



Dynegy Midwest Generation, LLC
1500 Eastport Plaza Drive
Collinsville, IL 62234

July 24, 2024

Illinois Environmental Protection Agency
DWPC – Permits MC#15
Attn: 35 I.A.C. § 845.650(e) Alternative Source Demonstration Submittal
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Re: Vermilion Power Plant New East Ash Pond; IEPA ID # W1838000002-04

Dear Mr. LeCrone:

In accordance with Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845.650(e), Dynegy Midwest Generation, LLC (DMG) is submitting this Alternative Source Demonstration (ASD) for exceedances observed from the Quarter 1 2024 sampling event at the Vermilion Power Plant New East Ash Pond, identified by Illinois Environmental Protection Agency (IEPA) ID No. W1838000002-04.

As allowed in 35 I.A.C. § 845.650(e), previous ASDs were submitted for GWPS exceedances at the New East Ash Pond. This ASD is being submitted within 60 days from the date of determination of an exceedance of a groundwater protection standard (GWPS) for constituents listed in 35 I.A.C. § 845.600. As required by 35 I.A.C. § 845.650 (e)(1), the ASD was placed on the facility's website within 24 hours of submittal to the agency.

One hard copy is provided with this submittal.

Sincerely,

A handwritten signature in blue ink that reads "Dianna Tickner".

Dianna Tickner
Sr. Director – Decommission and Demolition

Enclosures

Alternate Source Demonstration, Quarter 1 2024, New East Ash Pond Vermilion Power Plant

Intended for

Dynegy Midwest Generation, LLC

Date

July 24, 2024

Project No.

1940103584-009

35 I.A.C. § 845.650(E): ALTERNATIVE SOURCE DEMONSTRATION

NEW EAST ASH POND

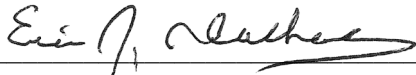
VERMILION POWER PLANT

OAKWOOD, ILLINOIS

IEPA ID: W1838000002-04

CERTIFICATIONS

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used other than for its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.



Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: July 24, 2024



I, Brian G. Hennings, a professional geologist in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used other than for its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.



Brian G. Hennings
Professional Geologist
196-001482
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: July 24, 2024



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ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
¹⁴ C	carbon-14
ASD	Alternative Source Demonstration
BCU	Bedrock Confining Unit
CCR	coal combustion residuals
CMA	Corrective Measures Assessment
cm/s	centimeters per second
DMG	Dynegy Midwest Generation, LLC
E001	Event 1, Quarter 2, 2023
E003	Event 3, Quarter 4, 2023
E004	Event 4, Quarter 1, 2024
EPRI	Electric Power Research Institute
GMP	Groundwater Monitoring Plan
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
IEPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geological Survey
IPCB	Illinois Pollution Control Board
IQR	Interquartile Range
LGU	Lower Groundwater Unit
LOE(s)	line(s) of evidence
mg/L	milligrams per liter
MGU	Middle Groundwater Unit
Middle Fork	Middle Fork of the Vermilion River
NAP	North Ash Pond
NAVD88	North American Vertical Datum of 1988
NEAP	New East Ash Pond
NGVD	National Geodetic Vertical Datum of 1929
OEAP	Old East Ash Pond
PCA	principal component analysis
PMP	Potential Migration Pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RYBP	Radiocarbon Years Before Present
SEP	Sequential Extraction Procedure
SI	surface impoundment
TDS	total dissolved solids
TU	tritium units
UCU	Upper Confining Unit
USEPA	United States Environmental Protection Agency
UU	Upper Unit
VPP	Vermilion Power Plant

EXECUTIVE SUMMARY

Groundwater samples collected at the Vermilion Power Plant (VPP) New East Ash Pond (NEAP) during February 2024 for the Quarter 1, 2024 compliance sampling event (Event 4 [E004]) were evaluated for exceedances of the groundwater protection standards (GWPS) described in Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.600. Exceedances were identified in the following hydrostratigraphic units and wells:

Bedrock confining unit (BCU) (potential migration pathway [PMP]) exceedances:

- Chloride at wells 35D and 70D
- Lithium at wells 35D and 70D
- Sulfate at well 35D
- Total dissolved solids (TDS) at wells 35D and 70D

Upper unit (UU; PMP) exceedances:

- Sulfate at well 70S
- TDS at well 70S

These are similar to GWPS exceedances determined during previous quarterly sampling events, with the exception of the TDS exceedance at well 70D, which was a new exceedance determined after the E004 sampling event. As a result of the newly identified E004 exceedance, this Alternative Source Demonstration (ASD) has been prepared to provide pertinent information pursuant to 35 I.A.C. § 845.650(e) for the VPP NEAP.

Two previous ASDs were submitted for the GWPS exceedances referenced above (except for the new TDS exceedance at well 70D addressed by this ASD) and a GWPS exceedance of chloride identified at well 71D during the Quarter 4, 2023 (E003) groundwater sampling event (Ramboll, 2023 and 2024a). The Illinois Environmental Protection Agency (IEPA) communicated in written correspondence (IEPA, 2023 and 2024) that they did not concur with these ASDs due to the following data gaps:

- Characterization that the draw water from the bedrock is completely isolated from local groundwater flow system.
- No assessment of the interaction between bedrock groundwater and the Old East Ash Pond (OEAP). Based on Fig. 1 shows to be upgradient of the NEAP. The Agency (IEPA) is unable to review for fate and transport or related concepts without source characterization of total CCR solids.
- Lack of analysis of the leachable metals from the CCR in the NEAP. Source characterization of the CCR at NEAP must include total solids sampling in accordance with the waste characterization and/or fate and transport characterization required in 35 Ill. Adm. Code 845 and analyzed in accordance with SW846.

As allowed in 35 I.A.C. § 845.650(e), DMG subsequently filed a petition on February 2, 2024 asking the Illinois Pollution Control Board (IPCB) to review the IEPA's denial (dated December 28, 2023) of the ASD for chloride, lithium, sulfate, and TDS at well 35D and chloride and lithium at well 70D. The IPCB accepted the petition for appeal on February 15, 2024 and on April 18, 2024

approved a partial stay, with no objections by the IEPA, of the requirements of 35 I.A.C. § 845.650(d), 35 I.A.C. § 845.660, 35 I.A.C. § 845.670, and 35 I.A.C. § 845.680, which pertain to corrective actions for the parameters with exceedances, pending final action by the Board.

This ASD provides additional information in response to concerns raised by IEPA in the prior denials:

- In response to IEPA's denial point regarding no characterization that draw water from the bedrock is completely isolated from the local groundwater flow system, additional hydrogeologic information is provided in **Sections 2.3.1 and 3.4** demonstrating the lack of a hydraulic connection between the bedrock and overlying shallow, unlithified soils that comprise the local groundwater flow system in the vicinity of the NEAP.
- In response to the IEPA's denial point regarding no assessment of the interaction of bedrock groundwater and the OEAP, additional hydrogeologic information is provided in **Section 2.3.1** regarding groundwater flow in the vicinity of the OEAP; and, the ionic composition of porewater collected from both the OEAP and NAP is included in the comparison of the ionic composition of CCR porewater to that of bedrock groundwater collected from the monitoring wells in the vicinity of the NEAP presented in **Sections 3.1 and 3.2**.
- In response to the IEPA's denial point regarding the lack of analysis of the leachable metals from the CCR in the NEAP, additional information is provided in **Section 2.4** demonstrating that analysis of available CCR source water collected from porewater wells screened near the base of ash within the unit is considered the primary CCR source term for the purpose of alternative source evaluation.

The four LOEs listed below, with elaboration provided herein, demonstrate that the NEAP, OEAP, and North Ash Pond (NAP) are not the source of the TDS GWPS exceedance in well 70D. The TDS exceedance is due to groundwater interactions with the bedrock, with chloride being the major contributor to TDS.

1. The ionic composition of bedrock groundwater is different than the ionic composition of NEAP, OEAP, and NAP porewater and consistent with published observations for Pennsylvanian Bedrock.
2. Concentrations of Chloride in the NEAP, OEAP, and NAP Porewater are Lower than Those Observed in Groundwater from Compliance Well 70D.
3. A Bedrock Solids and Geochemical Evaluation Identified Naturally Occurring Shales as the Source of Chloride, and thus the TDS Exceedance at Compliance Well 70D.
4. Bedrock Groundwater is Only Slightly Connected or Completely Isolated from the Groundwater in the Quaternary Deposits Based on Isotopic Analysis, Observed Hydraulic Conditions, and Hydraulic Conductivity of Associated Hydrostratigraphic Units.

This information serves as the written ASD prepared in accordance with 35 I.A.C. § 845.650(e), demonstrating that the TDS exceedance observed at well 70D during the Quarter 1, 2024 sampling event (E004) was not due to the NEAP and is attributable to natural groundwater interactions with bedrock. Therefore, assessment of corrective measures is not required for this TDS exceedance at the NEAP.

Sulfate and TDS GWPS exceedances at well 70S will be addressed in accordance with 35 I.A.C. § 845.660, and an associated Corrective Measures Assessment (CMA) was initiated on December

31, 2023. A request to extend the 90-day CMA completion deadline specified in 35 I.A.C. § 845.660(a)(2) by 60 days was submitted to IEPA on January 2, 2024 and approved in a written response from IEPA dated January 3, 2024. The CMA was completed and submitted to IEPA on May 29, 2024.

1. INTRODUCTION

Under 35 I.A.C. § 845.650(e), within 60 days from the date of determination of an exceedance of a GWPS for constituents listed in 35 I.A.C. § 845.600, an owner or operator of a coal combustion residuals (CCR) surface impoundment (SI) may complete a written demonstration that a source other than the CCR SI caused the contamination and the CCR SI did not contribute to the contamination, or that the exceedance of the GWPS resulted from error in sampling, analysis, statistical evaluation, natural variation in groundwater quality, or a change in the potentiometric surface and groundwater flow direction (ASD).

This ASD has been prepared on behalf of Dynegy Midwest Generation, LLC (DMG) by Ramboll Americas Engineering Solutions, Inc (Ramboll), to provide pertinent information pursuant to 35 I.A.C. § 845.650(e) for the VPP NEAP (*i.e.*, Site) located near Oakwood, Illinois.

The Quarter 1, 2024 sampling event (E004) was completed on February 21, 2024, and analytical data were received on March 26, 2024. In accordance with 35 I.A.C. § 845.610(b)(3)(C), comparison of statistically derived values with the GWPSs described in 35 I.A.C. § 845.600 to determine exceedances of the GWPS was completed by May 25, 2024, within 60 days of receipt of the analytical data (Ramboll, 2024a). The statistical comparison identified the following GWPS exceedances at compliance groundwater monitoring wells:

- Chloride at wells 35D and 70D
- Lithium at wells 35D and 70D
- Sulfate at wells 35D and 70S
- TDS at wells 35D, 70D, and 70S

These are similar to GWPS exceedances determined during previous quarterly sampling events, with the exception of the TDS exceedance at well 70D, which was a new exceedance determined after the E004 sampling event.

As allowed in 35 I.A.C. § 845.650(e), an ASD was submitted on December 1, 2023 for GWPS exceedances determined after the Quarter 2, 2023 sampling event (E001), including chloride, lithium, sulfate, and TDS exceedances at wells 35D and 70D (Ramboll, 2023). The IEPA communicated in a written response dated December 28, 2023 (IEPA, 2023) that it did not concur with the E001 ASD due to the following data gaps:

- Characterization that the draw water from the bedrock is completely isolated from local groundwater flow system.
- No assessment of the interaction between bedrock groundwater and the OEAP. Based on Fig. 1 shows to be upgradient of the NEAP.
- Lack of analysis of the leachable metals from the CCR in the NEAP.

DMG subsequently filed a petition asking the IPCB to review the IEPA's ASD denial. The petition included a motion for a partial stay of the 35 I.A.C. § 845 requirements as they apply to the exceedance of the chloride, lithium, sulfate, and TDS GWPS in BCU wells 35D and 70D. The IEPA had no objection to the requested stay, which was granted by the IPCB on April 18, 2024.

A second ASD was submitted on May 8, 2024, for a new GWPS exceedance of chloride at well 71D during the Quarter 4, 2023 sampling event (E003) (Ramboll, 2024a). This ASD referenced similar lines of evidence (LOEs) as the E001 ASD and included additional hydrogeologic information regarding groundwater flow in the area of the OEAP and demonstrating the lack of a hydraulic connection between the bedrock and overlying shallow, unlithified soils that comprise the local groundwater flow system in the area of the NEAP. The IEPA communicated in a written response dated June 5, 2024 (IEPA, 2024) that it did not concur with the E003 ASD due to the following data gaps:

- No assessment of the interaction between bedrock groundwater and the OEAP. Based on Fig. 1 shows to be up gradient of the NEAP. The IEPA is unable to review for fate and transport or related concepts without source characterization of total CCR solids.
- Lack of analysis of the leachable metals from the Coal Combustion Residuals in the NEAP. Source characterization of the CCR at NEAP must include total solids sampling in accordance with the waste characterization and/or fate and transport characterization required in 35 Ill. Adm. Code 845 and analyzed in accordance with SW846.

This ASD provides additional information in response to IEPA's denial points for the previous two ASDs:

- In response to IEPA's denial point regarding no characterization that draw water from the bedrock is completely isolated from the local groundwater flow system, additional hydrogeologic information is provided in **Sections 2.3.1 and 3.4** demonstrating the lack of a hydraulic connection between the bedrock and overlying shallow, unlithified soils that comprise the local groundwater flow system in the vicinity of the NEAP.
- In response to the IEPA's denial point regarding no assessment of the interaction of bedrock groundwater and the OEAP, additional hydrogeologic information is provided in **Section 2.3.1** regarding groundwater flow in the vicinity of the OEAP and the ionic composition of porewater collected from both the OEAP and NAP is included in the comparison of the ionic composition of CCR porewater to that of bedrock groundwater collected from the monitoring wells in the vicinity of the NEAP in **Sections 3.1 and 3.2**.
- In response to the IEPA's denial point regarding the lack of analysis of the leachable metals from the CCR in the NEAP, additional information is provided in **Section 2.4** demonstrating that analysis of available CCR source water collected from porewater wells screened near the base of ash within the unit is considered the primary CCR source term for the purpose of alternative source evaluation.

Pursuant to 35 I.A.C. § 845.650(e), the LOEs presented in **Section 3** demonstrate that sources other than the NEAP, OEAP, and NAP are the cause of the new TDS GWPS exceedance at well 70D listed above and the NEAP, OEAP, and NAP have not contributed to the exceedance.

This ASD was completed by July 24, 2024, within 60 days of determination of the exceedance (May 25, 2024), as required by 35 I.A.C. § 845.650(e). This ASD has been completed in conformance with guidance provided in the Electric Power Research Institute (EPRI) guidance for development of ASDs at CCR sites (EPRI, 2017), and the United States Environmental Protection Agency (USEPA)'s Solid Waste Disposal Facility Criteria: Technical Manual (USEPA, 1993).

Sulfate and TDS GWPS exceedances at **well 70S** will be addressed in accordance with 35 I.A.C. § 845.660, and an associated CMA was initiated on December 31, 2023. A request to extend the 90-day CMA completion deadline specified in 35 I.A.C. § 845.660(a)(2) by 60 days was submitted to IEPA on January 2, 2024, and approved in a written response from IEPA dated January 3, 2024. The CMA was completed and submitted to IEPA on May 29, 2024.

2. BACKGROUND

2.1 Site Location and Description

The former VPP is located four miles northeast of the Village of Oakwood in Vermilion County. The NEAP lies in the bottomlands of the Middle Fork and is bordered to the west by bluffs, to the south by unimproved DMG land, and to the north and east by the Middle Fork. Several underground coal mines and one surface mine were historically operated both beneath the NEAP and in the vicinity of the VPP.

2.2 Description of New East Ash Pond CCR Unit

The NEAP is a 29-acre inactive, unlined CCR SI constructed overtop a thick shale formation using berms constructed with a low-permeability clay core and cutoff walls keyed into the underlying shale formation.

The original East Ash Pond (1989 pond footprint) was constructed in 1989 and expanded in 2002 to form the present-day NEAP. The 1989 pond footprint was built overtop a thick shale formation which is greater than 80 feet thick in the vicinity of the ash ponds. The earthen berms on the north, east, and south sides of the 1989 pond footprint were constructed with a low-permeability clay core and cutoff walls keyed into the underlying shale formation. The cutoff walls extended approximately 8 feet into the underlying shale. A natural earthen bluff composed of low-permeability native clays formed the west side of the 1989 pond footprint.

New berms were constructed in 2002 to expand the capacity of the 1989 pond footprint, forming the footprint of the present-day NEAP. The new berms raised the height of the original berms and were constructed with clay liners keyed into the underlying clay core. A cutoff trench backfilled with low permeability fill was placed along the western side slope of the enlarged NEAP. The low-permeability materials surrounding the footprint of the present-day NEAP form the existing containment system. The secondary pond was not expanded or modified as part of the 2002 NEAP expansion. The VPP ceased operations in 2011 when the power plant was retired.

2.3 Geology and Hydrogeology

2.3.1 Site Hydrogeology

Significant site investigation has been completed at the VPP to fully characterize the geology, hydrogeology, and groundwater quality as provided in the October 2021 operating permit application (Geosyntec Consultants, 2021), the January 2022 construction permit application (Geosyntec Consultants, 2022a), and the HCR (Ramboll, 2021a). A site conceptual model has been developed and is summarized below.

In addition to the CCRs present in the NEAP, there are two different types of unlithified material present above the lithified bedrock, which were categorized into three hydrostratigraphic units in this report as follows:

- **Upper Unit (UU):** includes mixed Quaternary alluvial deposits of the Cahokia Alluvium described as sand with occasional layers of silty clay. The alluvial sand is generally a fine to medium sand that contains silts, clays, and gravels in varying amounts. This unit is present outside of the NEAP and in the bottomlands of the Middle Fork.

- **Upper Confining Unit (UCU):** consists of predominantly low permeability silty and clayey diamictons (glacial till) of the Wedron Formation with intermittent sand layers and lenses. This unit is present outside of the NEAP and along the western bluff of the Middle Fork.
- **Bedrock Confining Unit (BCU):** lowermost unit identified at the site and underlies all unlithified deposits. This unit occurs within Pennsylvanian shale which is the uppermost lithified unit at the Site.

None of the hydrostratigraphic units described above have been identified as an aquifer. However, the UU and BCU have been identified as PMPs.

The groundwater present in the unlithified and lithified materials present around the NEAP is isolated from the groundwater present in the vicinity of the NAP and OEAP. Interpreted groundwater flow direction and gradients toward the Middle Fork have not changed significantly since the hydrogeologic study of the NEAP was completed in 2003 (Ramboll, 2021a; Kelron, 2003), and recent data supports the existing conceptual site model. A groundwater elevation map for the BCU for February 19, 2024 is presented in **Figure 1**, but it was not possible to develop potentiometric surface contours because groundwater elevations in BCU monitoring wells 70D and 71D were observed to be consistently increasing before and after the E004 sampling event based upon data obtained from pressure transducers deployed in those wells (**Appendix A**). Groundwater elevations in those monitoring wells have not reached static equilibrium following the E003 sampling event, thus yielding groundwater elevations that are not representative of the potentiometric surface at these locations. However, groundwater elevations at wells 10 and 22 are screened within the UU and BCU, respectively and are considerably higher than groundwater elevations at or near the OEAP, therefore the NEAP bedrock wells are not downgradient of the OEAP.

No BCU groundwater elevation data is collected and available to complete a potentiometric surface map for the BCU in the area of the NAP and OEAP. However, a calibrated groundwater flow model was completed as part of the January 2022 construction permit application (Geosyntec Consultants, 2022b) for the NAP and OEAP, which included the BCU within the model domain. The simulated potentiometric surface map, which includes the area of the NAP and OEAP, for the BCU from the calibrated groundwater model is provided in **Appendix B**. Simulated groundwater elevations in the shale are highest in the topographically highest areas, such as in the vicinity of the NEAP, and the lowest groundwater elevations occur at wells located adjacent to the Middle Fork, consistent with the HCRs for the NAP/OEAP and NEAP (Ramboll, 2021a; Ramboll, 2021c) and as previously reported by Kelron (2003) for the NEAP. The simulated potentiometric surface indicates groundwater in the BCU does not flow from the OEAP to the area of the NEAP. The Middle Fork is the receiving body of water in the region, including for both the NAP and OEAP via a different hydrostratigraphic unit, referred to as the Middle Groundwater Unit (MGU) and described further below, and NEAP via the underlying BCU, consistent with the conceptual site model.

As described in the HCR for the NAP and OEAP (Ramboll, 2021c), groundwater flows into the Middle Fork through the unlithified MGU (alluvial deposits of coarser grained material encountered at the base of the Cahokia Alluvium and designated as the uppermost aquifer in the area of the NAP and OEAP) and Lower Groundwater Unit (LGU; glacial outwash and re-worked glacial deposits of the Henry Formation in the area of the NAP and OEAP) which are the primary pathways that contaminant migration could occur in the area of the NAP and OEAP. Water level

elevations collected from ND3 (a porewater well placed in the NAP) indicate the phreatic surface is above the water levels observed in the uppermost aquifer; however, the potentiometric surface of the uppermost aquifer (MGU) for February 19, 2024 (**Figure 2**) illustrate flow toward the Middle Fork with no observable radial component of flow outward along the perimeter of the NAP and OEAP (and toward the upland bluff and NEAP, both areas where the MGU does not exist and materials at similar elevations as the MGU along the perimeter of the NAP and OEAP consist of low permeability tills [with exception to bottomland areas north of the NAP]). The absence of a radial component of flow indicates the NAP and OEAP do not significantly impact regional groundwater flow direction toward the Middle Fork. As indicated by groundwater potentiometric surfaces, groundwater flows from beneath the NAP and OEAP toward the Middle Fork through the MGU, not toward the NEAP. Groundwater flow in the LGU beneath the bluff and Company Lake appears to reflect the topography, flowing from the VPP toward the NAP, OEAP and Middle Fork to the north, and toward Company Lake to the south, which results in localized groundwater divides (**Figure 3**). Company Lake is not downgradient of the NAP and OEAP. Neither the MGU nor the LGU are present in the upland area immediately southeast of the OEAP or in the area of the NEAP. Low permeability tills of the UCU and LCU occur at similar elevations as the MGU and LGU in the upland area immediately southeast of the OEAP between the OEAP and NEAP areas creating a localized groundwater flow divide. Consequently, groundwater does not flow through the low permeability till units between the OEAP area to the NEAP area, but instead preferentially flows along a direct path to the Middle Fork through the MGU and LGU. Thus, the NAP and OEAP areas are hydraulically isolated from the NEAP in the shallow, unlithified soils overlying the bedrock.

2.3.2 Regional Bedrock Geology

Regional investigations of the Illinois Basin have identified bedrock (specifically brines within the bedrock formations) as a source of chloride in groundwater (Kelley et al, 2012; Panno et al, 2018). Studies by Cartwright (1970) and Siegel (1989) indicate that groundwater migrates toward the center of the Illinois Basin and discharges upward through overlying confining units. The "Saline groundwater and brines can be brought near or to the land surface by natural conditions, such as migrating up prominent fractures and/or faults in bedrock, or by anthropogenic activities, such as exploration for and exploitation of petroleum. The mixing of upward-migrating saline groundwater with fresh groundwater from shallow aquifers can make groundwater from private wells undrinkable and can present a very expensive problem for municipalities (Panno and Hackley, 2010). Illinois State Geological Survey (ISGS) reporting includes 31 chloride results from available water samples (including some samples from VPP) which range from 2.1 to 30,269 milligrams per liter (mg/L) with mean value of 1,689 mg/L and median of 13 mg/L (ISGS, 2002). The report also concludes that water from the wells completed in shale contained higher concentrations of aluminum, barium, bromide, boron, chloride, fluoride, iron, lithium, potassium, sodium, and strontium. Tritium and carbon-14 (¹⁴C) age dating has demonstrated that groundwater from the bedrock is significantly older than that from the shallow Quaternary deposits (Kelron, 2003; ISGS, 2002).

