chatham Lane, Suite 103, Columbus, OH 43221

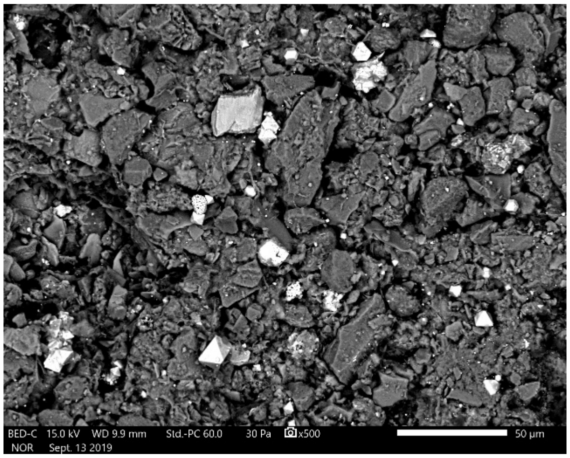
via Email: BSass@geosyntec.com

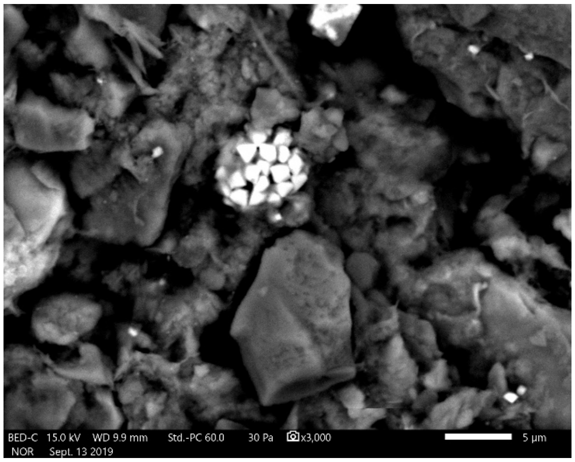


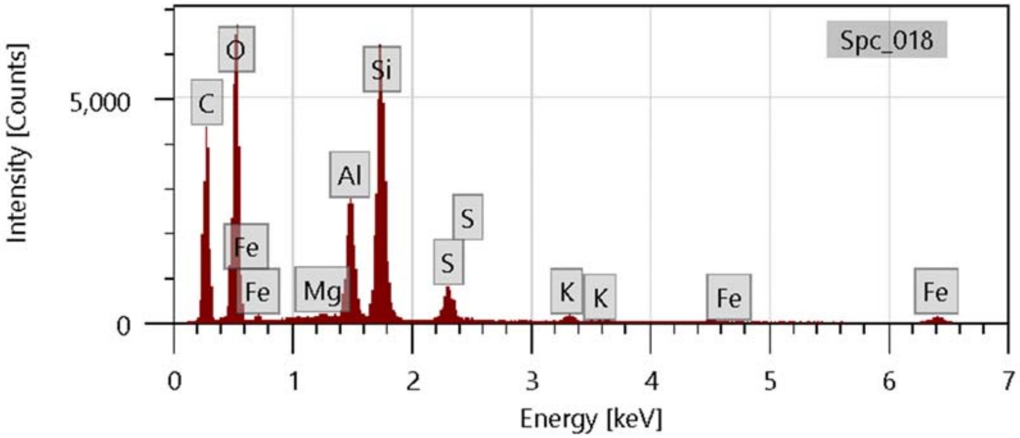
Lignite. Backscattered electron micrographs show the sample at 100X, 1,100X, and 1,500X. EDS spectrum at bottom is an area scan of the region shown in top right micrograph. Bright particles are mostly quartz and feldspar. Major peaks for carbon, oxygen, silicon, and aluminum suggest coal and clay.