2.4 Groundwater and NEAP Monitoring

The monitoring system for the NEAP was established in the Groundwater Monitoring Plan (GMP; Ramboll, 2021b) and consists of monitoring wells installed in the UU, UCU, and BCU, including background monitoring wells 10 and 22, located west of the NEAP, and compliance monitoring wells 16A, 16B, 35S, 35D, 70S, 70D, 71S and 71D (**Figure 1**). NED1 (installed in CCR) is used to

collect porewater samples and monitor water levels within the NEAP. CCR porewater is water "collected from the interstitial water between waste particles in surface impoundments as it occurs in the field" (USEPA, 2014) and represents the material potentially leached from impoundments. The CCR materials are the primary source of constituent loading to the CCR porewater. Over an extended period (*e.g.*, months to years), the CCR porewater (*i.e.*, water) reaches equilibrium with the CCR materials. The concentrations within the porewater are "the most representative data available for impoundments because these data are field-measured concentrations of leachate" (USEPA, 2014). CCR source water collected from porewater wells screened near the base of ash within the unit is considered as the primary CCR source term for the purpose of alternative source evaluation.

3. LINES OF EVIDENCE THAT GROUNDWATER PROTECTION STANDARD EXCEEDANCES ARE NOT RELATED TO THE NEAP, OEAP, OR NAP

As allowed by 35 I.A.C. § 845.650(e), this ASD demonstrates that sources other than the NEAP (the CCR unit) caused the TDS exceedance at compliance groundwater monitoring well 70D and the NEAP did not contribute to the exceedance. Specifically, the following LOEs conclude that the TDS exceedance is due to groundwater interactions with the bedrock.

1. The ionic composition of bedrock groundwater is different than the ionic composition of NEAP, OEAP, and NAP porewater and consistent with published observations for Pennsylvanian Bedrock.
2. Concentrations of Chloride in the NEAP, OEAP, and NAP Porewater are Lower than Those Observed in Groundwater from Compliance Well 70D.
3. A Bedrock Solids and Geochemical Evaluation Identified Naturally Occurring Shales as the Source of Chloride, and thus the TDS Exceedance, at Compliance Well 70D.
4. Bedrock Groundwater is Only Slightly Connected or Completely Isolated from the Groundwater in the Quaternary Deposits Based on Isotopic Analysis, Observed Hydraulic Conditions, and Hydraulic Conductivity of Associated Hydrostratigraphic Units.

These LOEs are described and supported in greater detail below.

Figure A (on the following page) shows boxplots summarizing the relative contribution of each major ion to TDS in groundwater from well 70D since 2021. Box plots graphically represent the range of a given dataset using lines to construct a box where the lower line, midline, and upper line of the box represent the values of the first quartile, median, and third quartile values, respectively. The minimum and maximum values of the dataset (excluding outliers) are illustrated by whisker lines extending beyond the first and third quartiles of (*i.e.*, below and above) the box plot. Outliers (values that are at least 1.5 times the IQR away from the edges of the box) are represented by single points plotted outside of the range of the whiskers. **Figure A** shows that chloride has the greatest contribution to TDS concentrations at 70D (median of 41 percent).

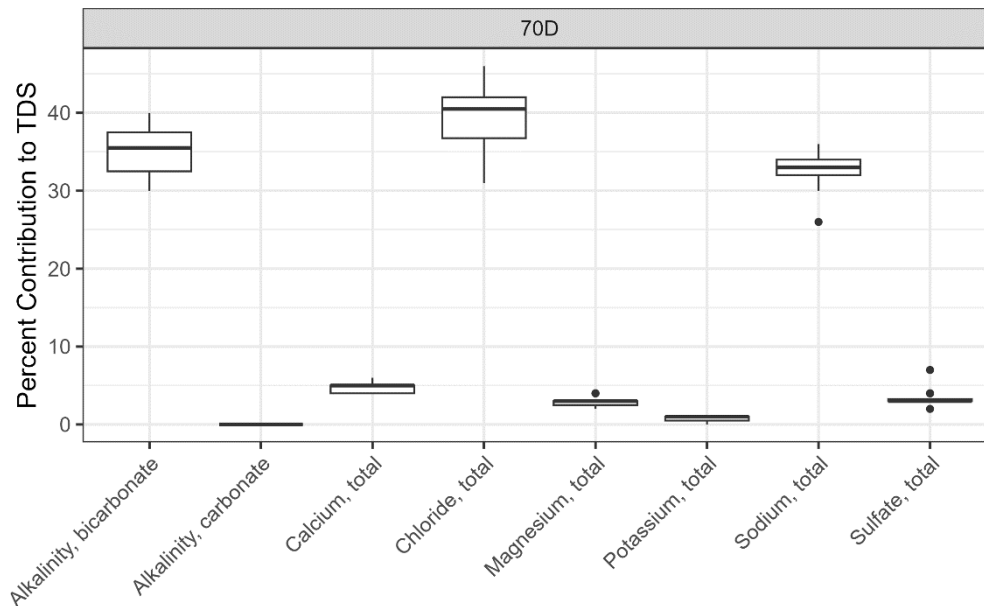


Figure A. Contribution of each major ion to TDS at well 70D.

3.1 LOE #1: The Ionic Composition of Bedrock Groundwater is Different Than the Ionic Composition of NEAP, OEAP, and NAP Porewater and Consistent with Published Observations for Pennsylvanian Bedrock

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples with respect to their major cation and anion content on the two lower triangular portions of the diagram, providing the information which, when combined on the central, diamond-shaped portion of the diagram, identify composition categories or groupings (hydrochemical facies). **Figure B** on the following page is a Piper diagram that displays the ionic composition of samples collected from the bedrock background and bedrock compliance wells associated with the NEAP (sampled February 20 and 21, 2024), porewater sampling location associated with the NAP (sampled February 20, 2024), porewater sampling location associated with the NEAP (sampled February 21, 2024), and porewater sampling location associated with the OEAP (sampled June 20, 2023).

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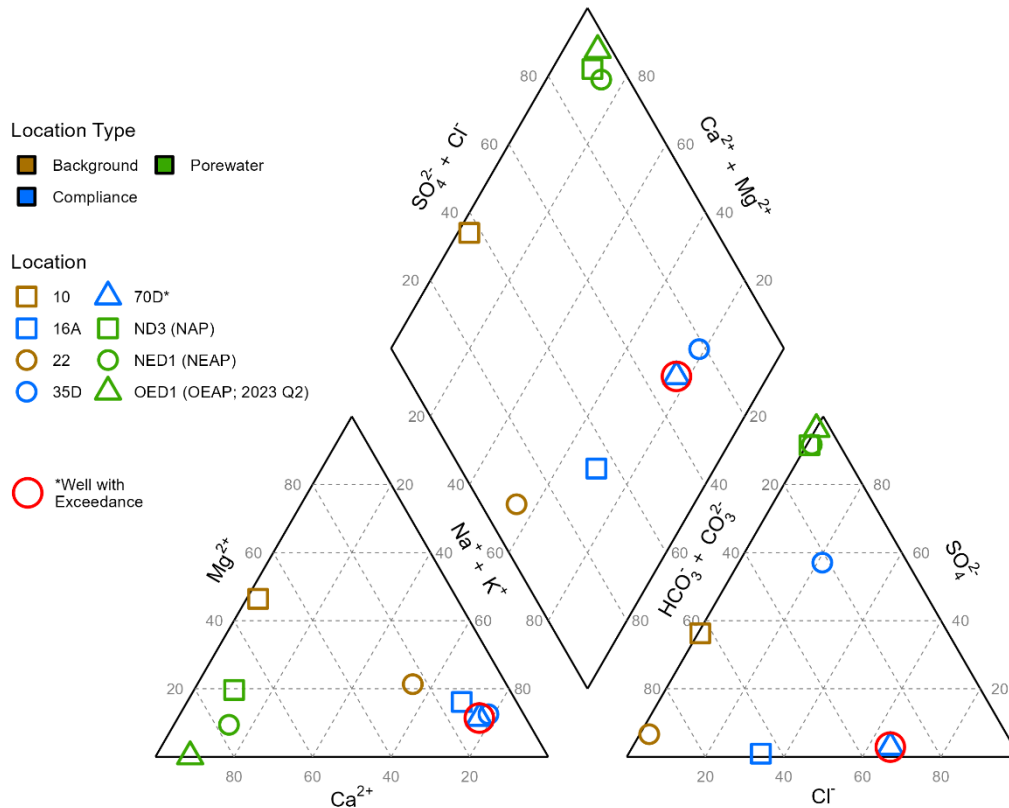


Figure B. Piper Diagram. Shows ionic composition of bedrock groundwater (February 20 and 21, 2024), porewater associated with the NAP (February 20, 2024), porewater associated with the NEAP (February 21, 2024), and porewater associated with the OEAP (June 20, 2023).

It is evident from the piper diagram (**Figure B**) that porewater from the NEAP (green circle symbol), OEAP (green triangle symbol), and NAP (green square symbol) are primarily in the calcium-sulfate hydrochemical facies, while the bedrock groundwater from wells 35D and 70D near the NEAP (blue triangle and blue circle symbols, respectively) are in the sodium-chloride hydrochemical facies. The background BCU sample (brown circle symbol) is in the sodium-bicarbonate hydrochemical facies. The background BCU sample is collected from well 22, which is screened at from 556 to 576 feet¹, and wells 35D and 70D are screened at lower elevations (536 to 546 feet and 541 to 551 feet, respectively). Groundwater from deeper in Pennsylvanian aquifers tends to be more dominant in chloride, and groundwater may change from a sodium-bicarbonate to a sodium-chloride facies over small changes in depth (Lloyd and Lyke, 1995). Therefore, compliance groundwater samples have a different ionic composition than NEAP, OEAP, and NAP porewater and a composition relative to background that is consistent with expected changes due to screen depth, indicating that NEAP, OEAP, and NAP porewater is not the source of CCR constituents detected in 70D.

¹ All elevations in this report are referenced to North American Vertical Datum 1988 (NAVD88) unless otherwise noted.

3.2 LOE #2: Concentrations of Chloride in the NEAP, OEAP, and NAP Porewater are Lower than Those Observed in Groundwater from Compliance Well 70D

A box plot of chloride concentrations in compliance monitoring well 70D and NEAP, OEAP, and NAP porewater wells NED1, OED1, and ND3, respectively, is provided in **Figure C** below. The chloride data ranges are April 2021 to February 2024 for 70D and NED1, June 2021 to June 2023 for OED1, and March 2021 to February 2024 for ND3. Chloride concentrations are significantly lower in the NEAP, OEAP, and NAP porewater samples than in compliance groundwater samples collected from well 70D. The maximum concentration of chloride detected in NEAP, OEAP, and NAP porewater (44 mg/L, 5 mg/L, and 10 mg/L, respectively) is lower than the minimum concentration of chloride in 70D (317 mg/L). In addition, the median concentration of chloride in well 70D (672.5 mg/L) is 31, 224, and 84 times greater than the median concentration of chloride (21.5 mg/L, 3 mg/L, and 8 mg/L) in NEAP, OEAP, and NAP porewater, respectively. Therefore, the porewater from the NEAP, OEAP, and NAP cannot be the source of the elevated chloride, and thus TDS, concentrations observed in 70D.

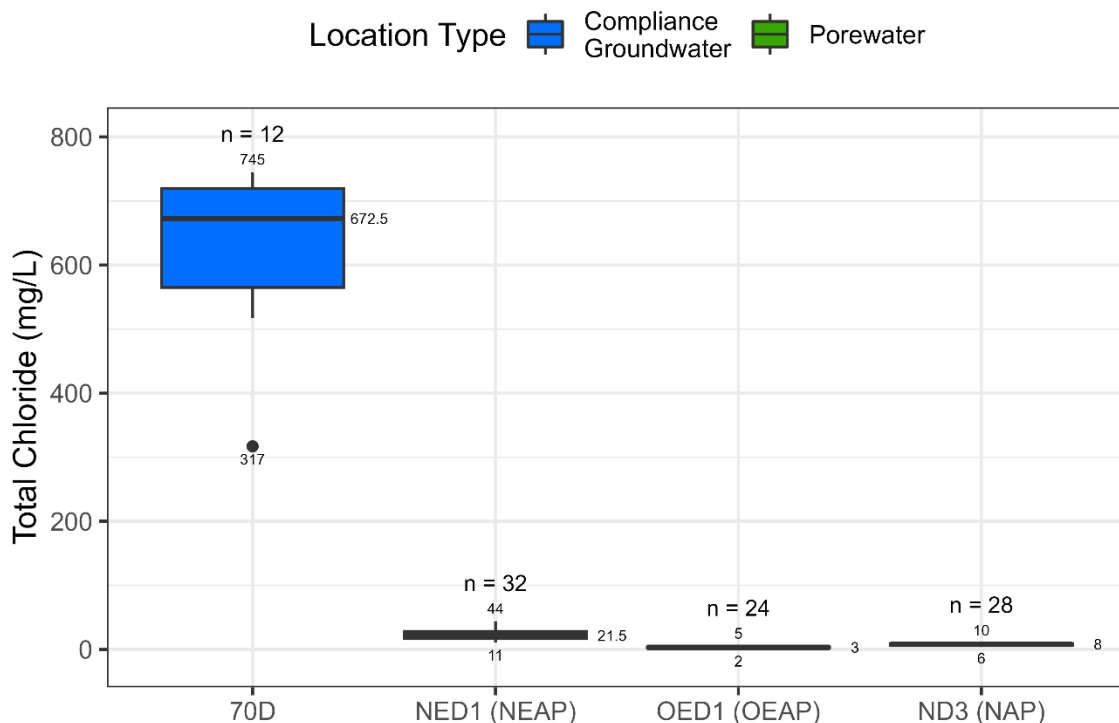


Figure C. Chloride Box Plot. The sample size (n), maximum, median, and minimum values are noted.

3.3 LOE #3: A Bedrock Solids and Geochemical Evaluation Identified Naturally Occurring Shales as the Source of Chloride, and thus the TDS Exceedance, at Compliance Well 70D

Appendix C presents an evaluation of site-specific solid phase compositions, geochemical conditions through multivariate statistical analyses, and literature review of Pennsylvanian-aged shale bedrock groundwaters that identifies naturally occurring chloride associated with shales as

the alternative source of this constituent and related TDS exceedance in the groundwater at 70D based on the following observations:

- Mineralogy of bedrock samples collected from the site consists of considerable quantities of clay and mica materials that retain dissolved ions (*i.e.*, chloride) from marine water trapped in the pore space at the time of deposition of these materials.
- Groundwater chloride concentrations observed in Pennsylvanian-age shale bedrock aquifers are comparable to or higher than those observed at well 70D.
- Principal component analysis (PCA) shows that BCU well groundwater is distinct from NEAP, OEAP, and NAP porewater.

3.4 LOE #4: Bedrock Groundwater is Only Slightly Connected or Completely Isolated from the Groundwater in the Quaternary Deposits Based on Isotopic Analysis, Observed Hydraulic Conditions, and Hydraulic Conductivity of Associated Hydrostratigraphic Units

In 2002, ISGS and DMG collected groundwater samples from eight monitoring wells and tested the samples for ^{14}C and hydrogen-3 (tritium) (ISGS, 2002). Six of the monitoring wells (25, 26, 27, 28, 29, and 30) were located adjacent to the NEAP (Figure 7, **Appendix D**). Wells 26 and 28 had well screens that intersected Quaternary deposits of the UU and the remaining wells were screened in shallow shale bedrock (BCU). Results of the testing are presented in Figure 7 included in **Appendix D**, and in Table 11 of the ISGS report (2002) included below as **Table A**.

Table A. Isotopic Data from ISGS Sampled Wells (Table 11 from ISGS, 2002)

Table 11. Isotopic data for ISGS sampled wells

Parameter	Units	Well Number							
		1349	25531	KELRON 25	KELRON 26	KELRON 27	KELRON 28	KELRON 29	KELRON 30
^{14}C	RYBP	2,180	21,160	13,920	210	19,400	modern	34,610	20,850
	% modern carbon	76	7.2	18	97	8.9	102	1.4	7.5
Tritium	TU	7.8	<0.43	<0.43	5.3	<0.43	5.8	<0.52	<0.43

^{14}C = carbon-14

RYBP = Radiocarbon Years Before Present

TU = tritium units

Tritium is generated in the atmosphere and decays in the isolated subsurface. Water with tritium concentrations greater than 5 TU is considered to be recent, while water with nondetectable tritium concentrations is considered to be greater than 50 years old (ISGS, 2002). Groundwater collected from shallow Quaternary deposits is recent (TU > 5), while groundwater from the shallow bedrock is older (no tritium detected). The tritium results are consistent with the ^{14}C results, which indicate that the shallow bedrock wells contain an inorganic carbon signature substantially older than that from wells screened in the Quaternary deposits. Groundwater collected from wells screened in shallow bedrock in the vicinity of the NEAP (wells 25, 27, 29, and 30) had estimated ages ranging from 13,920 to 34,610 years based on ^{14}C age dating. This is in

contrast to groundwater collected from wells 26 and 28 (screened in the Quaternary deposits) which had estimated ages of less than 210 years. These results indicated to ISGS that the wells that “draw water from the bedrock are either only slightly connected to or completely isolated from the local groundwater flow system [overlying Quaternary deposits]” (ISGS, 2002).

More recent observations of site conditions support the ISGS’ 2002 conclusion, including the following described in further detail below:

- The lack of groundwater elevation response in BCU wells to precipitation and short-term changes in Middle Fork River stage
- Mostly upward vertical hydraulic gradients in the BCU (and observed artesian conditions in the BCU)
- Differences in vertical hydraulic conductivities between UU and BCU units

Groundwater elevation in the alluvial deposits (UU) typically conforms to ground surface topography and fluctuates in response to changes in river stage and variations in precipitation (Kelron, 2003). Recent data available from pressure transducers installed in the NEAP monitoring wells screened in the UU indicate relatively quick responses (increases and decreases in a period of one month) to changes in river stage and variations in precipitation as illustrated in the hydrograph for wells 70S and 70D (**Appendix A**; note transducer data for other NEAP monitoring wells screened in the UU are not available as these wells are frequently dry). Recent transducer data available from NEAP monitoring wells screened in the BCU did not indicate a response to changes in river stage and variations in precipitation like those in NEAP monitoring wells screened in the UU, only steady increases in a period of one month as illustrated in the hydrograph for wells 22, 70D, and 71D (**Appendix A**; note transducer data is not available for BCU wells 16A and 35D). The lack of increases and decreases in the hydrographs for the BCU wells support a lack of hydraulic connection to the local groundwater flow system in the UU.

The progressively slow steady increase of water levels in the BCU as illustrated in the hydrographs for the BCU wells likely also indicates that groundwater elevations in these wells did not reach static equilibrium following sampling events when groundwater levels were drawn down during purging as a result of the low permeability of the shale. Further, wells 70D and 71D may not have fully recovered from installation and initial well development. Downgradient shallow UU wells 16B (nested with BCU well 16A) and 35S (nested with BCU well 35D) are frequently dry, and downgradient BCU wells 70D (nested with UU well 70S) and 71D (nested with UU well 71S) may not represent static groundwater elevations as previously described; therefore, the following discussion on vertical hydraulic gradient downgradient of the NEAP focuses on data collected by Kelron (2003) as recent data is not sufficient to evaluate vertical hydraulic gradients.

Further, as presented by Kelron (2003), groundwater in the shale (BCU) is at the end of its flow path as it migrates upward into the overlying alluvium (UU) and directly into the Middle Fork in some locations, as illustrated in the cross-section in Figure 28 from Kelron, 2003 and provided in **Appendix D**, preventing the downward migration into the shale of water in contact with CCR materials contained within the NEAP. In 2002, upward vertical gradients were observed between the shale and alluvial deposits at all of the nested wells within the bottomlands of the Middle Fork during at least part of the monitoring period, with the exception of nested wells 23/24 (these evaluations included alluvial deposit and shale wells nests 13B/13A, 16B/16A, 23/24, 26/27, and 28/29). The greatest upward gradients were observed between shallow shale well 13A and

nested deep shale well 32. Deep shale well 32 was also reported to be flowing under artesian conditions during the investigation completed for the 2003 Report. Note that well 35D (installed in March 2017) replaced well 13A, where the greatest upward gradients within the bedrock were observed and reported in the Kelron 2003 report; it is expected that vertical gradients are upward at well nest 35S/35D under normal conditions (static conditions). According to the Kelron 2003 report, high hydraulic heads and artesian groundwater flow conditions were also observed when the coal seam and overlying fractured shale in close proximity to the mined areas were intercepted at exploratory borings B201 and B202 (boring locations shown in Figure 7 of **Appendix D**). Nested wells 16B/16A experienced upward vertical gradients in only one of the eight groundwater level monitoring events in 2002 and the overall eight-month average vertical gradient was downward. As reported in the HCR (Ramboll, 2021a), groundwater elevations measured at BCU well 16A in 2021 ranged from 568.28 to 571.32 feet, which were consistently greater than the elevation of the top of bedrock at location 16A (approximately 566 feet National Geodetic Vertical Datum of 1929 [NGVD]) indicating the presence of upward gradients in the bedrock (nested well 16B was dry in eight monitoring events from March to August 2021). The upward vertical gradients discussed in Kelron, 2003 and the 2021 HCR (Ramboll, 2021a) support that BCU groundwater is hydraulically isolated from the overlying local groundwater flow system in the UU downgradient of the NEAP; groundwater does not flow from the UU downward into the BCU downgradient of the NEAP.

As described in the 2021 HCR (Ramboll, 2021a), the UU and the BCU are distinct water-bearing units based on stratigraphic relationships and hydrogeologic characteristics as described in **Section 2.3**. Field hydraulic conductivity tests indicated that the horizontal hydraulic conductivity for the UU ranged from 7.4×10^{-4} to 1.1×10^0 centimeters per second (cm/s), with a geometric mean of 1.1×10^{-2} cm/s (Ramboll, 2021a). Based on field hydraulic conductivity testing, the horizontal hydraulic conductivity for the BCU ranged from 1.1×10^{-6} to 2.3×10^{-5} cm/s, with a geometric mean of 7.1×10^{-6} cm/s (Ramboll, 2021a). Wells 70D and 71D were installed in 2021 in the BCU, where the hydraulic conductivity of the BCU is relatively low with a geometric mean of 7.09×10^{-6} cm/s. As described previously, water levels at wells 70D and 71D did not likely equilibrate to static water levels following installation and initial well development in 2021 as a result of the low permeability of the shale. Two samples were collected from the UU at two locations (70S and 71S) in the vicinity of the NEAP as part of the 2021 field investigation and the resulting vertical hydraulic conductivities for the samples ranged from 5.2×10^{-4} to 1.3×10^{-3} cm/s. The vertical hydraulic conductivity calculated from tests performed in the laboratory on one shale core ranged from 1×10^{-8} to 5×10^{-8} cm/s (Kelron, 2003). The geometric mean of field hydraulic conductivity tests were four orders of magnitude lower in the BCU when compared to the UU. The laboratory vertical hydraulic conductivity tests were a minimum of four orders of magnitude lower in the BCU when compared to the UU. The significant difference in both horizontal and vertical hydraulic conductivities between the BCU and overlying UU hydrostratigraphic units, as well as the primarily upward vertical gradients identified downgradient of the NEAP, indicate the preferred flow path of groundwater in the UU would be laterally east and discharging into the Middle Fork rather than vertically down into the low permeability BCU, further supporting that groundwater in the BCU is hydraulically isolated from and not influenced by the local groundwater flow system in the UU.

In addition to the spatial location of the wells tested for ^{14}C and tritium relative to the NEAP, the elevations of the well screens and lithology of the age dated wells overlap with the well screen

elevation and lithology of well 70D, which contains the TDS exceedance (**Table B** below), with the exception of MW30, which is screened at a lower elevation than all of the other wells.

Table B. Summary of Bedrock Well Screen Elevations and Lithology

Well ID	Screen Elevation (feet)	Lithology
MW70D – exceedance well	550 to 540	shale bedrock
MW25	560 to 540	shale bedrock
MW27	557 to 537	shale bedrock
MW29	558 to 538	shale bedrock
MW30	519 to 499	shale bedrock

This data demonstrates that bedrock groundwater in the vicinity of the NEAP is only slightly connected or completely isolated from the groundwater in the quaternary deposits and the NEAP is not the source of the TDS exceedance at well 70D.

4. CONCLUSIONS

Based on these four LOEs, it has been demonstrated that the NEAP, OEAP, and NAP are not the source of the TDS GWPS exceedance in well 70D. The TDS exceedance is due to groundwater interactions with the bedrock. The major contributor to TDS in well 70D is chloride.

1. The ionic composition of bedrock groundwater is different than the ionic composition of NEAP, OEAP, and NAP porewater and consistent with published observations for Pennsylvanian Bedrock.
2. Concentrations of Chloride in the NEAP, OEAP, and NAP Porewater are Lower than Those Observed in Groundwater from Compliance Well 70D.
3. A Bedrock Solids and Geochemical Evaluation Identified Naturally Occurring Shales as the Source of Chloride, and thus the TDS Exceedance, at Compliance Well 70D.
4. Bedrock Groundwater is Only Slightly Connected or Completely Isolated from the Groundwater in the Quaternary Deposits Based on Isotopic Analysis, Observed Hydraulic Conditions, and Hydraulic Conductivity of Associated Hydrostratigraphic Units.

This information serves as the written ASD prepared in accordance with 35 I.A.C. § 845.650(e), demonstrating that the TDS exceedance observed at well 70D during the Quarter 1, 2024 sampling event was not due to the NEAP and is attributable to natural groundwater interactions with bedrock. Therefore, assessment of corrective measures is not required for this TDS exceedance at the NEAP.

5. REFERENCES

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FIGURES

PROJECT: 169000XXXX | DATED: 7/10/2024 | DESIGNER: GALARNIMC
Y:\Mapping\Projects\22\2285\MXD\Alt_Sources\Dem\Verillion\NEAP_912\E004\ASD_E004.aprx\Figure 1_NEAP GW Elevations



- COMPLIANCE MONITORING WELL
- BACKGROUND MONITORING WELL
- PORE WATER WELL
- MONITORING WELL
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- PROPERTY BOUNDARY

NOTES:

1. ELEVATIONS IN PARENTHESES MAY HAVE NOT REACHED STATIC EQUILIBRIUM.

2. GROUNDWATER ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).



**NEW EAST ASH POND
GROUNDWATER ELEVATIONS
FEBRUARY 19, 2024**

**ALTERNATIVE SOURCE DEMONSTRATION
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS**

FIGURE 1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.





- COMPLIANCE MONITORING WELL
- BACKGROUND MONITORING WELL
- PORE WATER WELL
- MONITORING WELL
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- PROPERTY BOUNDARY

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).



**NORTH ASH POND AND OLD EAST ASH POND
POTENTIOMETRIC SURFACE MAP
FEBRUARY 19, 2024**

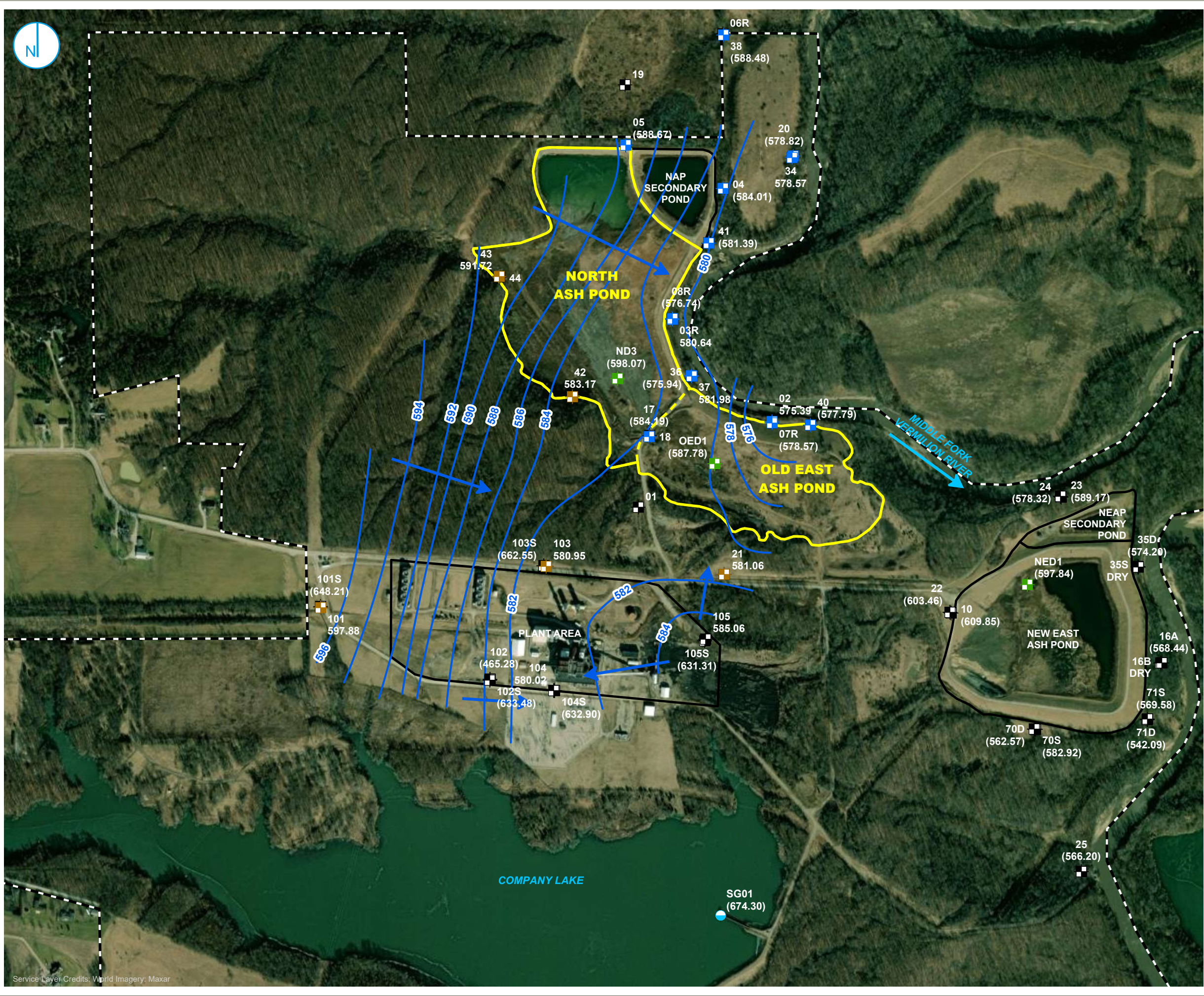
**ALTERNATIVE SOURCE DEMONSTRATION
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS**

FIGURE 2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



PROJECT: 169000XXXX | DATED: 7/8/2024 | DESIGNER: GALARNMC
Y:\Mapping\Projects\222285\MXD\Alt_Source_Dem\Vermilion\NEAP_912\E004\ASD_E004.aprx\Figure 3_VER 910 911 NAPs OEAP PMP Pot Surface 20240219



- COMPLIANCE MONITORING WELL
- BACKGROUND MONITORING WELL
- PORE WATER WELL
- STAFF GAGE, RIVER
- MONITORING WELL
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- GROUNDWATER FLOW DIRECTION
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- PROPERTY BOUNDARY

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 300 600
Feet

**POTENTIAL MIGRATION PATHWAY
LOWER GROUNDWATER UNIT
POTENTIOMETRIC SURFACE MAP
FEBRUARY 19, 2024**

**ALTERNATIVE SOURCE DEMONSTRATION
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS**

FIGURE 3

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

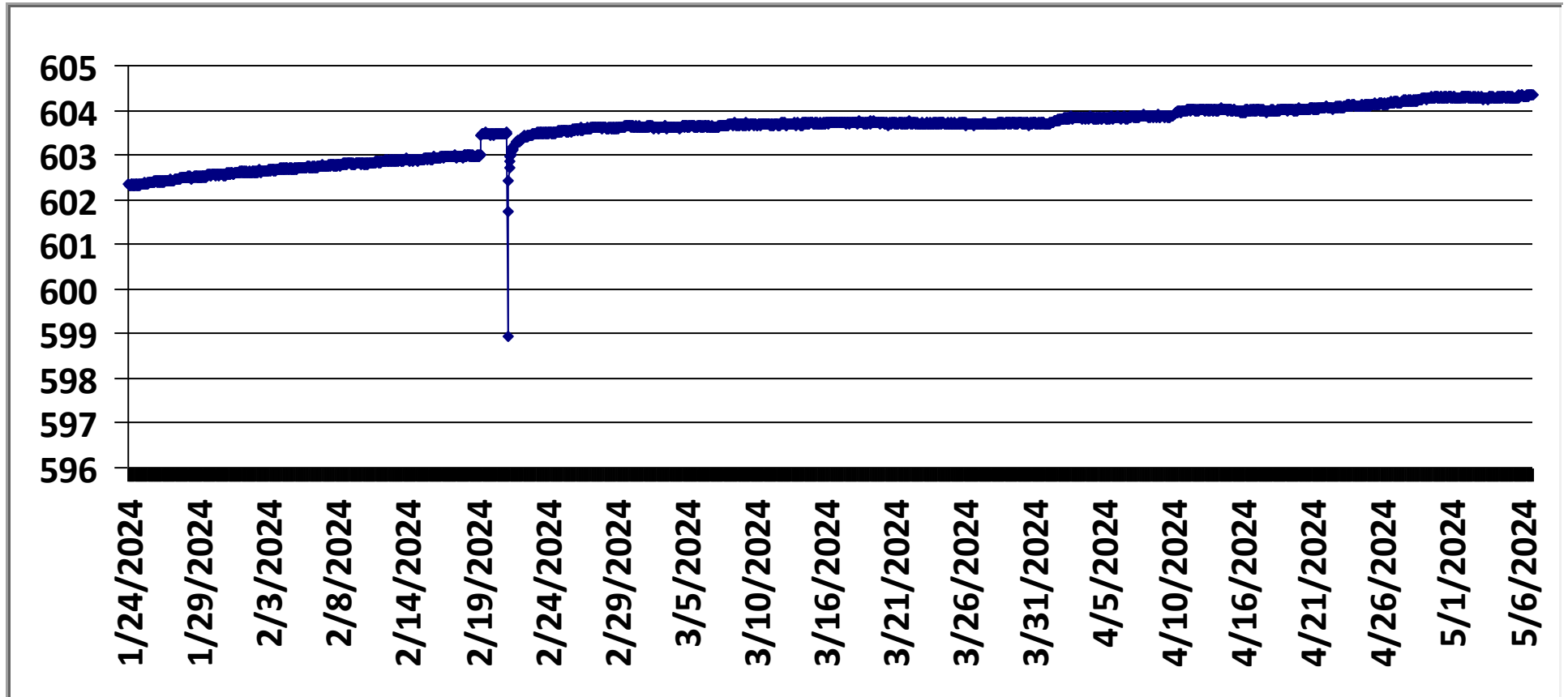


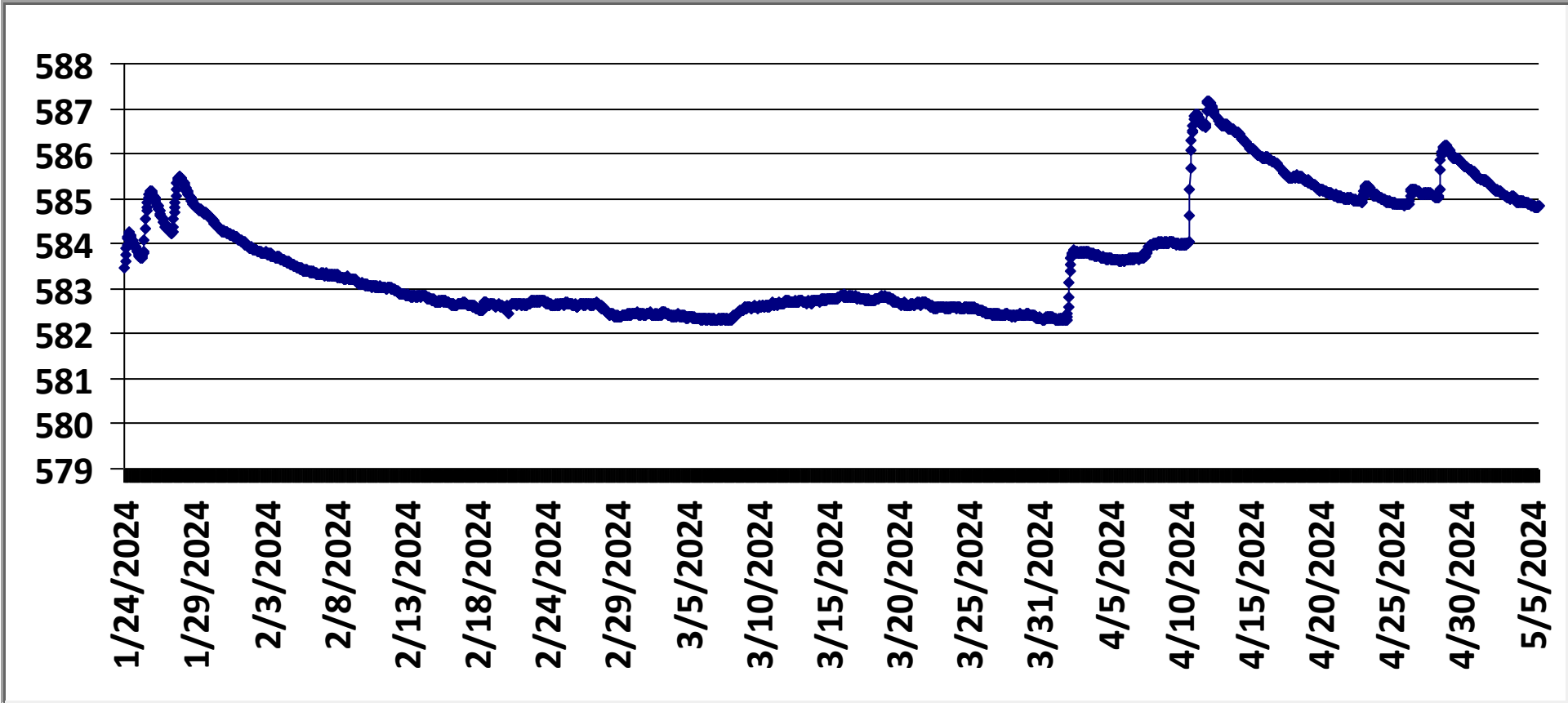
APPENDICES

**APPENDIX A
PLOTS OF GROUNDWATER ELEVATION DATA FROM
PRESSURE TRANSDUCERS INSTALLED IN MONITORING
WELLS 22, 70S, 70D, 71S, AND 71D**