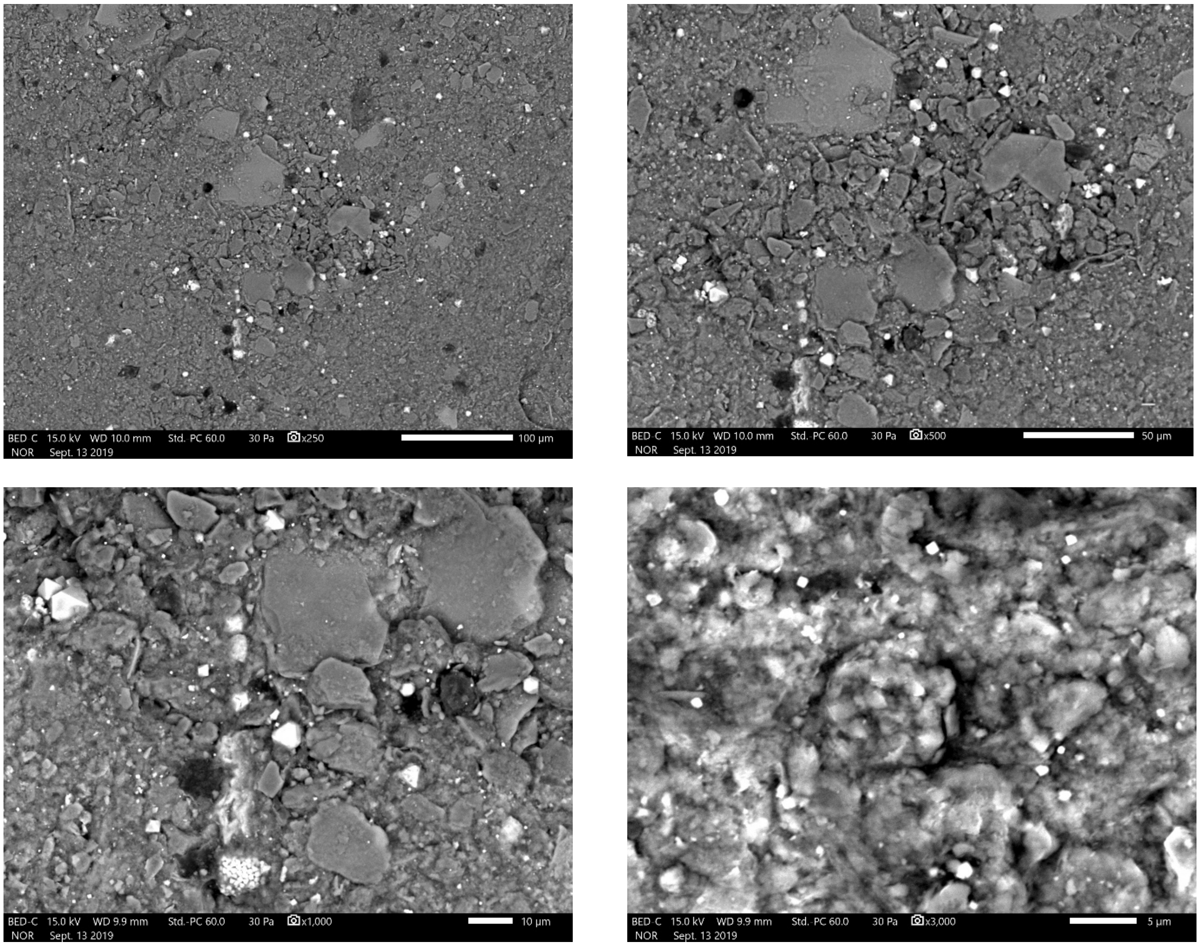


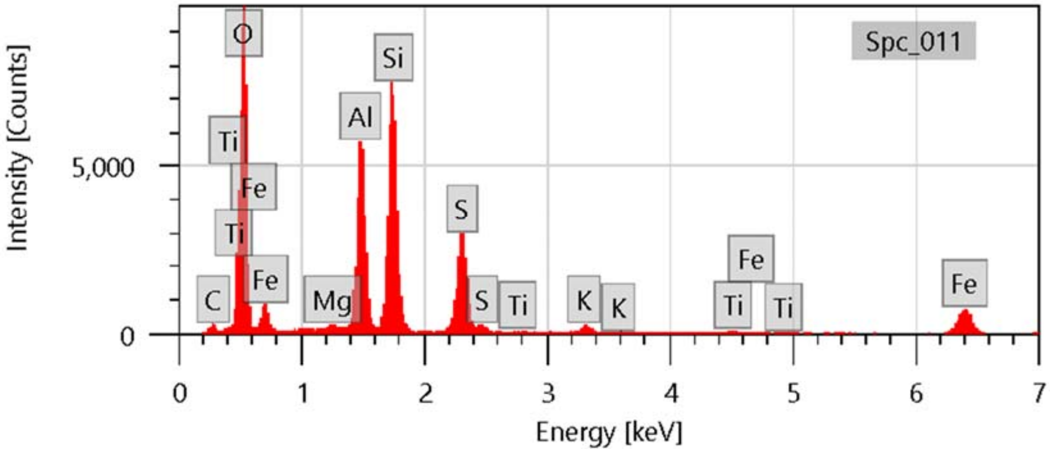






Sample VAP B3 40-45. Backscattered electron micrographs show the sample at 100X, 250X, 500X, and 3000X. EDS spectrum at bottom is an area scan of the region shown at 500X. Bright particles are pyrite (framboid in bottom right micrograph). Major peaks for carbon, oxygen, silicon, and aluminum suggest coal and clay.





Sample VAP B3 50-55. Backscattered electron micrographs show the sample at 250X, 500X, 1000X, and 3000X. EDS spectrum at bottom is an area scan of the region shown at 3000X. Bright particles are mostly pyrite (framboid in bottom left micrograph); occasional particles of Fe-Ti oxide are detected. Major peaks for oxygen, silicon, and aluminum suggest clay. Large blocky particles are mostly quartz, feldspar, and clay.

ATTACHMENT E

Tolerance Limit Calculation Using B-Series Data

Upper Tolerance Limits

Pirkey EBAP   Client: Geosyntec   Data: Pirkey EBAP   Printed 3/19/2025, 10:15 AM

Constituent	Well	Upper Lim.	Lower Lim.	Date	Observ.	Sig.	Bg N	%NDs	Transform	Alpha	Method
Lithium, total (mg/L)	n/a	0.1231	n/a	n/a	n/a	n/a	110	0.9091	ln(x)	0.05	Inter