VER_022

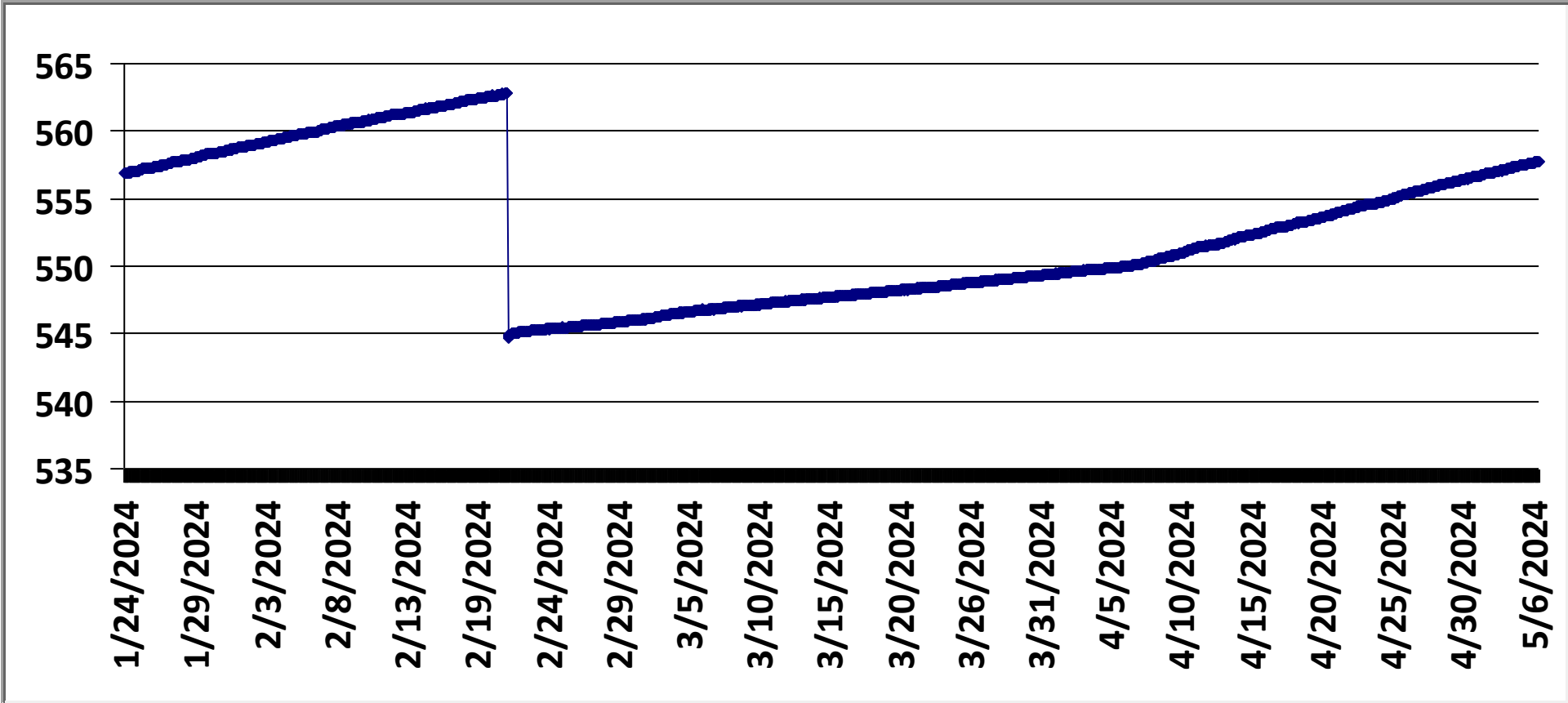
21739726





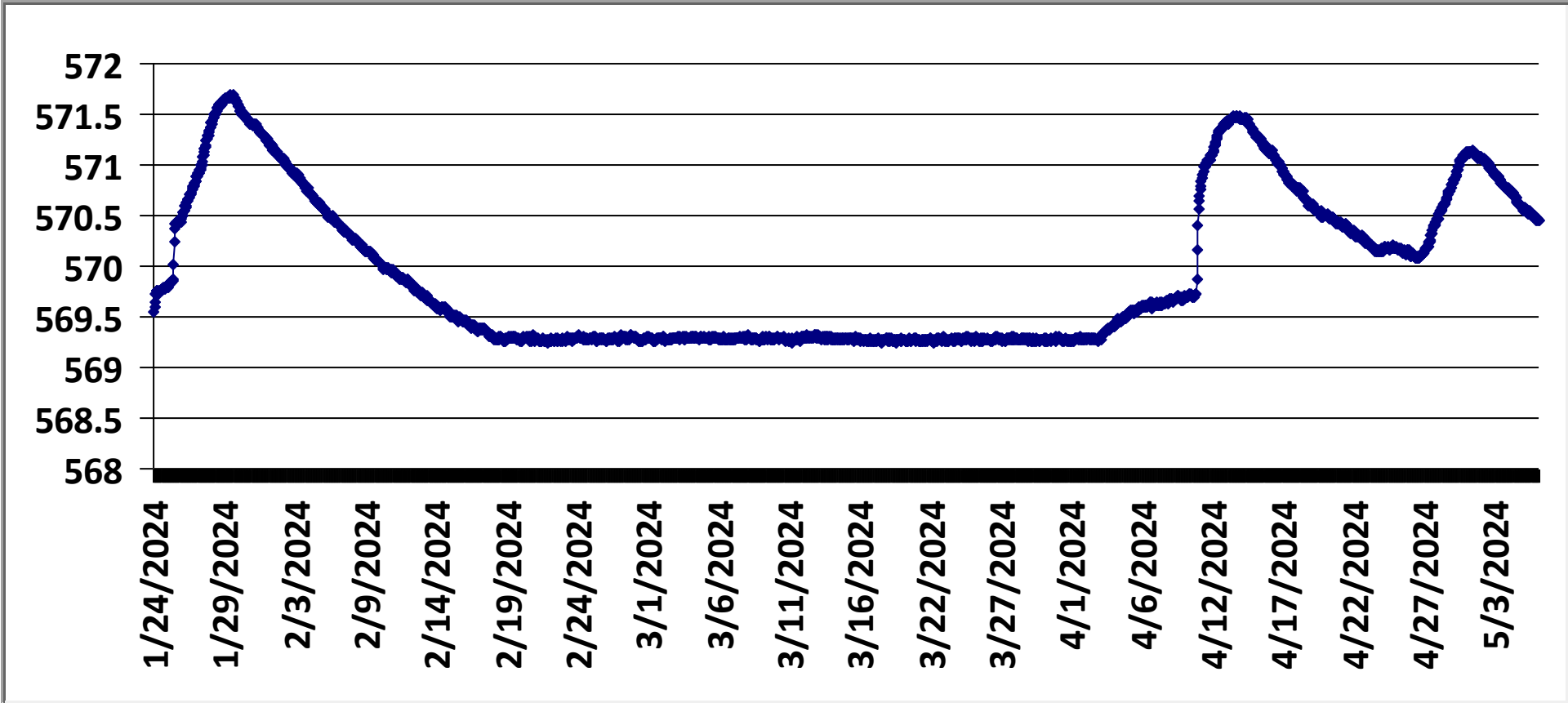
Groundwater Level Data

TIME SERIES



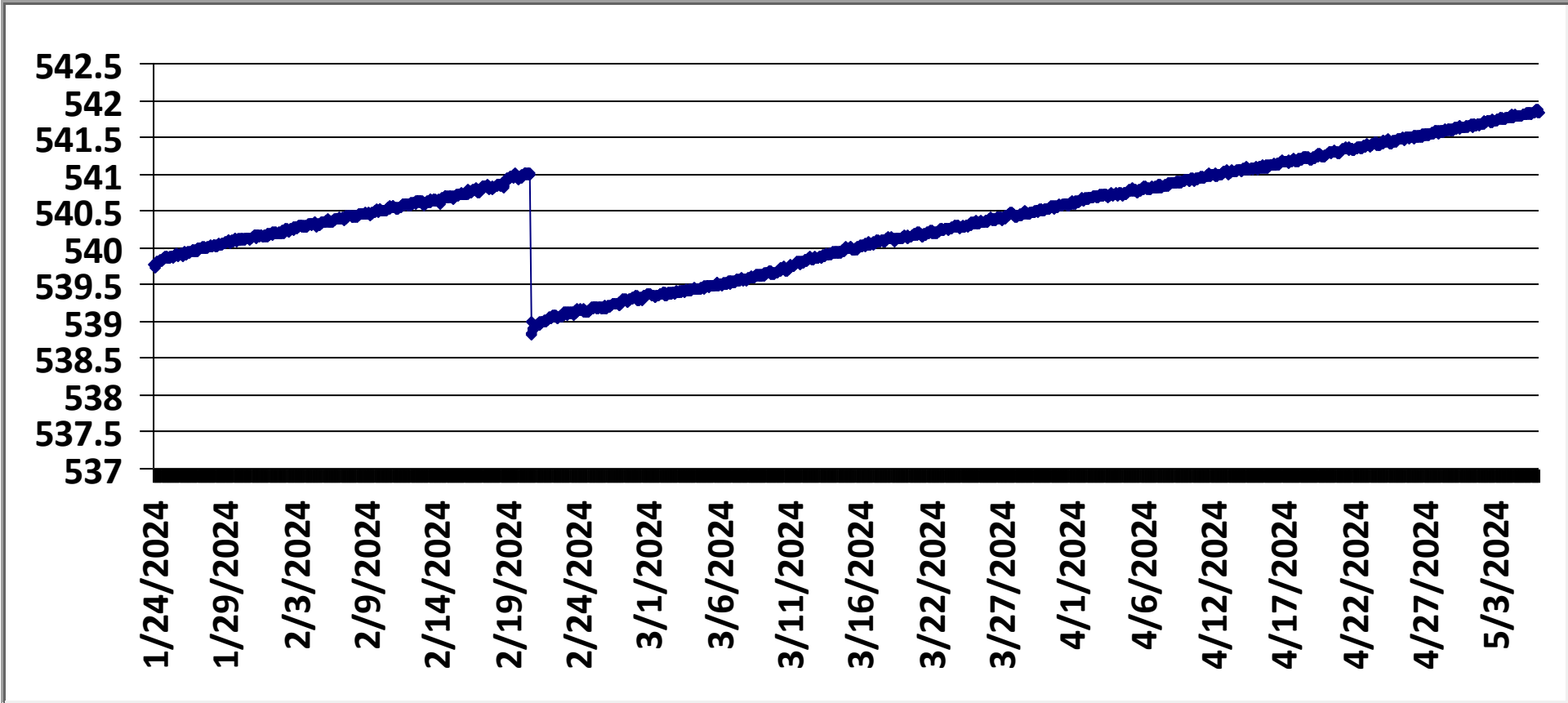
Groundwater Level Data

TIME SERIES



Groundwater Level Data

TIME SERIES

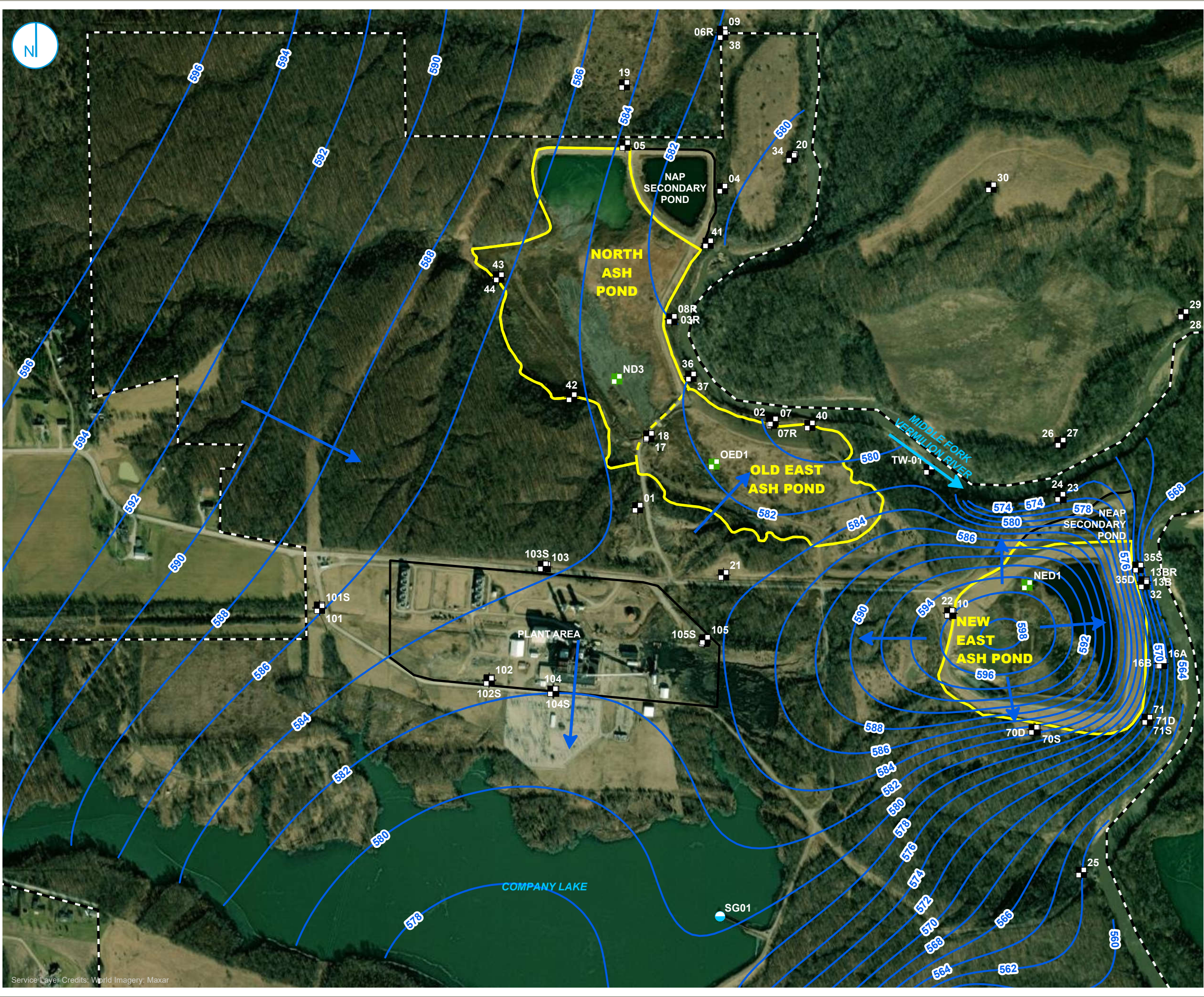


Groundwater Level Data

TIME SERIES

**APPENDIX B
SIMULATED BEDROCK CONFINING UNIT
POTENTIOMETRIC SURFACE CONTOURS FROM THE
JANUARY 2022 CONSTRUCTION PERMIT APPLICATION
FOR THE NORTH ASH POND AND OLD EAST ASH POND**

PROJECT: 169000XXXX | DATED: 7/8/2024 | DESIGNER: GALARNMC
Y:\Mapping\Projects\2212285\MXD\Alt_Source_Dem\Verillion\NEAP_912\E004\ASD_E004.aprx\Appendix A_Simulated BCU Contours VER NAP OEAP GMR



- MONITORING WELL
- PORE WATER WELL
- STAFF GAGE, LAKE
- SIMULATED POTENTIOMETRIC SURFACE ELEVATION (FEET)
- GROUNDWATER FLOW DIRECTION
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- PROPERTY BOUNDARY

NOTES:
1. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 300 600
Feet

**SIMULATED BEDROCK CONFINING UNIT
POTENTIOMETRIC SURFACE CONTOURS
FROM THE CONSTRUCTION PERMIT
APPLICATION FOR THE NORTH ASH
POND AND OLD EAST ASH POND**

**ALTERNATIVE SOURCE DEMONSTRATION
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS**

APPENDIX B

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



**APPENDIX C
GEOSYNTEC CONSULTANTS, 2024. TECHNICAL
MEMORANDUM: EVALUATION OF ALTERNATIVE
SOURCES FOR TOTAL DISSOLVED SOLIDS WITHIN
BEDROCK AQUIFER SOLIDS, VERMILION POWER PLANT -
NEW EAST ASH POND. JULY 10, 2024.**

TECHNICAL MEMORANDUM

Date: July 18, 2024

To: Brian Voelker, Dynegy Midwest Generation, LLC

Copies to: Stu Cravens and Phil Morris, Dynegy Midwest Generation, LLC
Eric Tlachac and Brian Hennings, Ramboll

From: Allison Kreinberg, Geosyntec Consultants

Subject: Evaluation of Alternative Sources for Total Dissolved Solids within Bedrock Solids
Vermilion Power Plant – New East Ash Pond

This document serves as an Appendix to the July 24, 2024, Alternative Source Demonstration (ASD) for the Vermilion Power Plant New East Ash Pond (NEAP) (Site) for the Quarter 1 2024 sampling event completed to fulfill the requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.650(e) (VER NEAP E004 ASD).

The Q1 2024 sampling event identified an exceedance of the GWPS for TDS at monitoring well 70D (Ramboll 2024a). The statistical result for TDS at well 70D was calculated to be 1,270 mg/L, which exceeds the GWPS of 1,200 mg/L. Geosyntec Consultants, Inc. (Geosyntec) has completed a review of geochemical and geologic conditions at the Site to evaluate the elevated TDS values observed in groundwater at compliance monitoring well 70D. Using evidence from laboratory analyses, statistical evaluations, and the depositional history of the geologic units at the Site, this technical memorandum demonstrates that naturally occurring major ion concentrations associated with bedrock underlying the Site are the likely source of the TDS statistical exceedance in Site groundwater.

SITE CONDITIONS

Site geology consists primarily of unlithified alluvial and glacial deposits overlying shale bedrock that contains a major coal seam mined in the region. The alluvial deposits consist of the Cahokia Alluvium composed primarily of sand with occasional layers of silty clay and the Upper Till Unit (Wedron Formation and Glasford Formation Till) consisting of clay and silty clay with occasional

sand lenses. The Cahokia Alluvium comprises the Upper Unit (UU) at the NEAP and is generally 10 to 25 feet thick. Below this unit is the Upper Confining Unit (UCU) that is comprised of the lower permeability Wedron and Glasford Formations. The UCU is of variable thickness, ranging from up to 100 feet west of the NEAP and absent east of the NEAP (Ramboll 2021).

The Bedrock Confining Unit (BCU), which is typically greater than 80 feet thick, consists of the Pennsylvanian-age Shelburn Formation, which is primarily a low permeability shale with thin limestone, sandstone, and coal beds. The top of the shale unit in the vicinity of the NEAP is described as highly weathered and decomposed. This unit contains the Danville (No. 7) Coal, which was encountered near the NEAP at approximately 80 to 100 feet below ground surface (ft bgs). Well 70D is screened within the BCU.

Additional information regarding Site hydrogeology and stratigraphy is provided in the ASD prepared by Ramboll.

NATURAL VARIABILITY OF TOTAL DISSOLVED SOLIDS

Aquifer solids samples were collected from soil borings VER-35 and VER-70 advanced in June 2023 near compliance wells 35D and 70D (**Figure 1**). Field boring logs for these soil borings are provided in **Attachment 1** and boring logs for monitoring wells 35D and 70D are provided in **Attachment 2**. Due to access limitations and health and safety considerations at the Site, the boring locations were adjusted in the field and are approximately 200-250 feet offset from the well locations. Differences in ground surface elevations and bedrock dip were considered during drilling and sample selection so that the sampled intervals correspond with the well screen interval for wells 35D and 70D. Boring locations and well screen intervals are shown in the cross sections provided in **Attachment 3**. Two samples were collected from the boring near well 35D (VER-35), and three samples were collected from the boring near well 70D (VER-70) at various depths.

Samples were submitted for analysis of mineralogy via X-ray diffraction (XRD) to determine the mineralogical components of shale samples.¹ Whole rock mineralogy results are provided in **Table 1** and **Attachment 4**. Sample mineralogy consists of quartz, mica (muscovite), feldspars (albite and microcline), iron-carbonate mineral siderite, and clay minerals (illite, chlorite, and kaolinite) (**Table 1**). Shale samples were found to contain between 43.0 to 47.4 percent (%) phyllosilicate (clay and mica) minerals by weight.

¹ Two samples from the unlithified units from VER-70 (30-40 ft bgs) and (41-42 ft bgs) are excluded from subsequent results tables and discussion to emphasize findings associated with shale lithologies in support of an assessment of naturally occurring chloride in bedrock.

Monitoring well 70D is screened within shale of the Shelburn formation. The Shelburn formation, like many of the Pennsylvanian-age deposits within the Illinois Basin, represents marine cyclic depositional sequences which feature transgressive and regressive periods that cause the deposition of interbedded sequences of sandstone, shale, and limestone (Weller 1930; Weller 1931). In such depositional environments, fine grained shales are deposited and cyclically exposed to high ionic strength marine waters which are concentrated in major cations and anions. Fine-grained marine shales specifically are known to retain these aqueous parameters for long periods, resulting in elevated concentrations of major ions in formation water (Hem 1985).

Transgression-regression cycling creates sequences in which saline marine waters saturate open pore space in these sediments, which are then retained due to the subsequent deposition of and burial by additional fine-grained sediment, trapping the marine water at the time of deposition. While the original water within the pore space is typically replaced by meteoric recharge early after deposition, the dissolved ions in the water are typically retained by membrane filtration as an effect of the phyllosilicate (clay/mica) mineralogy of the shales (Drever 1988). These clay and mica minerals are observed in all shale samples from the Site at notable quantities of 43.0 through 47.4 weight % (**Table 1**), suggesting this mechanism is applicable to groundwater at the Site. In addition to the retention of marine water within the pore space of fine-grained sedimentary rocks, deposited sediment in cyclic marine environments also may become impregnated with soluble salts like halite (crystalline sodium chloride, NaCl), sylvite (crystalline potassium chloride, KCl), or anhydrite/gypsum (crystalline calcium sulfate CaSO₄). These evaporites are known to be highly soluble and subject to dissolution during pore fluid evolution. Dissolution of these salts results in further increases in the concentrations of aqueous ions in pore fluid from rocks of coastal marine origin, regardless of whether the evaporite minerals are still present currently.

Well 70D contains TDS concentrations exceeding the GWPS. TDS is the summation of all dissolved constituents in a water sample, with major ions comprising the majority of TDS in most natural waters (Boyd 2019). Unlike specific parameters, TDS does not have a singular source but rather is influenced by concentrations of individual components of groundwater composition. At well 70D, chloride comprises the largest component of the TDS value, with chloride comprising 41% of TDS for well 70D (Figure A of the Ramboll ASD document).

Seeps with high naturally occurring salinity (i.e., brines) are known to occur in southern Illinois. These seeps contain relatively high concentrations of major ions such as chloride, which comprises large portions of TDS concentrations in NEAP groundwater. These seeps are known to be of geogenic origin and demonstrate the degree of variability associated with major ion chemistry in the region. Samples of seeps and shallow wells affected by brine in Illinois had highly variable chloride concentrations ranging from ~100 mg/L up to more than 30,000 mg/L at the Vermilion Salines in Kickapoo Creek State Park (Kelly et al. 2012). These observed concentrations further

support the prominence of elevated naturally occurring chloride, and thus TDS, within groundwater from Pennsylvanian aquifer units in the region due to the depositional history of these units. Additional studies have documented the connection between basin brine movement along geologic structures and through permeable strata to saline seeps in alluvial material throughout the Illinois Basin, with seeps containing highly saline chemistry with TDS values in excess of 60,000 mg/L driven primarily from sodium, chloride, and sulfate concentrations (Panno et al. 2022). These studies demonstrate the degree of connectivity between highly saline basin formation waters and surficial material such as the Cahokia Alluvium. In these instances, the TDS concentrations of both Illinois Basin groundwater and water within alluvial material (which combined comprise the groundwater beneath the NEAP) in the area contain elevated TDS values that are associated with natural salinity derived from the depositional history of strata in the region.

STATISTICAL EVALUATION OF GROUNDWATER COMPOSITION

Advanced statistical analyses were employed to evaluate the similarity or dissimilarity among different groundwater samples or groups based on a broad suite of analytes. Dimensional reduction techniques, such as principal component analysis (PCA), are especially effective in identifying the analytes responsible for statistical differences between samples and revealing underlying patterns related to environmental factors, contamination sources, or other natural characteristics of the Site. Clustering methods were further utilized to group samples based on their combined chemical composition through maximizing intra-group similarity.

PCA is often used to simplify large datasets with multiple variables by creating new uncorrelated variables known as principal components (PCs). The PCs are linear combinations of the original variables; the first few PCs typically capture most of the variation within the dataset. Factor loadings are calculated based on the correlation between PCs and the original variables. As such, variables with notably higher positive or negative factor loadings are main drivers of similarity or dissimilarity and clustering of samples. Factor scores are calculated based on the correlation between the chemical composition of each sample and the PCs. Samples with similar chemical compositions show similar factor scores and tend to cluster together on a PCA plot.

In this study, the dataset used for PCA included 90 groundwater samples collected in 2021, 2023 and 2024 from upgradient wells (10 and 22), downgradient wells (70S, 71S, 70D, 71D, 16A, and 35D), and a NEAP porewater wells (NED1), ND3 and OED1).² Samples were also included from two porewater wells associated with the Old East Ash Pond/North Ash Pond (OEAP/NAP) CCR unit (ND3, OED1) to evaluate the potential influence of the OEAP/NAP on groundwater

² Analytes included in this PCA include alkalinity, boron, calcium, pH, barium, chloride, and fluoride. The complete dataset used for PCA analysis is provided with this submission as **Attachment 5**.

composition at NEAP downgradient well 70D. The CCR porewater chemistry from both the NEAP and OEAP/NAP is significantly different from that of the monitoring wells (e.g., boron concentration in porewater was 28.73 ± 12.19 mg/L compared to 2.02 ± 4.24 mg/L in the rest of the wells). Therefore, the total variability in the dataset is expected to be dominated by the greater variance of CCR signatures between pore water and the rest of the wells, potentially obscuring the variabilities in samples from monitoring wells. As such, two parallel scenarios – one with and one without porewater samples - were evaluated.

The results from the evaluation with porewater are discussed first and shown in **Figures 2 to 4**. PCA requires that input variables have similar scales of measurement and variances. As such, data were standardized by mean-centering and scaling to unit variance prior to performing PCA. Data were further square transformed to reduce the skewness of dataset. The fraction of total variation explained by each PC is shown in **Figure 2a**, with the first two PCs accounting for approximately 85% of the total variation in the datasets. Additionally, the quality of representation of each variable by the first two PCs is presented in **Figure 2b**. As illustrated in the figure, the first dimension is dominated by calcium, bicarbonate alkalinity, and boron, while the second dimension is dominated by chloride and barium.

PCA results are often visualized using biplots where samples are projected on the first two PCs (i.e., factor scores), and factor loadings are represented as vectors. The closer the data points are on the graph, the greater the similarity in their chemical composition. The result from this study is shown on **Figure 3**, where the samples acquired from the BCU are orange, UCU and UU samples are shades of blue, and the porewater samples are gray. The biplot suggests that porewater samples cluster separately from the groundwater samples in all hydrostratigraphic units (i.e., BCU, UCU, and UU samples). The factor loadings, represented as vectors on the biplot, suggest that constituents such as boron and calcium are responsible for the chemical signature of the porewater cluster.

Clustering was further explored using Ward's hierarchical clustering method, a distance measure employed in agglomerative algorithms and commonly applied in hydrogeochemical studies. The analysis was performed on a scaled and centered dataset. The results from clustering (**Figure 4**), align with findings from the PCA (**Figure 3**). Both PCA and clustering analysis supported the distinction between porewater samples and groundwater samples from both downgradient and upgradient locations.

The results of the evaluation without porewater samples included are shown in **Figures 5 to 7**. In this scenario, the first two principal components captured approximately 76% of total variance (**Figure 5a**), with fluoride and chloride dominating the first dimension and bicarbonate alkalinity dominating the second dimension (**Figure 5b**). The biplot is presented on **Figure 6**, which shows

that the BCU samples are clustered separately from the combined UCU and UU samples. Clustering was also performed for this second analysis, as shown in **Figure 7**, with the results indicating upgradient and downgradient samples from the BCU cluster separately from the combined UCU and UU samples. This PCA analysis and clustering suggested that lithology is the main driver for the chemistry of groundwater samples. Overall, the results of the PCA and clustering analyses from different scenarios support the conclusion that the TDS exceedance at 70D is not attributed to the CCR unit and instead the groundwater geochemistry is influenced primarily by the native lithology.

Due to anomalously high sulfate concentrations in well 35D (Ramboll 2023), sulfate and TDS were excluded from both multivariate analyses described above. Two additional scenarios which included sulfate and TDS but exclude 35D samples are presented in **Attachment 6**. As before, the evaluation included one analysis with porewater samples and one without porewater samples included. The findings were consistent with the multivariate analyses described, in that groundwater composition is influenced by native lithology.

CONCLUSION

TDS concentrations at well 70D were determined to be the result of naturally occurring chloride. The TDS and chloride concentrations are likely from original formation water in the aquifer unit which contains notable major ion concentrations sourced from the depositional conditions of the BCU. XRD analysis of solid phase samples collected near BCU wells 35D and 70D identified abundant micas and clay minerals hosted in the shale bedrock that facilitate the retention of elevated concentrations of major ions resulting from depositional conditions, such as chloride. Advanced statistical methods demonstrate that groundwater geochemical signatures from the BCU, the UCU, and the UU are distinctly different from that of the porewater based on a combination of parameters.

This information serves as the written ASD demonstrating that the GWPS exceedance of TDS at well 70D is not due to the NEAP CCR unit.

REFERENCES

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TABLES

**Table 1 - Summary of X-Ray Diffraction Analysis
Vermillion Power Plant - New East Ash Pond**

Geosyntec Consultants, Inc.

Field Boring Location			VER-35	VER-35	VER-70
Sample Depth (ft bgs)			(55-60)	(60-63)	(75-80)
Location			Downgradient	Downgradient	Downgradient
Field Boring Log Description			Weathered Shale	Highly Weathered Shale	Highly Weathered Shale
Mineral/Compound	Formula	Mineral Type	(wt %)	(wt %)	(wt %)
Quartz	SiO ₂	Silicate	38.5	38.1	35.0
Muscovite	KAl ₂ (AlSi ₃ O ₁₀)(OH) ₂	Mica	23.4	23.0	27.0
Albite	NaAlSi ₃ O ₈	Feldspar	12.6	12.6	11.5
Illite	K(Al,Mg,Fe) ₂ (Si,Al) ₄ O ₁₀ (OH) ₂	Clay	7.1	8.0	5.2
Chlorite	(Fe,(Mg,Mn) ₅ ,Al)(Si ₃ Al)O ₁₀ (OH) ₈	Clay	6.9	6.8	7.7
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	Clay	5.6	5.4	7.5
Siderite	FeCO ₃	Carbonate	4.9	5.0	5.4
Microcline	KAlSi ₃ O ₈	Feldspar	1.0	1.1	0.70
Clay Minerals Total			19.6	20.2	20.4
Clays + Muscovite Total			43.0	43.2	47.4

Notes

Sample depth is shown in feet below ground surface (ft bgs).

wt %: percentage by weight

FIGURES

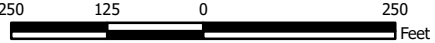


Legend

-  Monitoring Well
-  Boring Location
-  New East Ash Pond (NEAP)
-  NEAP Secondary Pond

Notes

- Soil boring locations are approximate.
- Only select monitoring well locations are shown.
- Ash pond boundaries are approximate.



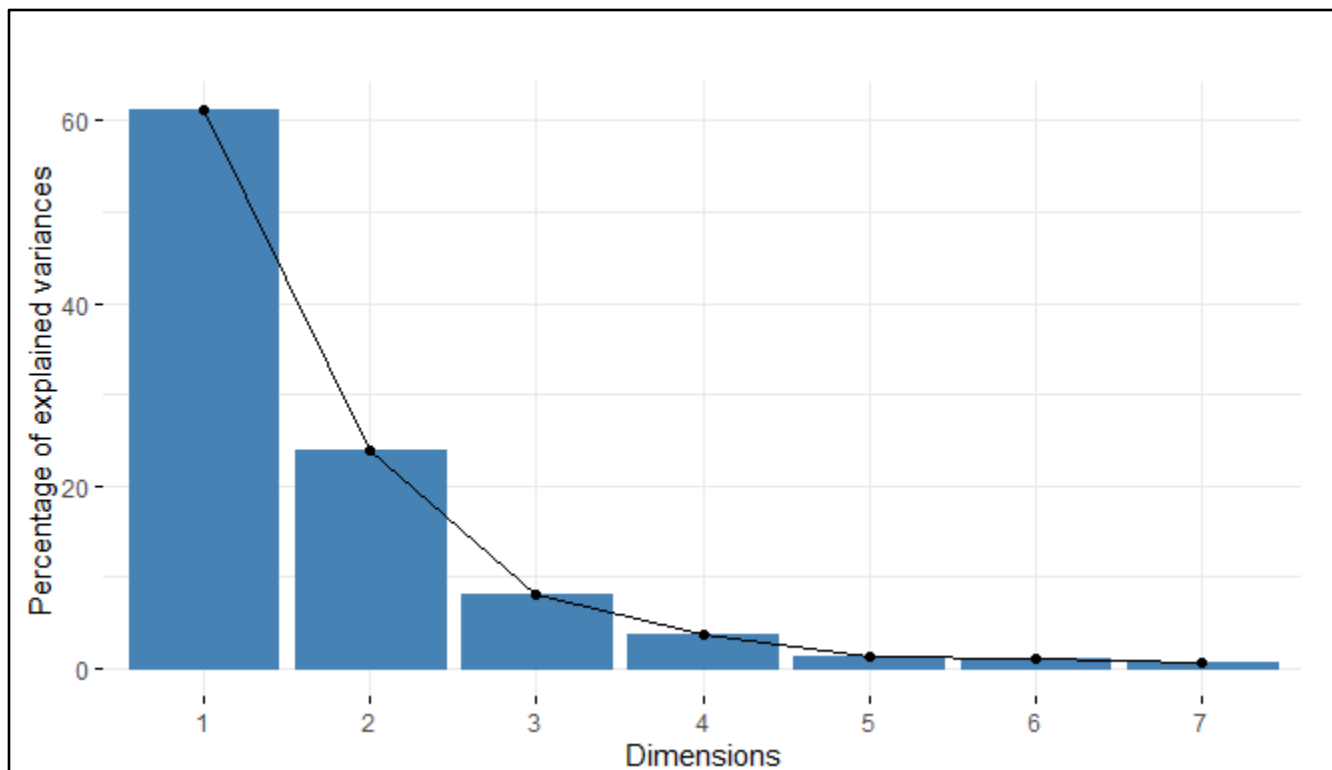
Boring Locations

Dynegy Midwest Generation
Vermilion Site
Oakwood, Illinois

Geosyntec
consultants

Columbus, Ohio April 2024

Figure
1



Notes:

1. Samples collected from upgradient wells 10 and 22, downgradient wells 70S, 71S, 16A, 35D, 70D, and 71D, and porewater wells NED1, ND3 and OED1 were included in the evaluation.

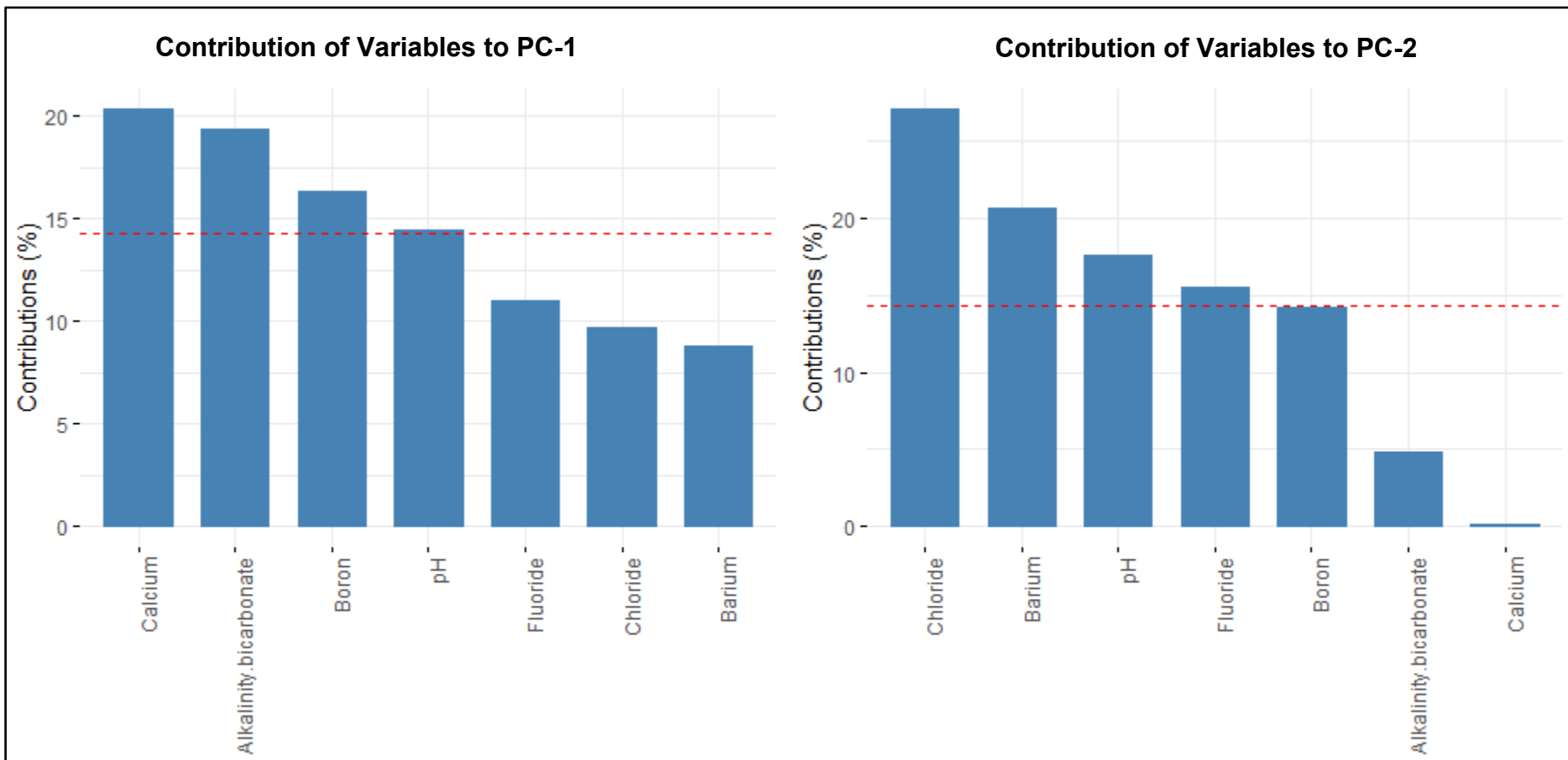
PCA Analysis - Quality of Representation of Principal Components
Vermilion Power Plant – New East Ash Pond

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July 2024

Figure
2a



Notes:

1. The dashed red line represents the anticipated value for uniform contribution. The constituents with a contribution exceeding the reference line are considered significant in its contribution to each PC (principal component).

Contribution of Variables to First Two Principal Components

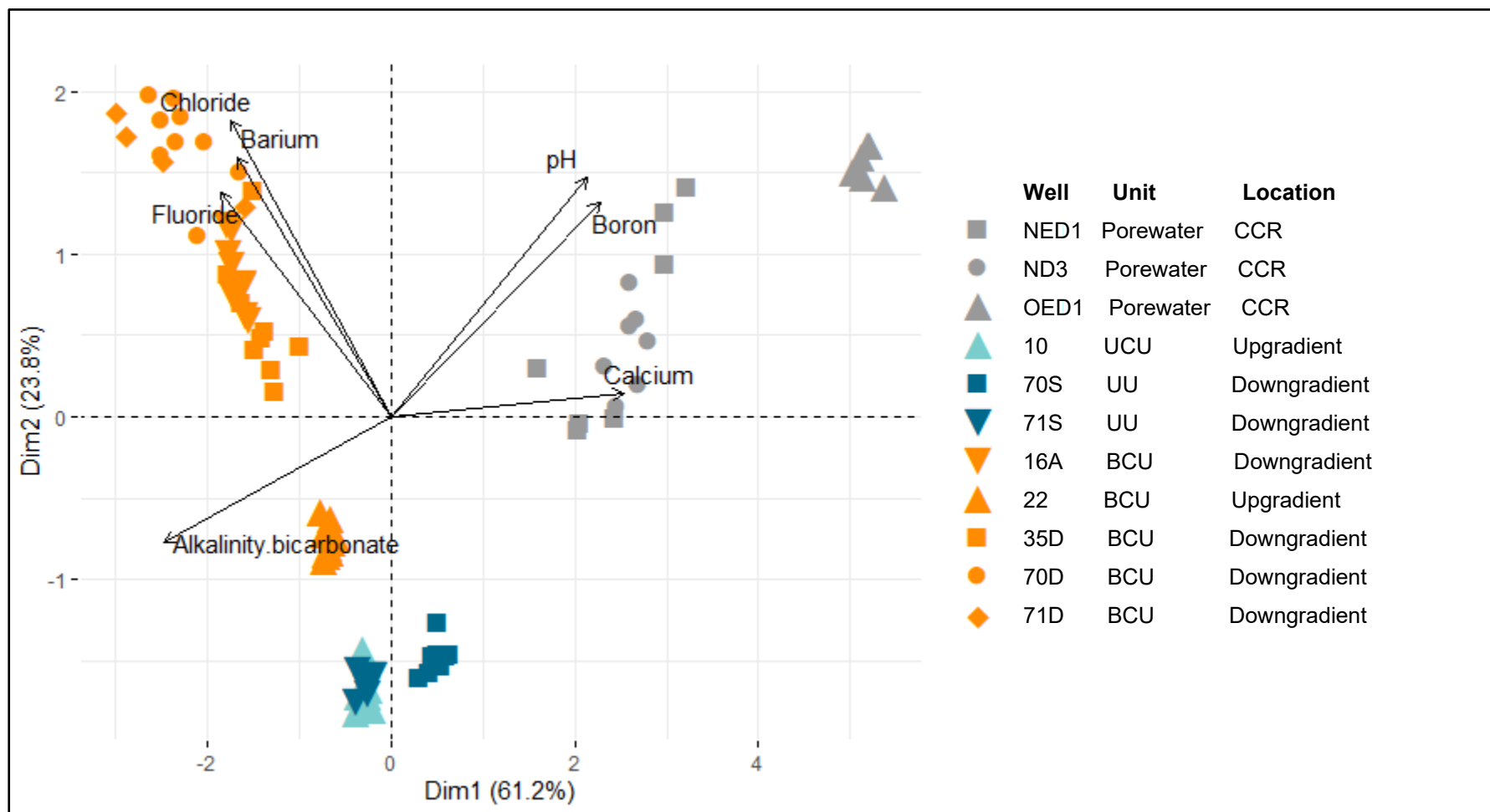
Vermilion Power Plant – New East Ash Pond

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Figure
2b

Columbus, Ohio

July 2024



Notes:

- The arrows signify the correlations between the constituents and the principal components.
- Datapoints are colored based on hydrostratigraphic unit of sampling locations as follows:
 - Bedrock Confining Unit (BCU) wells: 16A, 22, 35D, 70D, 71D.
 - Upper Confining Unit (UCU) well: 10.
 - Upper Unit (UU) wells: 70S, 71S.
 - Coal Combustion Residual (CCR) wells: NED1, ND3, OED1.

Principal Components Analysis Biplot

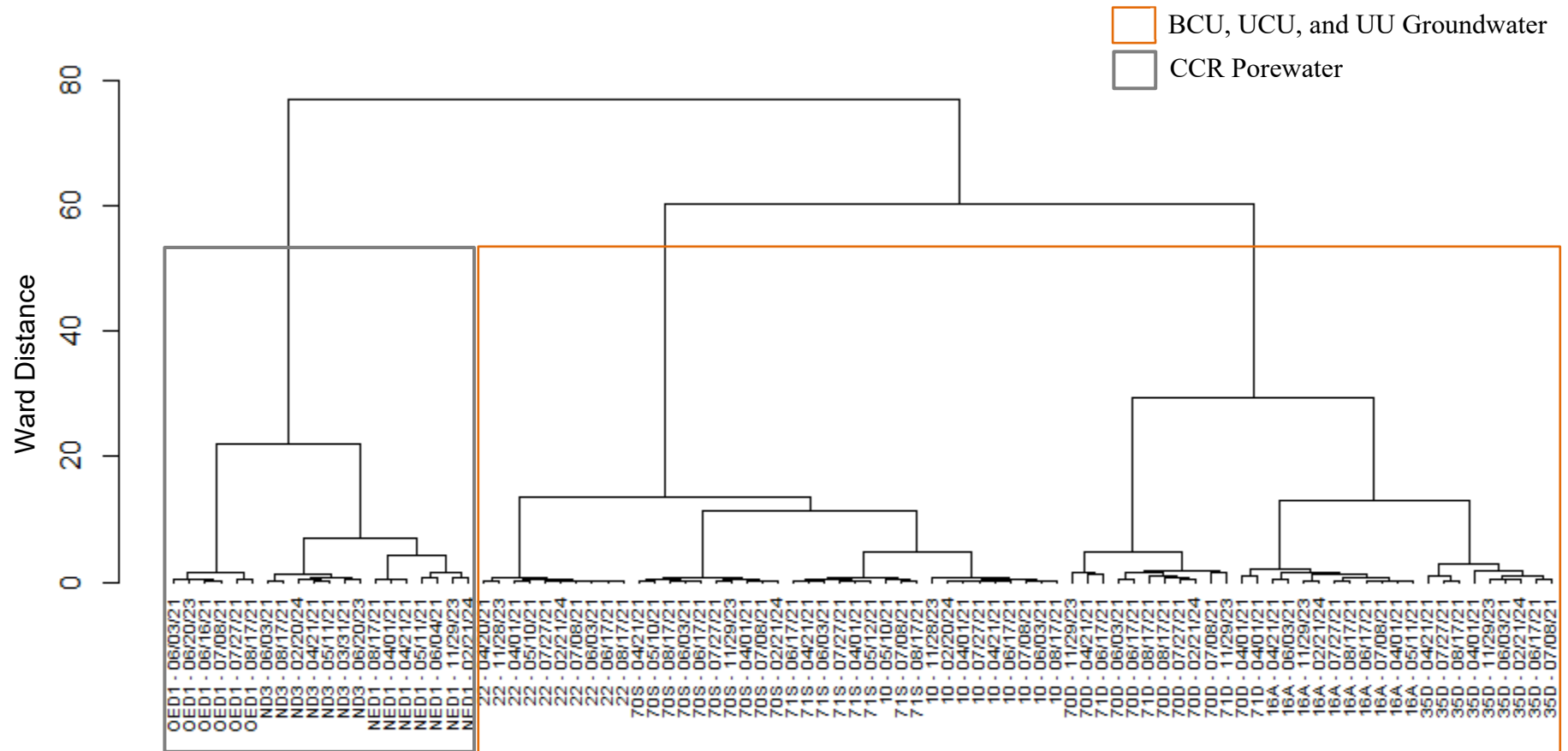
Vermilion Power Plant – New East Ash Pond

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Figure
3



Notes:

1. The cluster analysis used Euclidean distances, and Ward's method as the clustering algorithm.
2. In the dendrogram, samples on the same branch are more similar to each other. The samples with the highest similarity are on the closest branches.
3. The boxes around the branches represent the two clusters into which samples from each source grouped.
4. BCU, CCR, UCU and UU refer to Bedrock Confining Unit, Coal Combustion Residual, Upper Confining Unit, and Upper Unit, respectively.

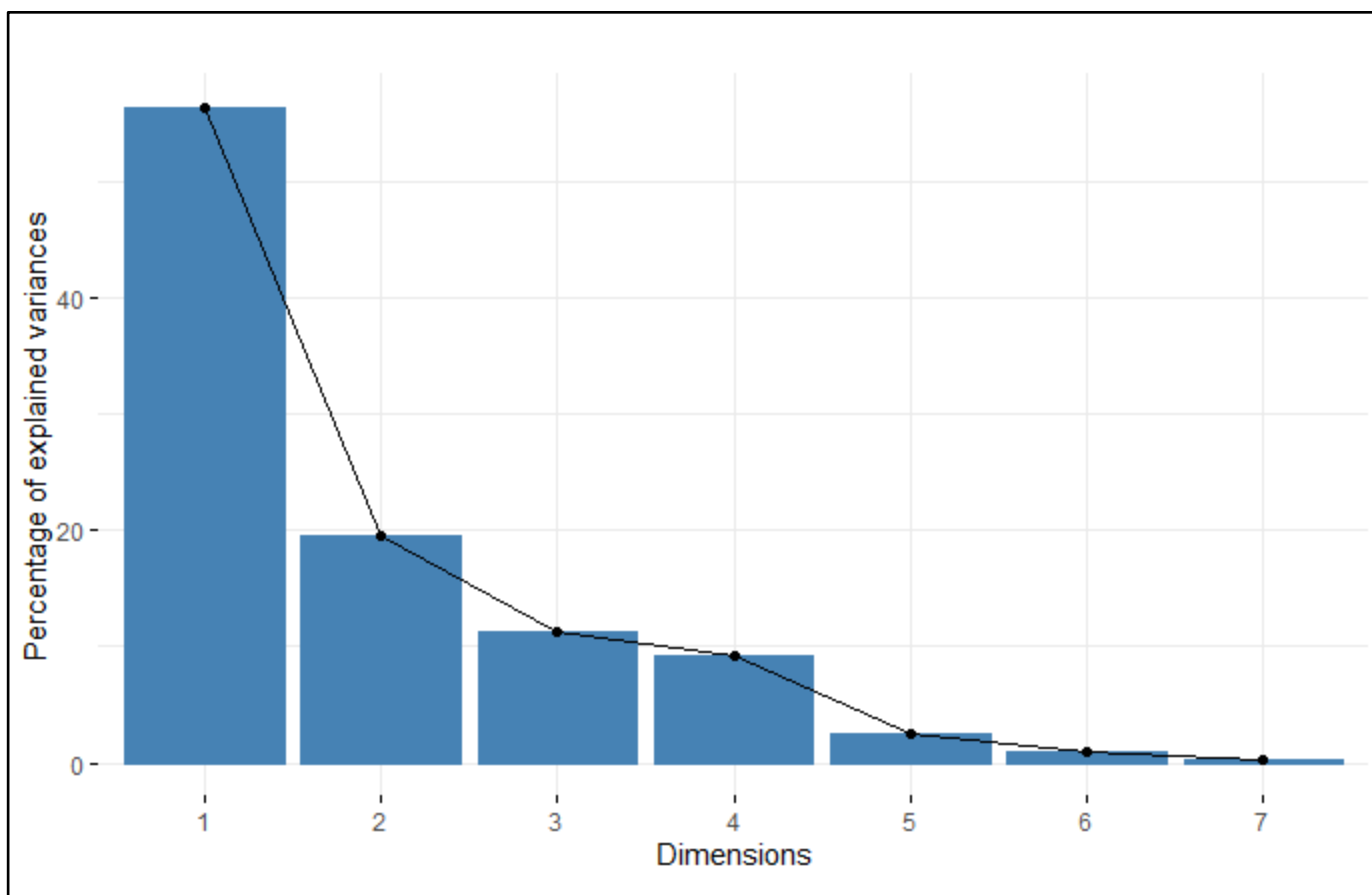
**Dendrogram Graph from Cluster Analysis
MW-35 Excluded**

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**Figure
4**



Notes:

1. Samples collected from upgradient wells 10 and 22 and downgradient wells 70S, 71S, 16, 35D, 70D, and 71D were included in the evaluation.

PCA Analysis - Quality of Representation of Principal Components (Porewater Excluded)
Vermilion Power Plant – New East Ash Pond

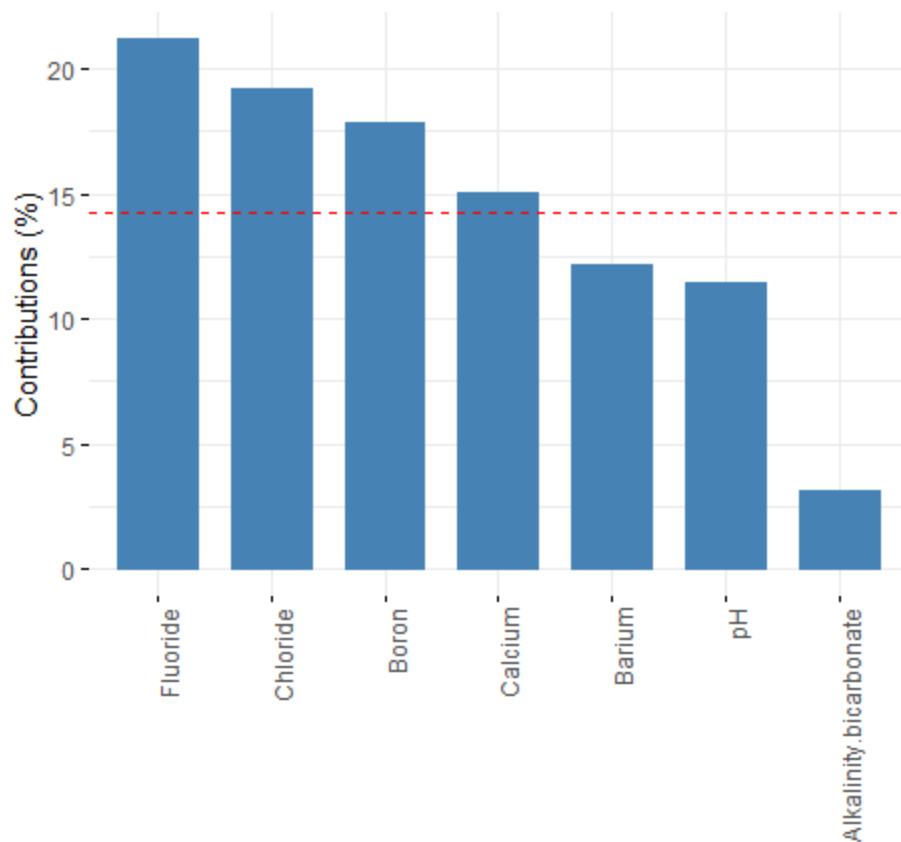
Geosyntec
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Columbus, Ohio

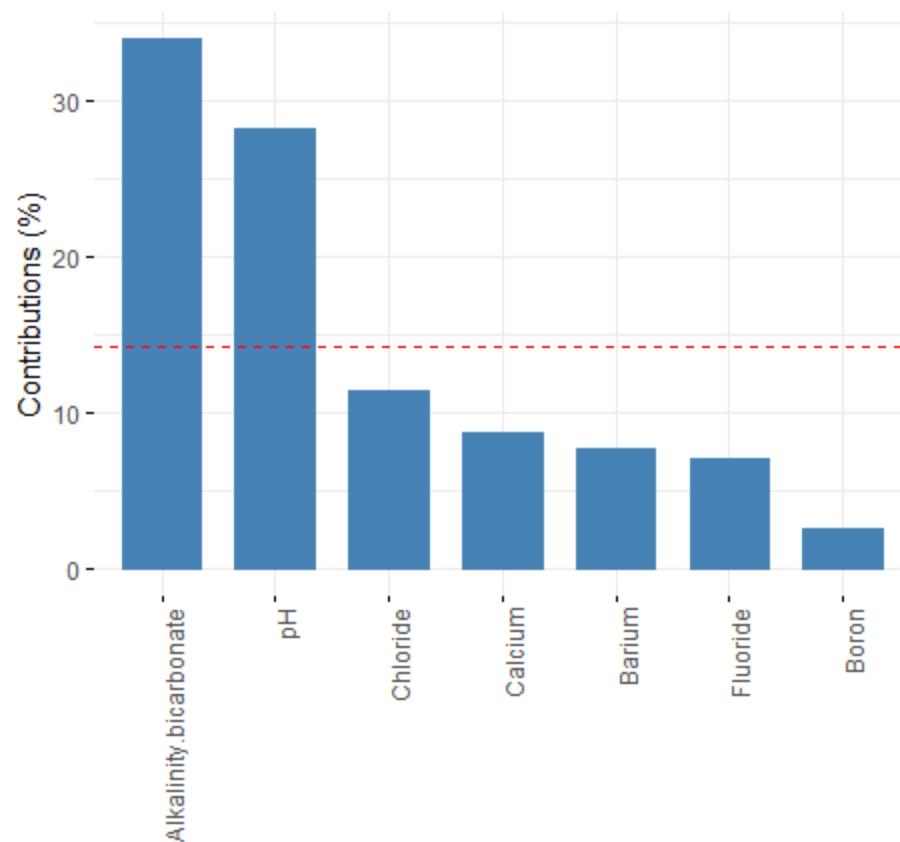
July 2024

Figure
5a

Contribution of Variables to PC-1



Contribution of Variables to PC-2



Notes:

1. The dashed red line represents the anticipated value for uniform contribution. The constituents with a contribution exceeding the reference line are considered significant in its contribution to each PC (principal component).