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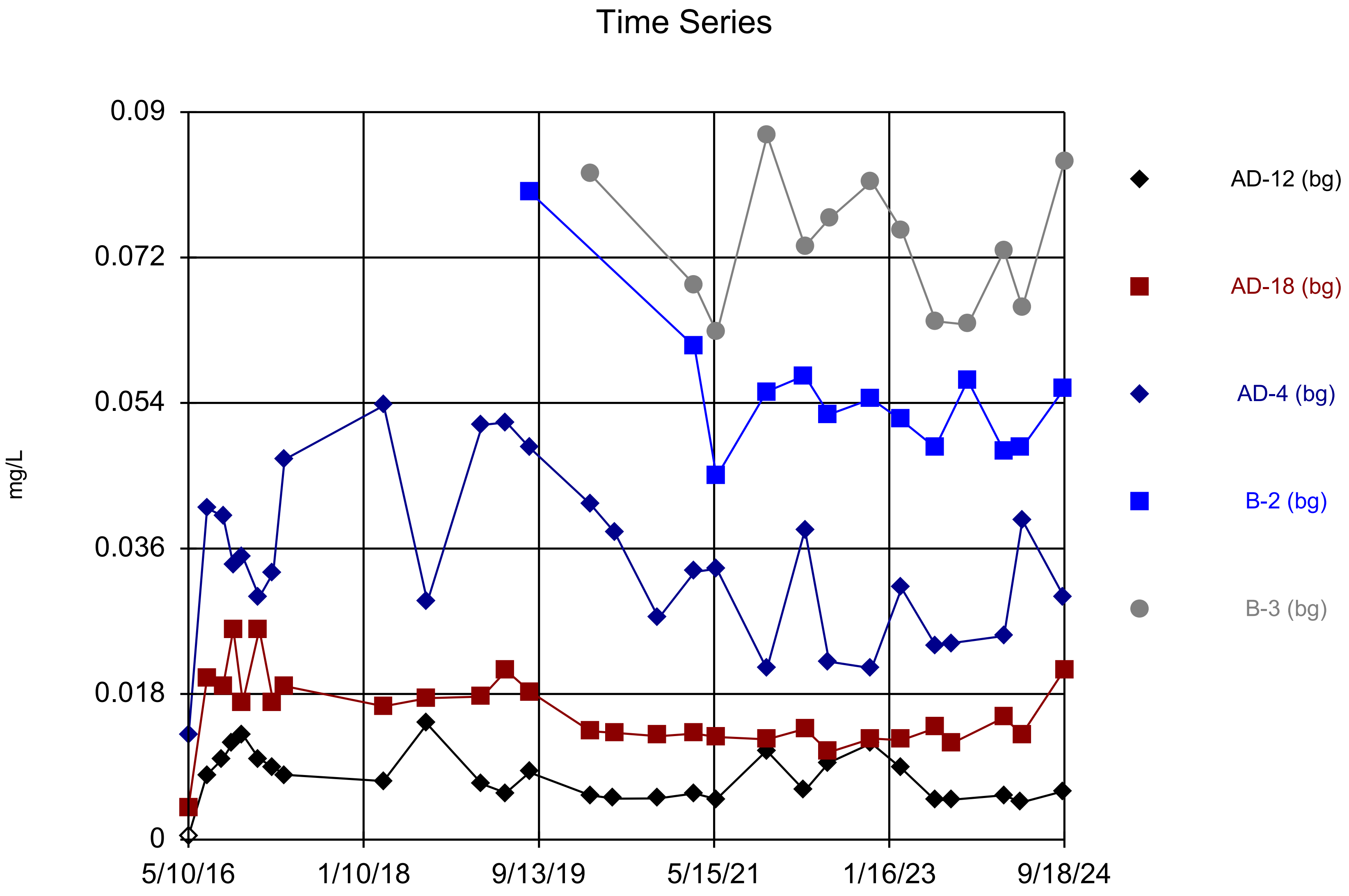
Hollow symbols indicate censored values.



Constituent: Lithium, total   Analysis Run 3/19/2025 9:56 AM   View: Lithium UTLs

Pirkey EBAP   Client: Geosyntec   Data: Pirkey EBAP

Tolerance Limit

Interwell Parametric

95% coverage. Background Data Summary (based on natural log transformation): Mean=-3.867, Std. Dev.=0.9275, n=110, 0.9091% NDs. Normality test: Chi Squared @alpha = 0.01, calculated = 11.09, critical = 14.07. Report alpha = 0.05.

Constituent: Lithium, total Analysis Run 3/19/2025 9:55 AM View: Lithium UTLs

Pirkey EBAP Client: Geosyntec Data: Pirkey EBAP

ATTACHMENT F
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 Pirkey East Bottom Ash Pond CCR management area and that the requirements of 30 TAC §352.951(e) have been met.

BETH ANN GROSS
79864

Beth Ann Gross
Printed Name of Licensed Professional Engineer

Beth Ann Gross
Signature

Geosyntec Consultants
2039 Centre Pointe Blvd, Suite 103
Tallahassee, Florida 32308

Texas Registered Engineering Firm
No. F-1182

79864	Texas	March 20, 2025
License Number	Licensing State	Date