Contribution of Variables to First Two Principal Components (Porewater Excluded)

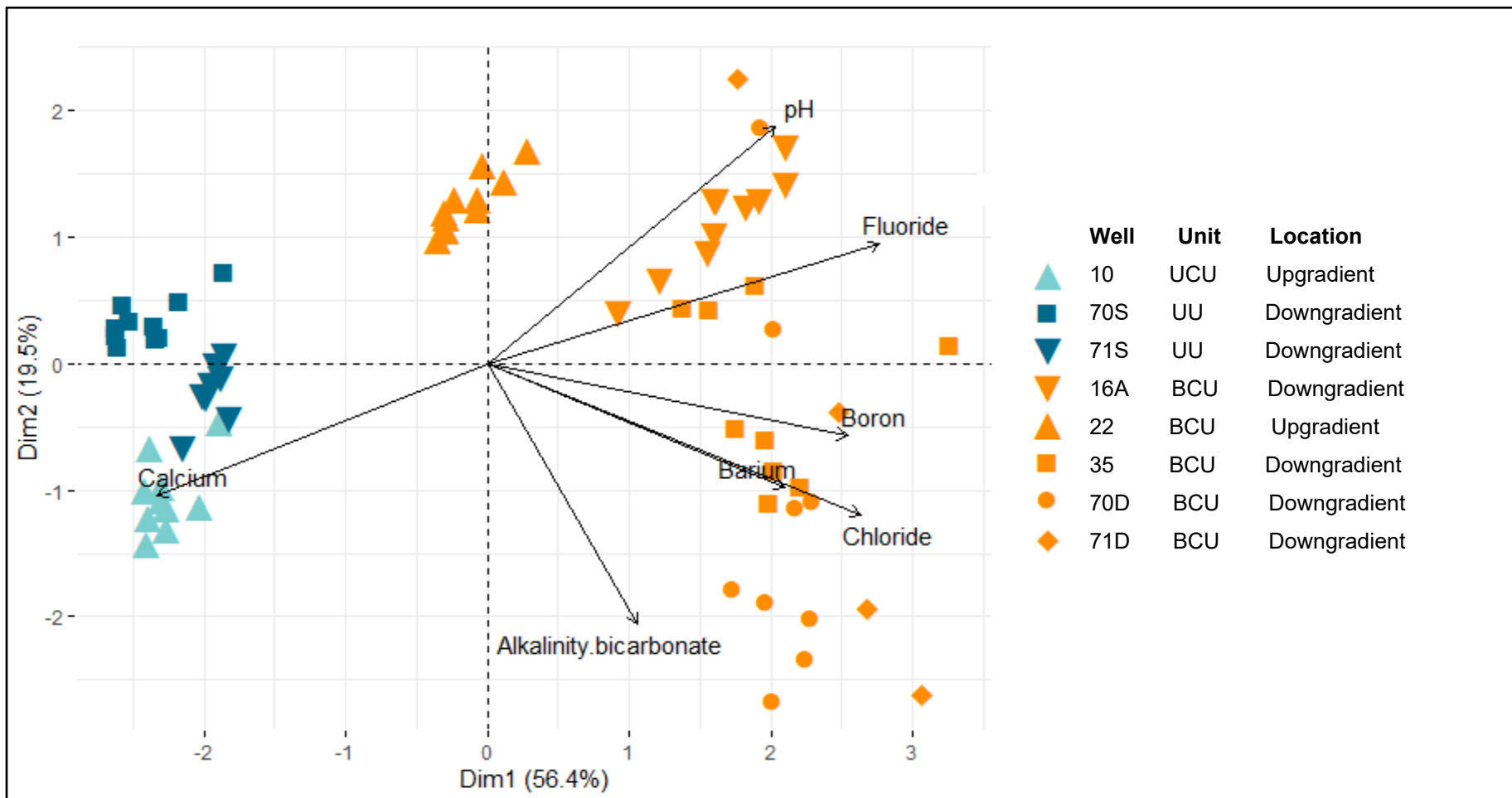
Vermilion Power Plant – New East Ash Pond

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July 2024

Figure
5b



Notes:

- The arrows signify the correlations between the constituents and the principal components.
- Datapoints are colored based on hydrostratigraphic unit of sampling locations as follows:
 - Bedrock Confining Unit (BCU) wells: 16A, 22, 35D, 70D, 71D.
 - Upper Confining Unit (UCU) well: 10.
 - Upper Unit (UU) wells: 70S, 71S.

**Principal Components Analysis Biplot
(Porewater Excluded)**

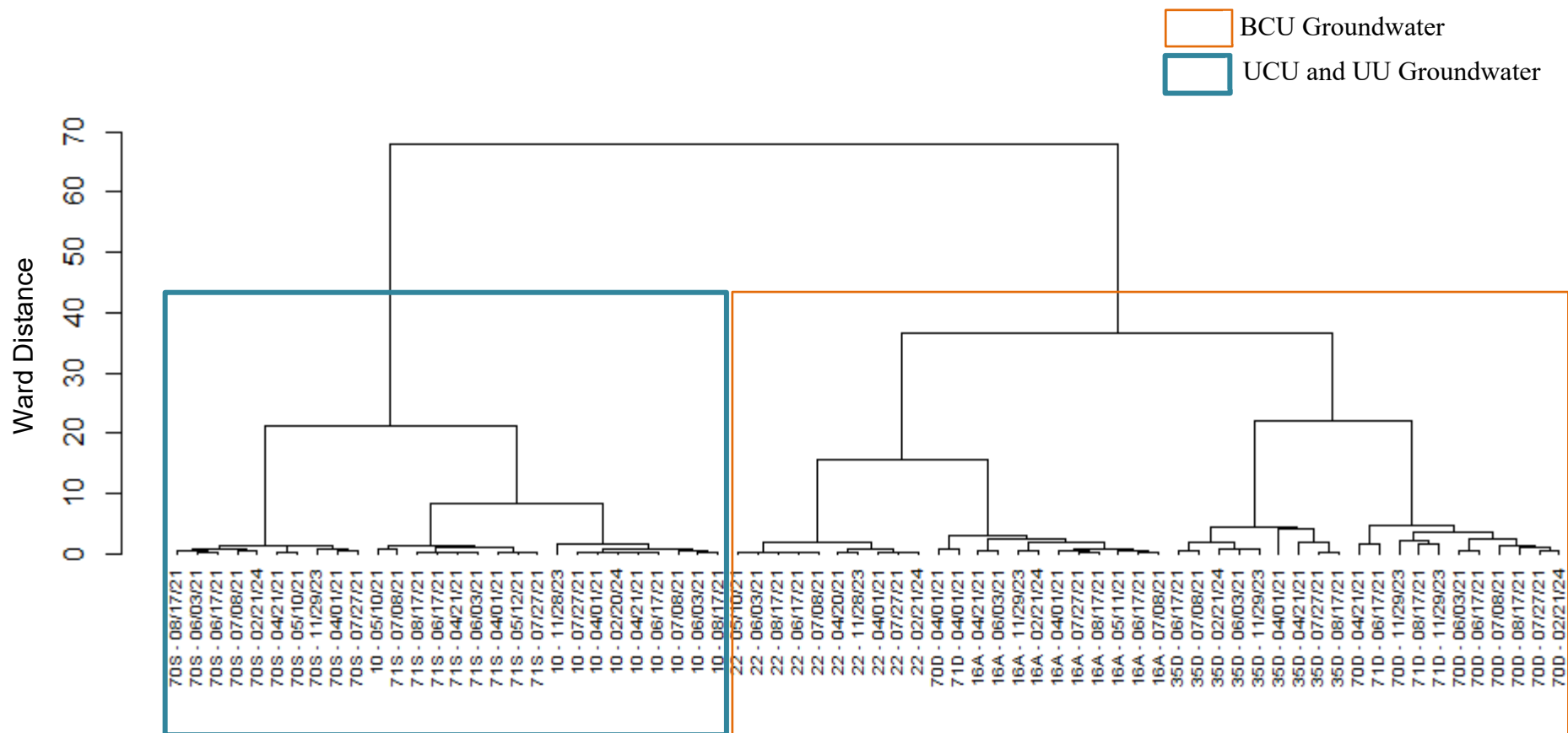
Vermilion Power Plant – New East Ash Pond

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July 2024

Figure
6



Notes:

1. The cluster analysis used Euclidean distances, and Ward's method as the clustering algorithm.
2. In the dendrogram, samples on the same branch are more similar to each other. The samples with the highest similarity are on the closest branches.
3. The boxes around the branches represent the two clusters into which samples from each source grouped.
4. BCU, UCU and UU refer to Bedrock Confining Unit, Upper Confining Unit, and Upper Unit, respectively.

**Dendrogram Graph from Cluster Analysis
(Porewater Excluded)**

Vermilion Power Plant – New East Ash Pond

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Columbus, Ohio

July 2024

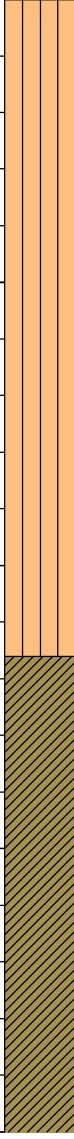
Figure
7

ATTACHMENT 1

Field Boring Logs

Drilling Start Date: 06/24/2023
Drilling End Date: 06/24/2023
Drilling Company: Cascade Drilling
Drilling Method: Sonic
Drilling Equipment: Geoprobe
Driller: Jeff Jehn
Logged By: Andrew Kelley

Boring Depth (ft): 63
Boring Diameter (in): 6
Ground Surface Elev. (ft): Not surveyed
Boring was advanced adjacent to well 35D.
Samples collected from 55-60 ft bgs and 60-63 ft bgs

DEPTH (ft)	LITHOLOGY	WATER LEVEL	BORING COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION
				Sample Type	Date & Time	Blow Counts	Recovery (ft)	
0					10:35	NA	5.1/10	(0') GRAVELLY SILT (ML); light gray to brown (darkens downward), dry, loose, little sand, minor concretions.
5					10:45			(3') CLAYEY SILT (ML); dark reddish brown, moist, firm, some black organics staining, few gravel, minor iron oxide stains.
10								(10') As above.
10.6								(10.6') GRAVELLY SILT (ML); light gray to brown, moist, loose, fine to coarse gravel, little sand.
11.6								(11.6') SILTY CLAY (CL); dark grayish brown, moist, stiff, medium plasticity.
15								
20								

NOTES:

Boring Depth (ft):	63
Boring Diameter (in):	6
Ground Surface Elev. (ft):	Not surveyed
Boring was advanced adjacent to well 35D.	
Samples collected from 55-60 ft bgs and 60-63 ft bgs	

[illegible]

Boring Depth (ft):	63
Boring Diameter (in):	6
Ground Surface Elev. (ft):	Not surveyed
Boring was advanced adjacent to well 35D.	
Samples collected from 55-60 ft bgs and 60-63 ft bgs	

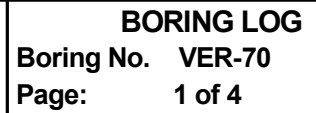
[illegible]

Drilling Start Date: **06/24/2023**
Drilling End Date: **06/24/2023**
Drilling Company: **Cascade Drilling**
Drilling Method: **Sonic**
Drilling Equipment: **Geoprobe**
Driller: **Jeff Jehn**
Logged By: **Andrew Kelley**

Boring Depth (ft): **63**
Boring Diameter (in): **6**
Ground Surface Elev. (ft): **Not surveyed**
Boring was advanced adjacent to well 35D.
Samples collected from 55-60 ft bgs and 60-63 ft bgs

DEPTH (ft)	LITHOLOGY	WATER LEVEL	BORING COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION
				Sample Type	Date & Time	Blow Counts	Recovery (ft)	
60					14:50	NA	2/3	(60') As above: gray, moist, highly decomposed, highly disintegrated, few fragments are slightly more competent.
65								(63') End of Boring.

NOTES:



Drilling Start Date: **06/23/2023**
Drilling End Date: **06/23/2023**
Drilling Company: **Cascade Drilling**
Drilling Method: **Sonic**
Drilling Equipment: **Geoprobe**
Driller: **Jeff Jehn**
Logged By: **Andrew Kelley**

Boring Depth (ft): **80**
Boring Diameter (in): **6**
Ground Surface Elev. (ft): **Not surveyed**
Boring was advanced adjacent to well 70D.
Samples collected from 30-40 ft bgs, 41-42 ft bgs and 75-80 ft bgs

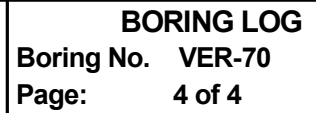
DEPTH (ft)	LITHOLOGY	WATER LEVEL	BORING COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION
				Sample Type	Date & Time	Blow Counts	Recovery (ft)	
20					13:00	NA	3/10	(20') CLAY WITH SILT (CL); grayish brown, wet, stiff, little sand, little fine to coarse gravel.
								(21') SILTY CLAY (CL); grayish brown, wet, soft, little fine gravel, few sand.
								(21.3') SANDY CLAY (CL); grayish brown, wet, very stiff, some gravel.
25								
30							3/10	(30') GRAVELLY CLAY WITH SAND (CL); grayish brown, wet, firm, sand coarsens downward.
35								(31.8') CLAY (CL); dark gray to black, wet, firm, little gravel, few roots observed, dark organics.
40								

NOTES:

Boring Depth (ft):	80
Boring Diameter (in):	6
Ground Surface Elev. (ft):	Not surveyed
Boring was advanced adjacent to well 70D.	
Samples collected from 30-40 ft bgs, 41-42 ft bgs and 75-80 ft bgs	

[illegible]

NOTES:



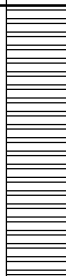
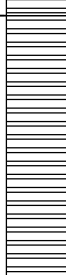
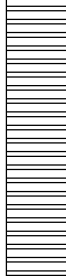
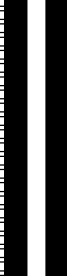
ATTACHMENT 2
Boring Logs and Well Construction
Logs



I hereby certify that the information on this form is true and correct to the best of my knowledge.		
Signature 	Firm Natural Resource Technology 234 W. Florida St., Fifth Floor, Milwaukee, WI 53204	Tel: (414) 837-3607 Fax: (414) 837-3608

Boring Number **MW35D**

Page 2 of 3

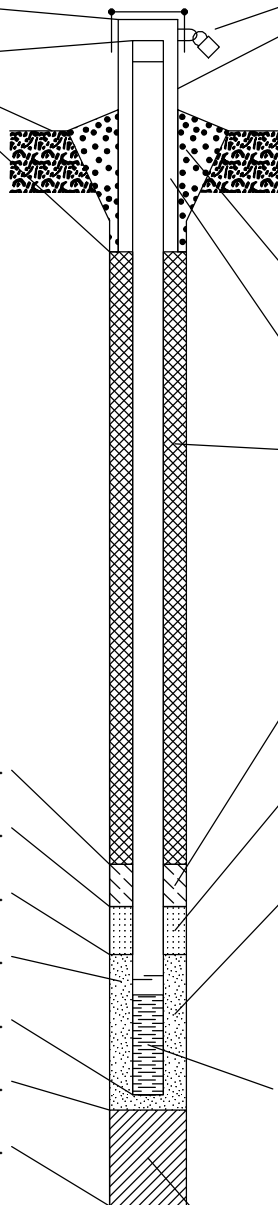
Sample		Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	Soil Properties						RQD/ Comments
Number and Type	Length Att. & Recovered (in)							Compressive Strength (tsf)	Moisture Content	Liquid Limit	Plasticity Index	P 200		
7 SS	8 9	45 50 for 2"	13	10 - 15.6' Weathered SHALE Bedrock to SHALE : BDX (SH), gray (GLEY 1 6/N), weak, fissile, intensely fractured, red (7.5YR 4/6) discoloration, dry. <i>(continued)</i>	BDX (SH)									
8 SS	9 7	31 50 for 3"	14											
9 CORE	120 120		15											
			16	15.6 - 45.8' SHALE : BDX (SH), dark reddish gray (10YR 4/1) to gray (2.5Y 5/1), microcrystalline, thinly bedded to laminated, weak, slightly decomposed (very dark gray (10YR 3/1) to black (10YR 2/1) discoloration in partly healed fractures), competent, dry to moist in fractures.	BDX (SH)								Core 9, RQD = 89%. Light brown gray return water. 4" diameter outer casing set from 0-16 ft bgs.	
			17											
			18											
			19											
			20											
			21											
			22											
			23											
			24											
			25											
			26											
10 CORE	131.3 120		27	25.6' partly to totally healed fractures.	BDX (SH)								Core 10, RQD = 89%. Light gray return water.	
			28											
			29											
			30											
			31											
			32											



Page 3 of 3

11	111.1
CORE	120

Facility/Project Name Vermilion Power Station		Local Grid Location of Well _____ ft. ☐ N. _____ ft. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.		Well Name MW35D	
Facility License, Permit or Monitoring No.		Local Grid Origin ☐ (estimated: ☐) or Well Location ☒ Lat. <u>40° 10' 47.142"</u> Long. <u>87° 44' 8.067"</u> or			
Facility ID		St. Plane <u>1,279,955.58</u> ft. N, <u>1,151,276.17</u> ft. E. ☒ W		Date Well Installed <u>03/03/2017</u>	
Type of Well mw		Section Location of Waste/Source _____ 1/4 of _____ 1/4 of Sec. _____, T. _____ N. R. _____ ☐ E ☐ W		Well Installed By: (Person's Name and Firm) Bruno Williamson	
Distance from Waste/ Source _____ ft.	State IL	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known		Gov. Lot Number _____	
				Ramsey Geotechnical Engineering	

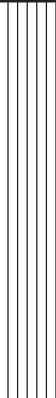
A. Protective pipe, top elevation _____ ft. MSL B. Well casing, top elevation <u>584.15</u> ft. MSL C. Land surface elevation <u>581.25</u> ft. MSL D. Surface seal, bottom <u>579.3</u> ft. MSL or <u>2.0</u> ft. 12. USCS classification of soil near screen: GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐ SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐ Bedrock ☒ 13. Sieve analysis attached? ☐ Yes ☒ No 14. Drilling method used: Rotary ☐ Hollow Stem Auger ☐ <u>HSA / Rotary</u> Other ☒ 15. Drilling fluid used: Water ☒ 0.2 Air ☐ Drilling Mud ☐ 0.3 None ☐ 16. Drilling additives used? ☐ Yes ☒ No Describe _____ 17. Source of water (attach analysis, if required): <u>City of Champaign</u> E. Bentonite seal, top <u>551.3</u> ft. MSL or <u>30.0</u> ft. F. Fine sand, top _____ ft. MSL or _____ ft. G. Filter pack, top <u>548.3</u> ft. MSL or <u>33.0</u> ft. H. Screen joint, top <u>546.3</u> ft. MSL or <u>35.0</u> ft. I. Well bottom <u>536.3</u> ft. MSL or <u>45.0</u> ft. J. Filter pack, bottom <u>535.5</u> ft. MSL or <u>45.8</u> ft. K. Borehole, bottom <u>535.5</u> ft. MSL or <u>45.8</u> ft. L. Borehole, diameter <u>7.3</u> in. M. O.D. well casing <u>2.38</u> in. N. I.D. well casing <u>1.99</u> in.	 1. Cap and lock? ☒ Yes ☐ No 2. Protective cover pipe: a. Inside diameter: <u>6.0</u> in. b. Length: <u>6.0</u> ft. c. Material: Steel ☒ Other ☐ d. Additional protection? ☒ Yes ☐ No If yes, describe: <u>4" diameter protective PVC casing</u> 3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐ 4. Material between well casing and protective pipe: Bentonite ☒ Sand ☒ Other ☐ 5. Annular space seal: a. Granular/Chipped Bentonite ☐ b. _____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ c. _____ Lbs/gal mud weight . . . Bentonite slurry ☐ d. <u>30</u> % Bentonite . . . Bentonite-cement grout ☒ e. _____ Ft³ volume added for any of the above f. How installed: Tremie ☒ Tremie pumped ☐ Gravity ☐ 6. Bentonite seal: a. Bentonite granules ☐ b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ c. _____ Other ☐ 7. Fine sand material: Manufacturer, product name & mesh size a. _____ b. Volume added _____ ft³ 8. Filter pack material: Manufacturer, product name & mesh size a. <u>NSF Quartz Sand #10-20</u> b. Volume added _____ ft³ 9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ _____ Other ☐ 10. Screen material: <u>Schedule 40 PVC</u> a. Screen Type: Factory cut ☒ Continuous slot ☐ Other ☐ b. Manufacturer _____ c. Slot size: <u>0.100</u> in. d. Slotted length: <u>10.0</u> ft. 11. Backfill material (below filter pack): None ☒ Other ☐
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I hereby certify that the information on this form is true and correct to the best of my knowledge.

Date Modified: 4/6/2017

Signature 	Firm Natural Resource Technology 234 W. Florida Street, Floor 5, Milwaukee, WI 53204	Tel: (414) 837-3607 Fax: (414) 837-3608
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Facility/Project Name Vermilion Power Station		License/Permit/Monitoring Number		Boring Number 70D	
Boring Drilled By: Name of crew chief (first, last) and Firm Jason Greer Cascade Drilling		Date Drilling Started 3/4/2021		Date Drilling Completed 3/4/2021	
Common Well Name 70D		Final Static Water Level Feet (NAVD88)		Surface Elevation 591.90 Feet (NAVD88)	
				Borehole Diameter 6.0 inches	
Local Grid Origin ☐ (estimated: ☐) or Boring Location ☐		Lat ° ' "		Local Grid Location	
State Plane 1,278,929.46 N, 1,150,617.15 E ☒ W		Long ° ' "		☐ N ☐ E	
1/4 of 1/4 of Section , T N, R				Feet ☐ S Feet ☐ W	
Facility ID		County Vermilion		State Illinois	
				Civil Town/City/ or Village Oakwood	

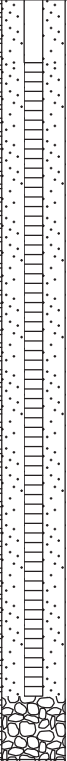
Sample		Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Soil Properties					RQD/ Comments	
Number and Type	Length Att. & Recovered (in)								Compressive Strength (tsf)	Moisture Content	Liquid Limit	Plasticity Index	P 200		
1 CS	60 47		1	0 - 6.3' SILT : ML, dark brown (10YR 3/3) to brown (10YR 4/3), clay (15-25%), sand, (0-5%), roots (0-5%), stiff, slow dilatancy, low toughness, low plasticity, moist.	ML					1.5					CS= Core Sample
			2							1.5					
			3							1.5					
			4							1.5					
2 CS	60 60		5	6.3 - 11.3' SILTY CLAY : CL/ML, brown (10YR 4/3), sand (0-10%), gravel (0-5%), firm, slow dilatancy, low toughness, medium plasticity, moist.	CL/ML					1.5					
			6							0.75					
			7							0.75					
			8												
			9												
			10							9.4' color change to yellowish brown (10YR 5/4).					
3 CS	120 120		11	11.3 - 14.7' CLAYEY SAND : SC, yellowish brown (10YR 5/6), rounded fine sand, silt (5-10%), gravel (0-5%), loose, wet.	SC										
			12												
			13												
			14												
			15												

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature 	Firm Ramboll 234 W. Florida Street, Milwaukee, WI 53204	Tel: (414) 837-3607 Fax: (414) 837-3608
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Boring Number 70D

Page 3 of 3

Sample		Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Soil Properties					RQD/ Comments
Number and Type	Length Att. & Recovered (in)								Compressive Strength (tsf)	Moisture Content	Liquid Limit	Plasticity Index	P 200	
6 CS	132 132		41	20.3 - 52' SHALE: BDX (SH), gray (10YR 5/1). <i>(continued)</i>	BDX (SH)									
			42											
			43											
			44											
			45											
			46											
			47											
			48											
			49											
			50											
			51											
			52	52' End of Boring.										

Facility/Project Name Vermilion Power Station		Local Grid Location of Well _____ ft. ☐ N. _____ ft. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.		Well Name 70D	
Facility License, Permit or Monitoring No.		Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. _____ ° _____ ' _____ " Long. _____ ° _____ ' _____ " or			
Facility ID		St. Plane 1,278,929 ft. N, 1,150,617 ft. E. (E)/W		Date Well Installed 03/04/2021	
Type of Well Well Code 12/pz		Section Location of Waste/Source _____ 1/4 of _____ 1/4 of Sec. _____, T. _____ N, R. _____ ☐ E ☐ W		Well Installed By: (Person's Name and Firm) Jason Greer	
Distance from Waste/Source ft.	State Illinois	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known		Gov. Lot Number _____	
				Cascade Drilling	

A. Protective pipe, top elevation _____ 595.10 ft. MSL B. Well casing, top elevation _____ 594.52 ft. MSL C. Land surface elevation _____ 591.9 ft. MSL D. Surface seal, bottom _____ 590.9 ft. MSL or _____ 1.0 ft. 12. USCS classification of soil near screen: GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐ SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐ Bedrock ☒ 13. Sieve analysis attached? ☐ Yes ☒ No 14. Drilling method used: Rotary ☐ Hollow Stem Auger ☐ Sonic _____ Other ☒ 15. Drilling fluid used: Water ☒ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☐ 16. Drilling additives used? ☐ Yes ☒ No Describe _____ 17. Source of water (attach analysis, if required): Potable City Water E. Bentonite seal, top _____ 557.9 ft. MSL or _____ 34.0 ft. F. Fine sand, top _____ ft. MSL or _____ ft. G. Filter pack, top _____ 552.9 ft. MSL or _____ 39.0 ft. H. Screen joint, top _____ 550.9 ft. MSL or _____ 41.0 ft. I. Well bottom _____ 540.9 ft. MSL or _____ 51.0 ft. J. Filter pack, bottom _____ 540.9 ft. MSL or _____ 51.0 ft. K. Borehole, bottom _____ 539.9 ft. MSL or _____ 52.0 ft. L. Borehole, diameter _____ 6.0 in. M. O.D. well casing _____ 2.38 in. N. I.D. well casing _____ 2.07 in.		1. Cap and lock? ☒ Yes ☐ No 2. Protective cover pipe: a. Inside diameter: _____ 4.0 in. b. Length: _____ 5.0 ft. c. Material: Steel ☒ Other ☐ d. Additional protection? ☒ Yes ☐ No If yes, describe: _____ 4 Steel Bollards 3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐ 4. Material between well casing and protective pipe: Bentonite ☐ Sand _____ Other ☒ 5. Annular space seal: a. Granular/Chipped Bentonite ☐ b. _____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ c. 9.2 Lbs/gal mud weight . . . Bentonite slurry ☒ d. _____ % Bentonite . . . Bentonite-cement grout ☐ e. _____ Ft³ volume added for any of the above f. How installed: Tremie ☐ Tremie pumped ☒ Gravity ☐ 6. Bentonite seal: a. Bentonite granules ☐ b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ c. _____ Other ☐ 7. Fine sand material: Manufacturer, product name & mesh size a. _____ NA b. Volume added _____ 0 ft³ 8. Filter pack material: Manufacturer, product name & mesh size a. _____ FILTERSIL 0.85 b. Volume added _____ ft³ 9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐ 10. Screen material: _____ Schedule 40 PVC a. Screen Type: Factory cut ☒ Continuous slot ☐ Other ☐ b. Manufacturer _____ Johnson Screens c. Slot size: _____ 0.010 in. d. Slotted length: _____ 10.0 ft. 11. Backfill material (below filter pack): None ☐ Formation Materials _____ Other ☒
--	--	---

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Date Modified: 3/31/2021

Signature 	Firm Ramboll 234 W. Florida Street, Milwaukee, WI 53204	Tel: (414) 837-3607 Fax: (414) 837-3608
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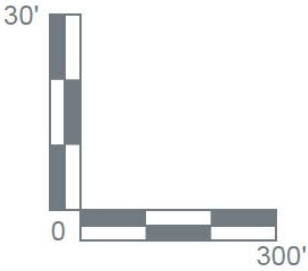
ATTACHMENT 3

Cross Sections

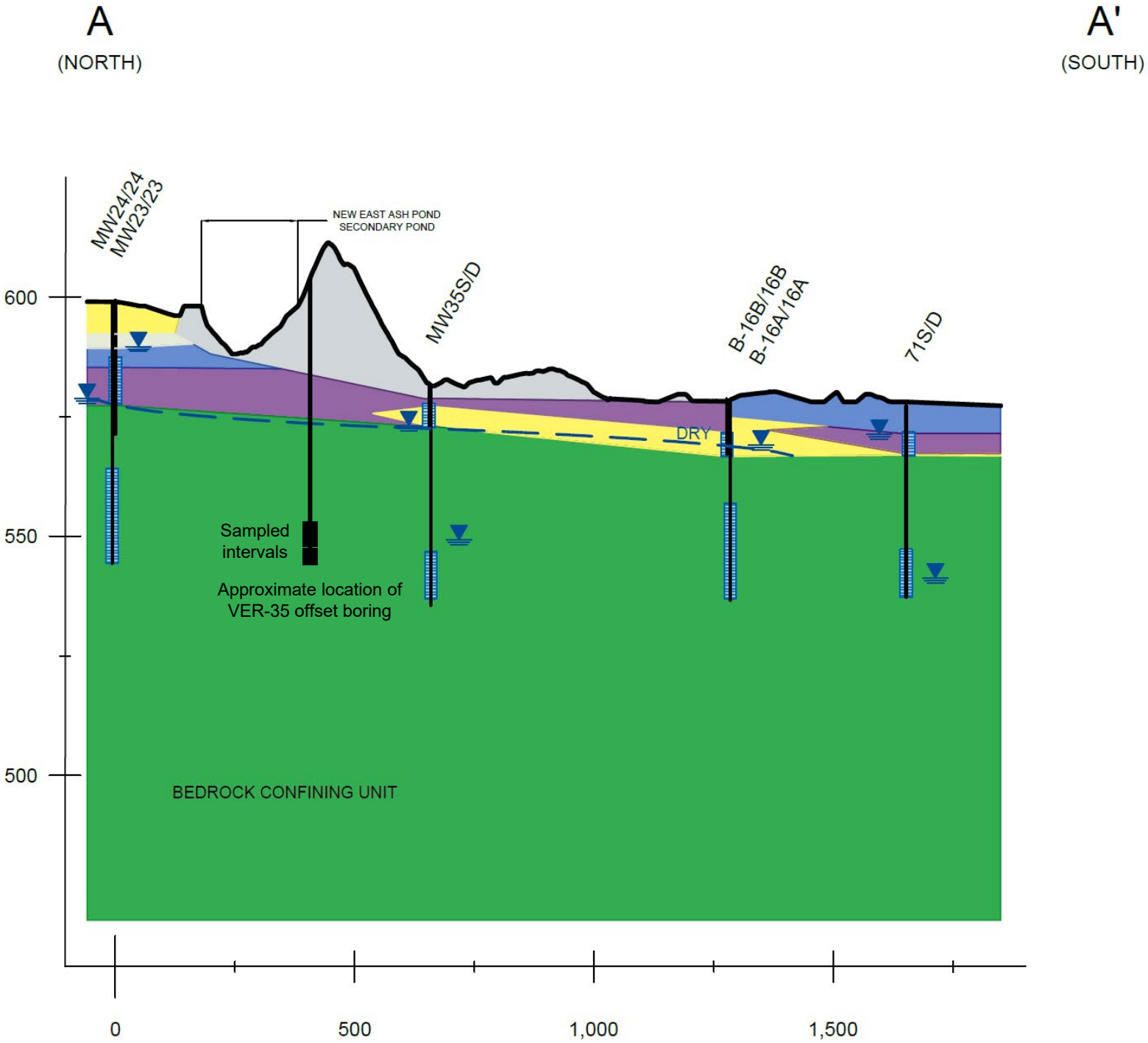
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- NOTES**
1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
 2. Scale is approximate.
 3. Vertical scale is exaggerated 10X.
 4. Groundwater elevations measured on March 29, 2021.
 5. PMP = Potential Migration Pathway



LEGEND	
	FILL
	CLAY (CL/CH)
	TILL (CL/CH)
	SILT (ML)
	SAND (SP/SM/SW)
	GRAVEL (GP/GW)
	BEDROCK / WEATHERED BEDROCK (INTERBEDDED SHALE, LIMESTONE, SANDSTONE, V. LITTLE SS)
	WELL SCREEN INTERVAL
	BEDROCK CONFINING UNIT POTENTIOMETRIC SURFACE
	BEDROCK CONFINING UNIT / PMP GROUNDWATER / OTHER GROUNDWATER / SURFACE WATER ELEVATION(S)



GEOLOGIC CROSS SECTION
A-A'

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

FIGURE 2-9

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



ATTACHMENT 4
X-Ray Diffraction
Laboratory Analytical Report



Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for: Environmental Services

Project Number/ LIMS No. Custom XRD/MI4526-AUG23

Sample Receipt: August 10, 2023

Sample Analysis: August 31, 2023

Reporting Date: September 13, 2023

Instrument: BRUKER AXS D8 Advance Diffractometer

Test Conditions: Co radiation, 35 kV, 40 mA; Detector: LYNXEYE
Regular Scanning: Step: 0.02°, Step time: 0.75s, 2θ range: 6-80°
Clay Section Scanning: Step: 0.01°, Step time: 0.2s, 2θ range: 3-40°

Interpretations : PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva and Topas software.

Detection Limit : 0.5-2%. Strongly dependent on crystallinity.

Contents:

- 1) Method Summary
- 2) Quantitative XRD Results
- 3) XRD Pattern(s)

Zhihai (Adrian) Zhang, Ph.D
Mineralogist

Kim Gibbs, H.B.Sc., P.Geo.
Senior Mineralogist

ACCREDITATION: SGS Natural Resources Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada Inc. - Minerals: <https://www.sgc.ca/en/search/palcan>.



Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Natural Resources is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involves matching the diffraction pattern of an unknown material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) database and released on software as Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds, except when internal standards have been added by request. Mineral proportions may be strongly influenced by crystallinity, crystal structure and preferred orientations. Mineral or compound identification and quantitative analysis results should be accompanied by supporting chemical assay data or other additional tests.

Clay Mineral Separation and Identification:

Clay minerals are typically fine-grained ($<2\ \mu\text{m}$) phyllosilicates in sedimentary rock. Due to the poor crystallinity and fine size of clay minerals, separation of the clay fraction from bulk samples by centrifuge is required. A slide of the oriented clay fraction is prepared and scanned followed by a series of procedures (the addition of ethylene glycol and high temperature heating). Clay minerals are identified by their individual diffraction patterns and changes in their diffraction pattern after different treatments. Clay speciation and mineral identification of the bulk sample are performed using DIFFRACplus EVA (Bruker AXS).

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Topas 4.2 (Bruker AXS), a graphics based profile analysis program built around a non-linear least squares fitting system, to determine the amount of different phases present in a multicomponent sample. Whole pattern analyses are predicated by the fact that the X-ray diffraction pattern is a total sum of both instrumental and specimen factors. Unlike other peak intensity-based methods, the Rietveld method uses a least squares approach to refine a theoretical line profile until it matches the obtained experimental patterns.

Rietveld refinement is completed with a set of minerals specifically identified for the sample. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05wt%. Minerals not identified by the analyst are not included in refinement calculations for specific samples and are indicated with a dash.

DISCLAIMER: This document is issued by the Company under its General Conditions of Service accessible at <http://www.sgs.com/en/Terms-and-Conditions.aspx>. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

WARNING: The sample(s) to which the findings recorded herein (the "Findings") relate was(were) drawn and / or provided by the Client or by a third party acting at the Client's direction. The Findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The Company accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted.



Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	VER-35 55-60 20230624 AUG4526-01 (wt %)	VER-35 60-63 20230624 AUG4526-02 (wt %)	VER-70 30-40 20230623 AUG4526-03 (wt %)	VER-70 41-42 20230623 AUG4526-04 (wt %)	VER-70 75-80 20230623 AUG4526-05 (wt %)
Quartz	38.5	38.1	48.6	48.2	35.0
Chlorite	6.9	6.8	1.2	3.6	7.7
Muscovite	23.4	23.0	13.5	15.2	27.0
Albite	12.6	12.6	10.6	10.8	11.5
Microcline	1.0	1.1	1.3	1.1	0.7
Siderite	4.9	5.0	0.9	0.1	5.4
Actinolite	-	-	0.8	-	-
Dolomite	-	-	11.7	11.7	-
Clays					
Illite	7.1	8.0	7.4	5.6	5.2
Kaolinite	5.6	5.4	3.2	3.7	7.5
Montmorillonite	-	-	0.8	-	-
TOTAL	100	100	100	100	100

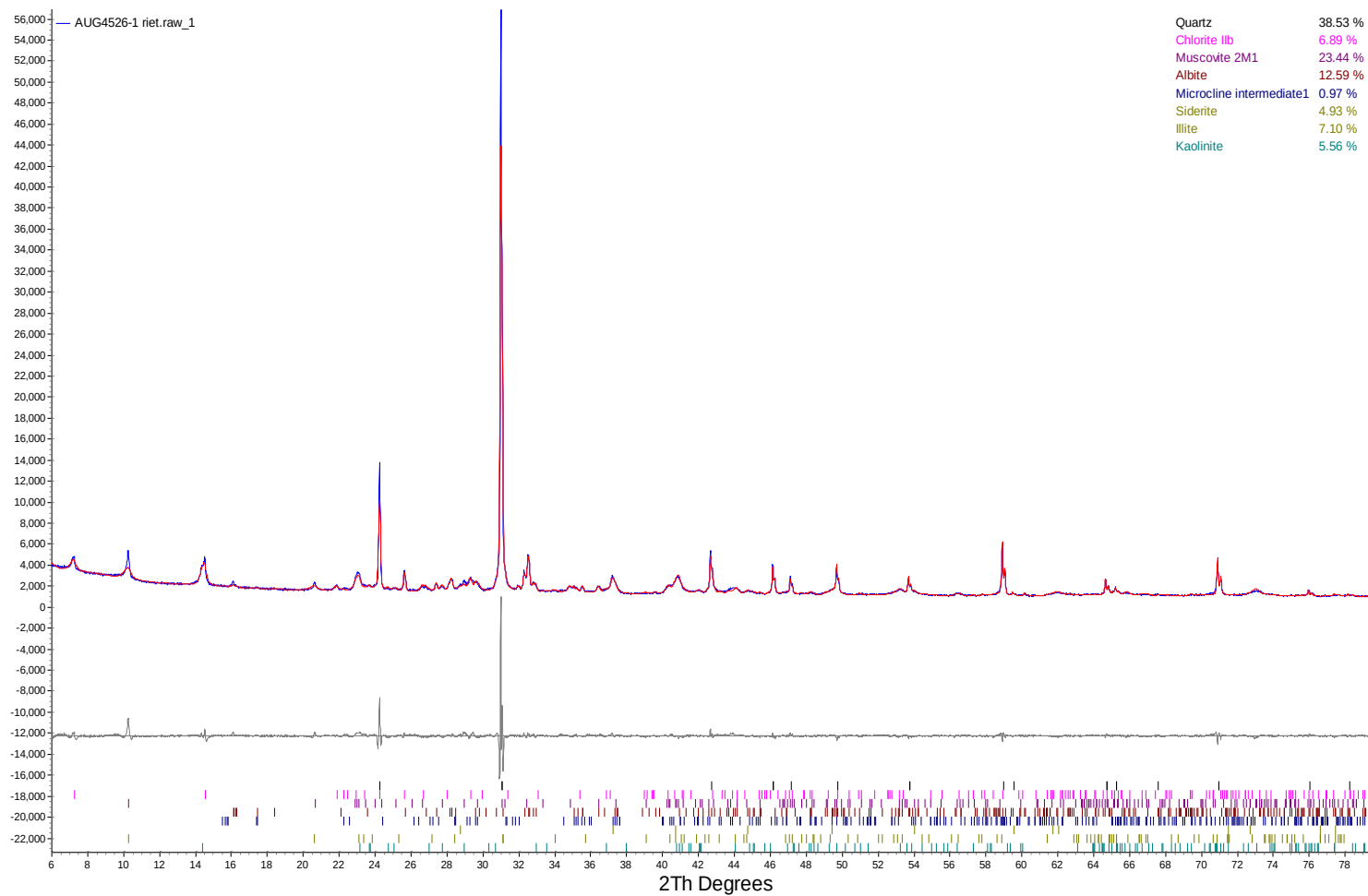
Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identified by the analyst and not included in the refinement calculation for the sample.

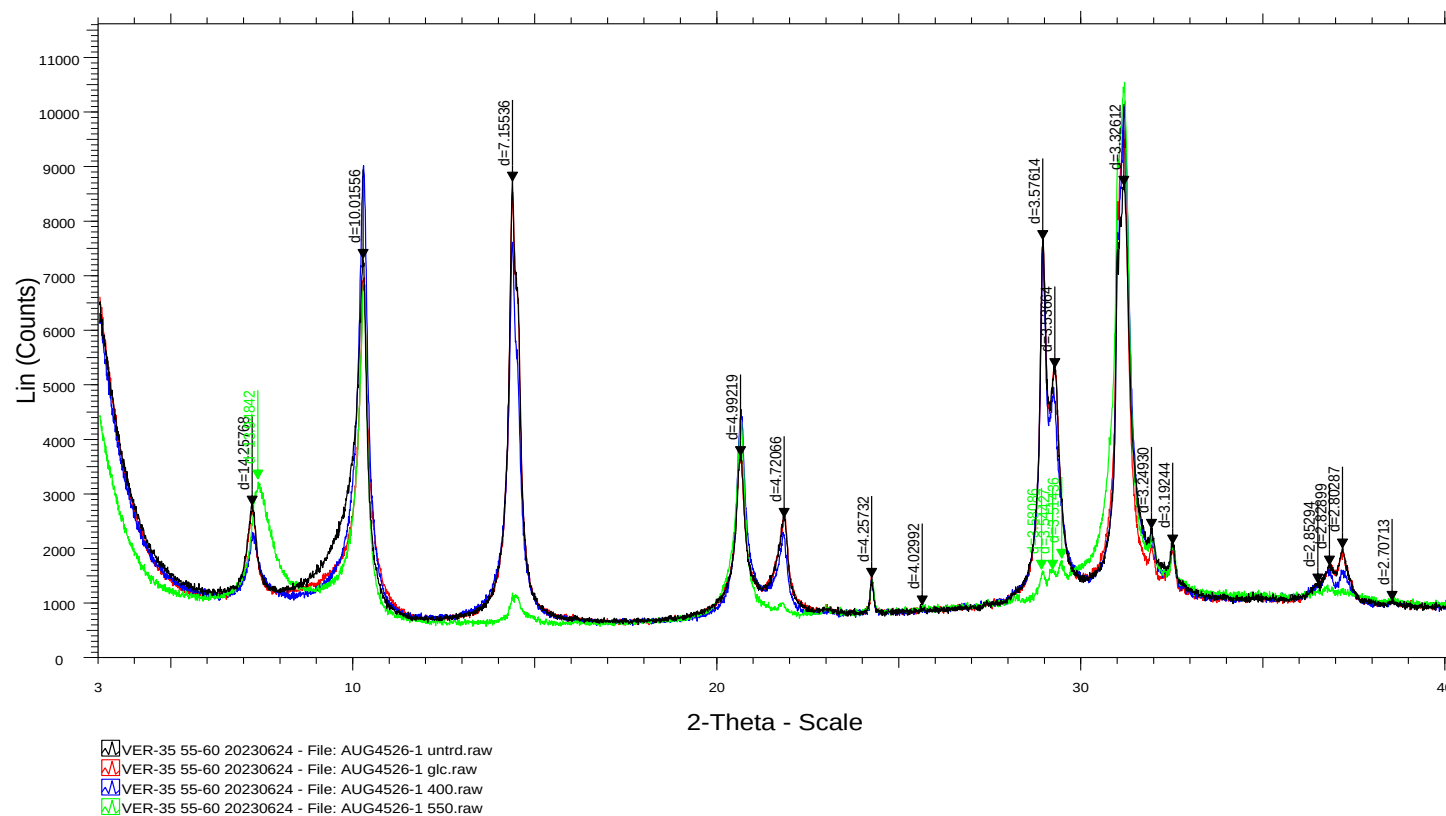
The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO ₂
Chlorite	(Fe,(Mg,Mn) ₅ ,Al)(Si ₃ Al)O ₁₀ (OH) ₈
Muscovite	KAl ₂ (AlSi ₃ O ₁₀)(OH) ₂
Albite	NaAlSi ₃ O ₈
Microcline	KAlSi ₃ O ₈
Siderite	FeCO ₃
Illite	(K,H ₃ O)(Al,Mg,Fe) ₂ (Si,Al) ₄ O ₁₀ [(OH) ₂ ,(H ₂ O)]
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄
Actinolite	Ca ₂ (Mg,Fe) ₅ Si ₈ O ₂₂ (OH) ₂
Dolomite	CaMg(CO ₃) ₂
Montmorillonite	(Na,Ca) _{0.3} (Al,Mg) ₂ Si ₄ O ₁₀ (OH) ₂ ·10H ₂ O

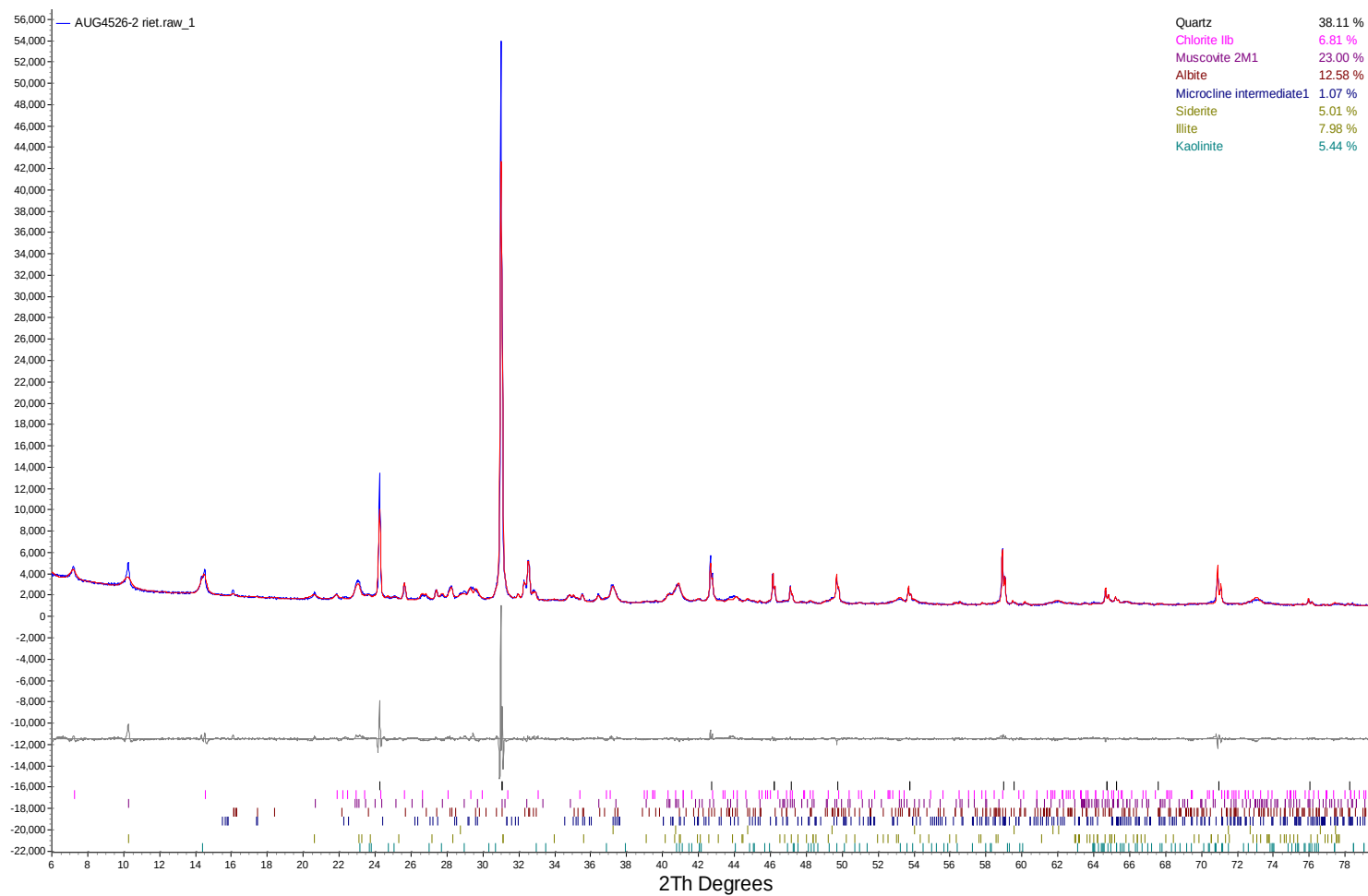
VER-35 55-60 20230624



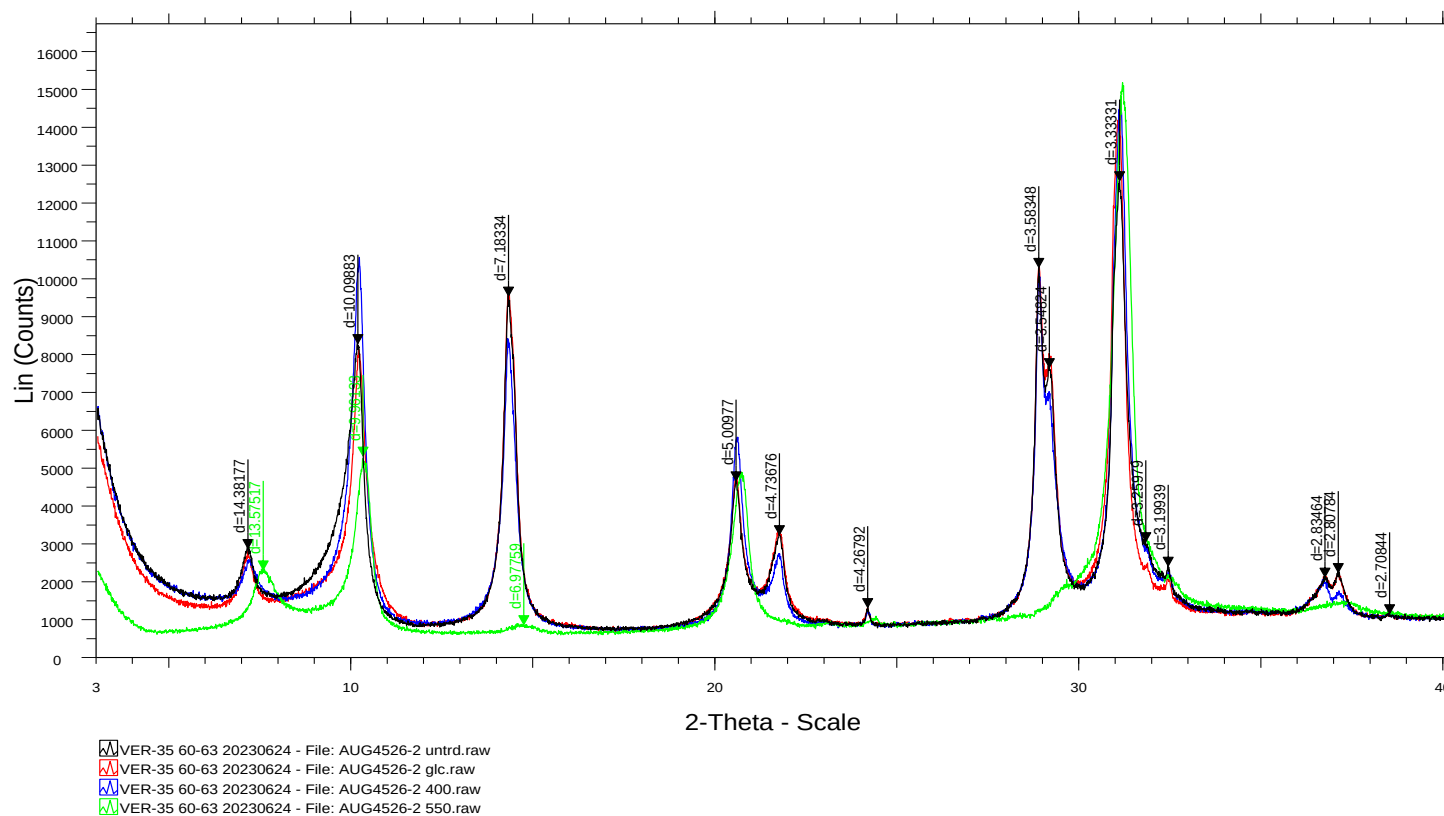
VER-35 55-60 20230624



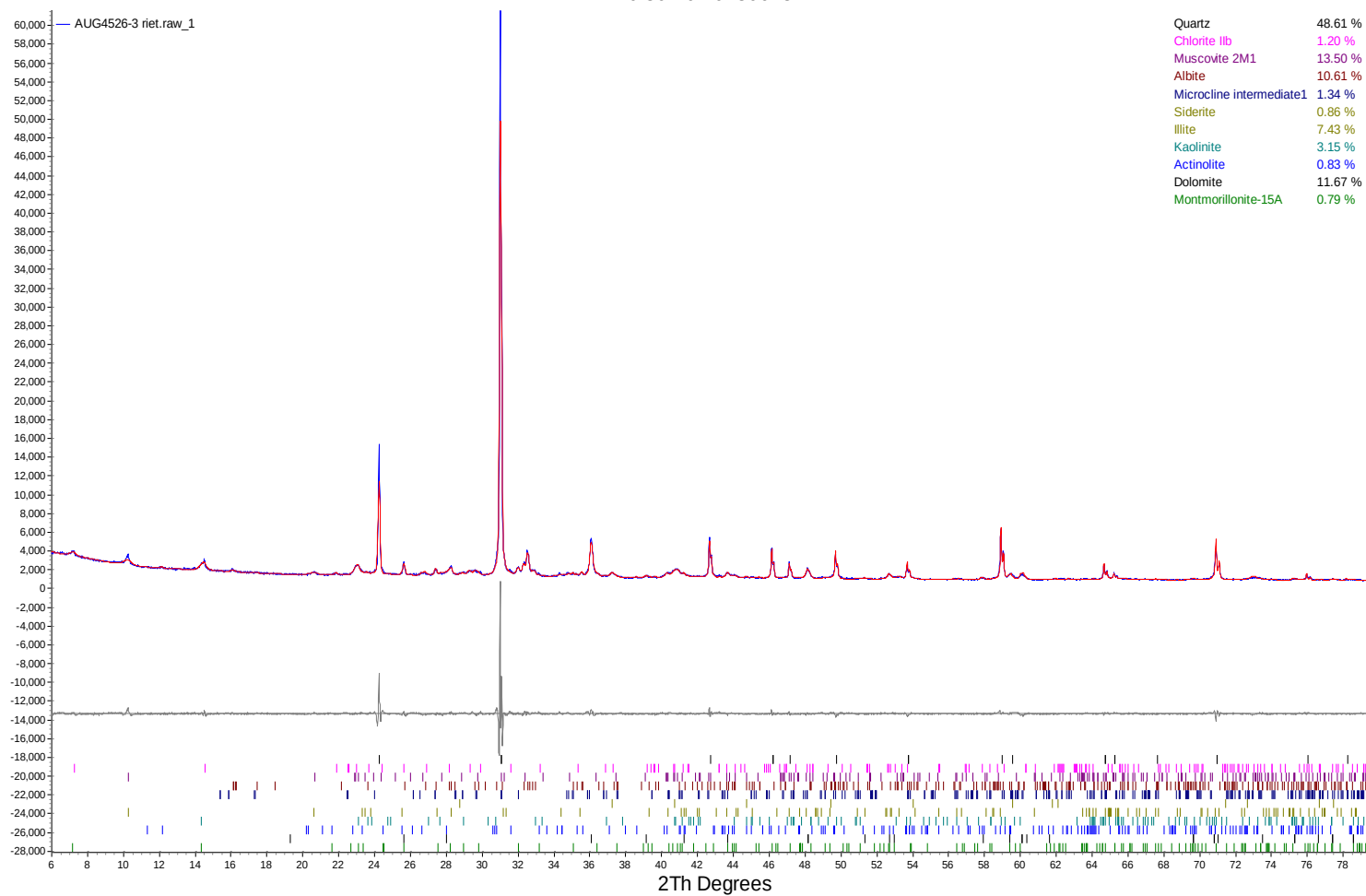
VER-35 60-63 20230624



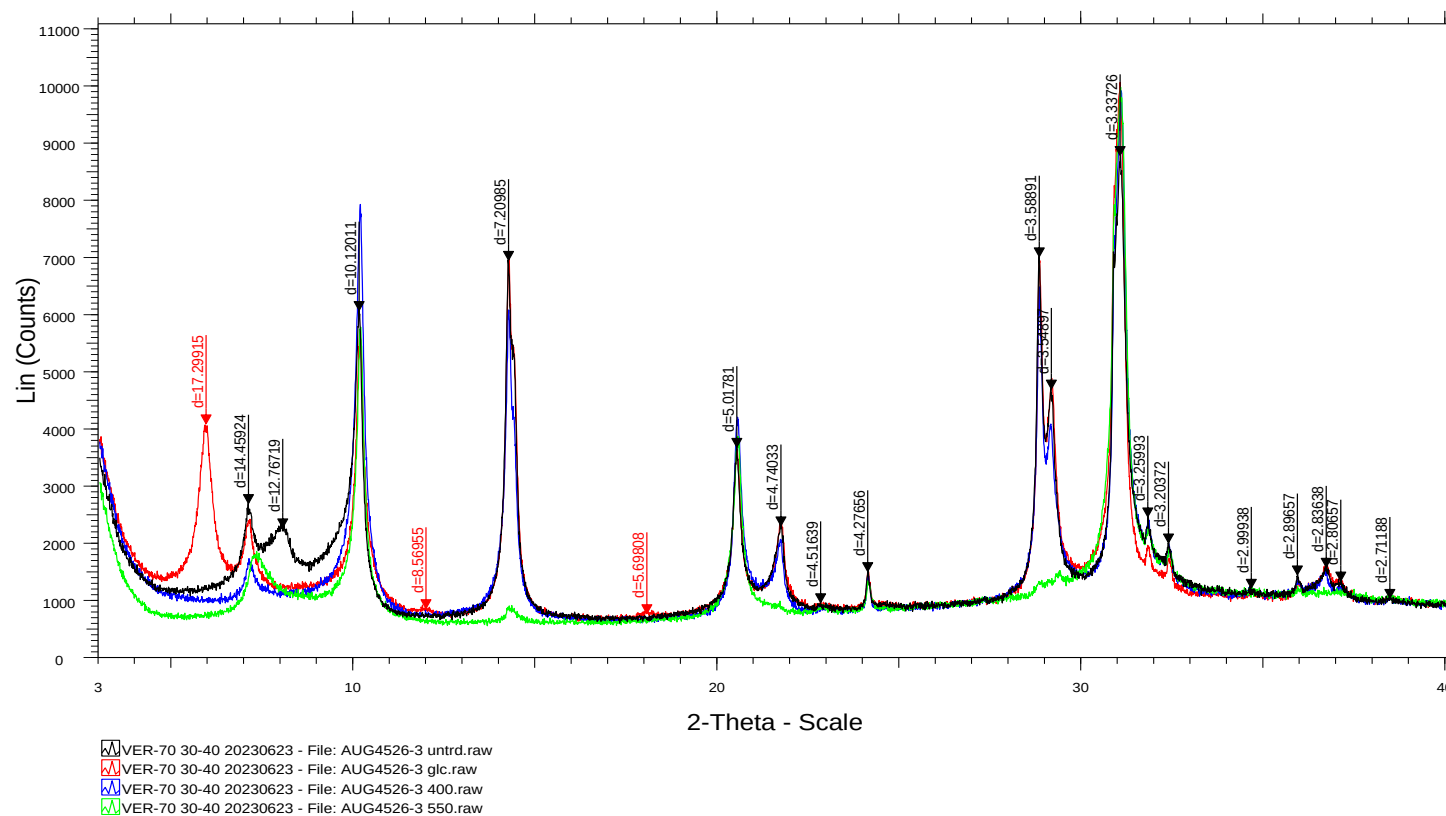
VER-35 60-63 20230624



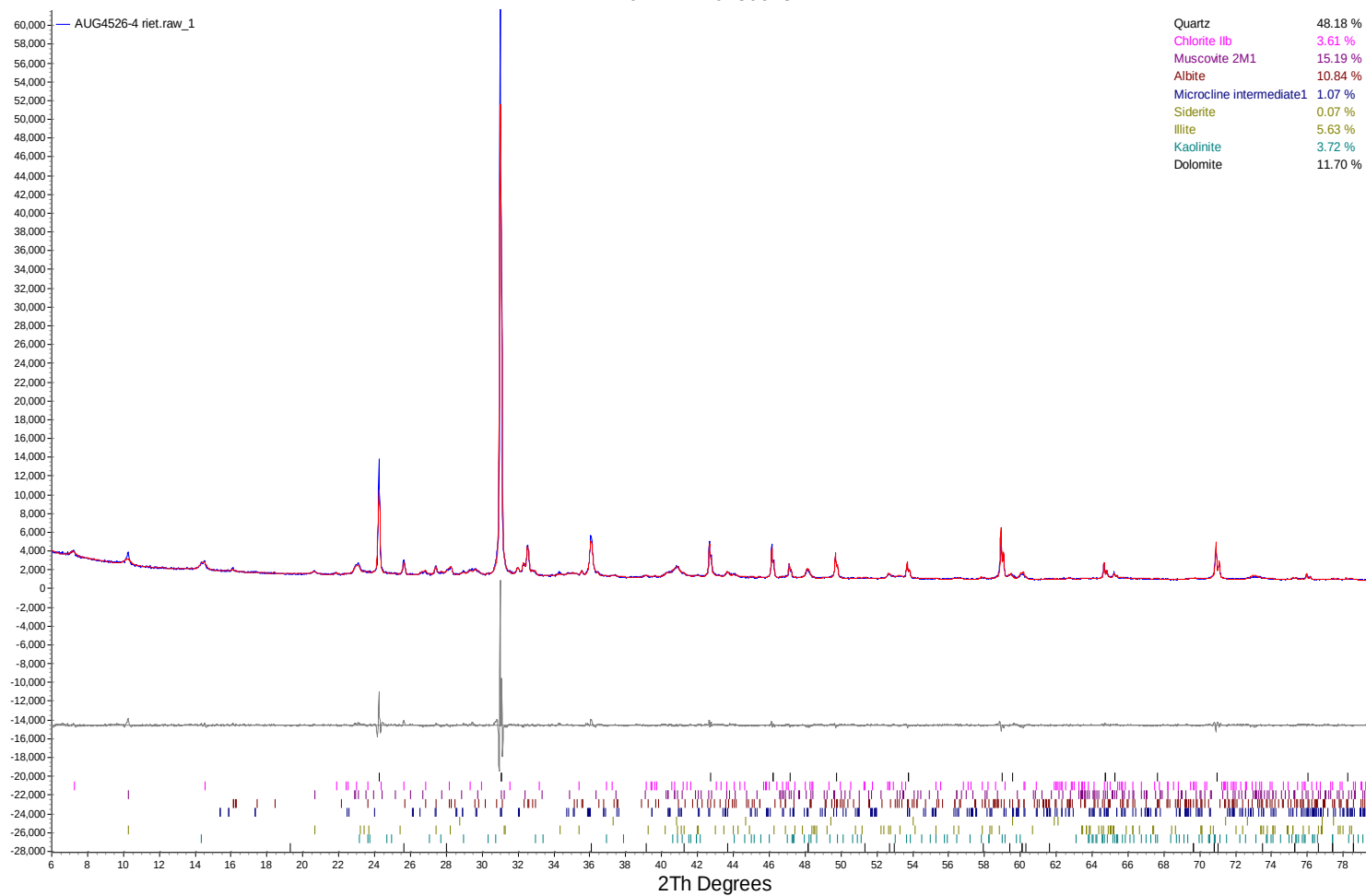
VER-70 30-40 20230623



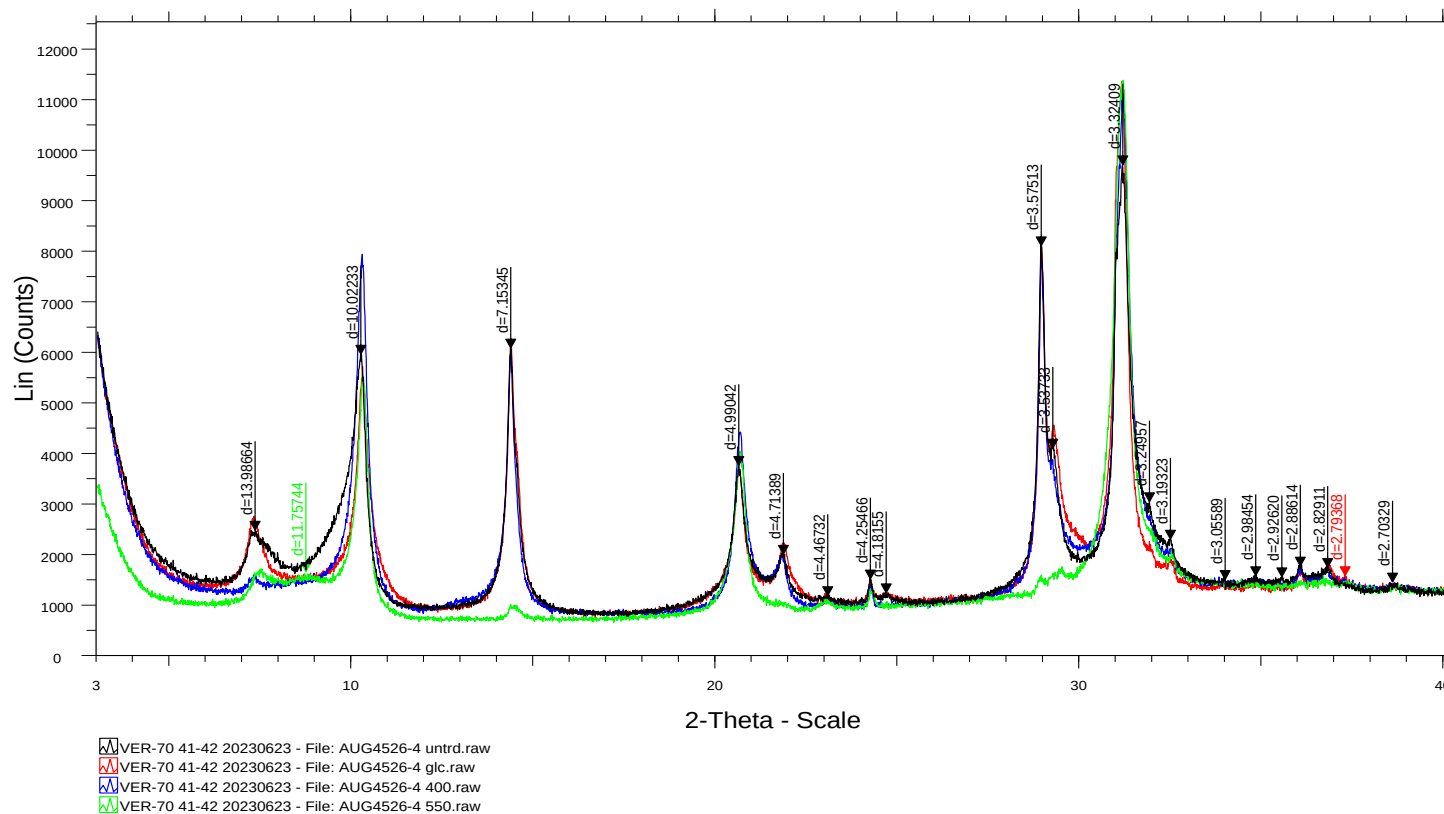
VER-70 30-40 20230623



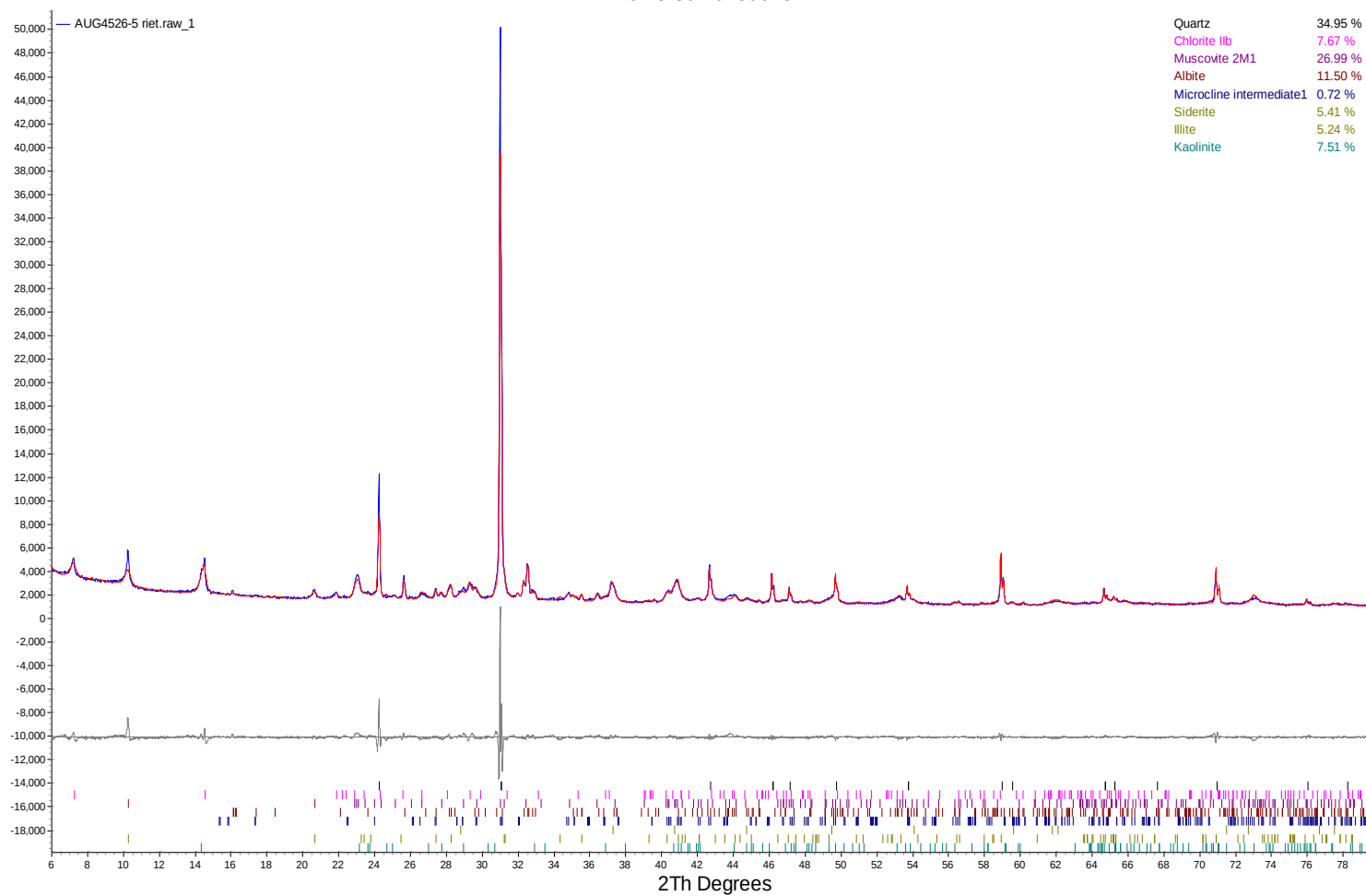
VER-70 41-42 20230623



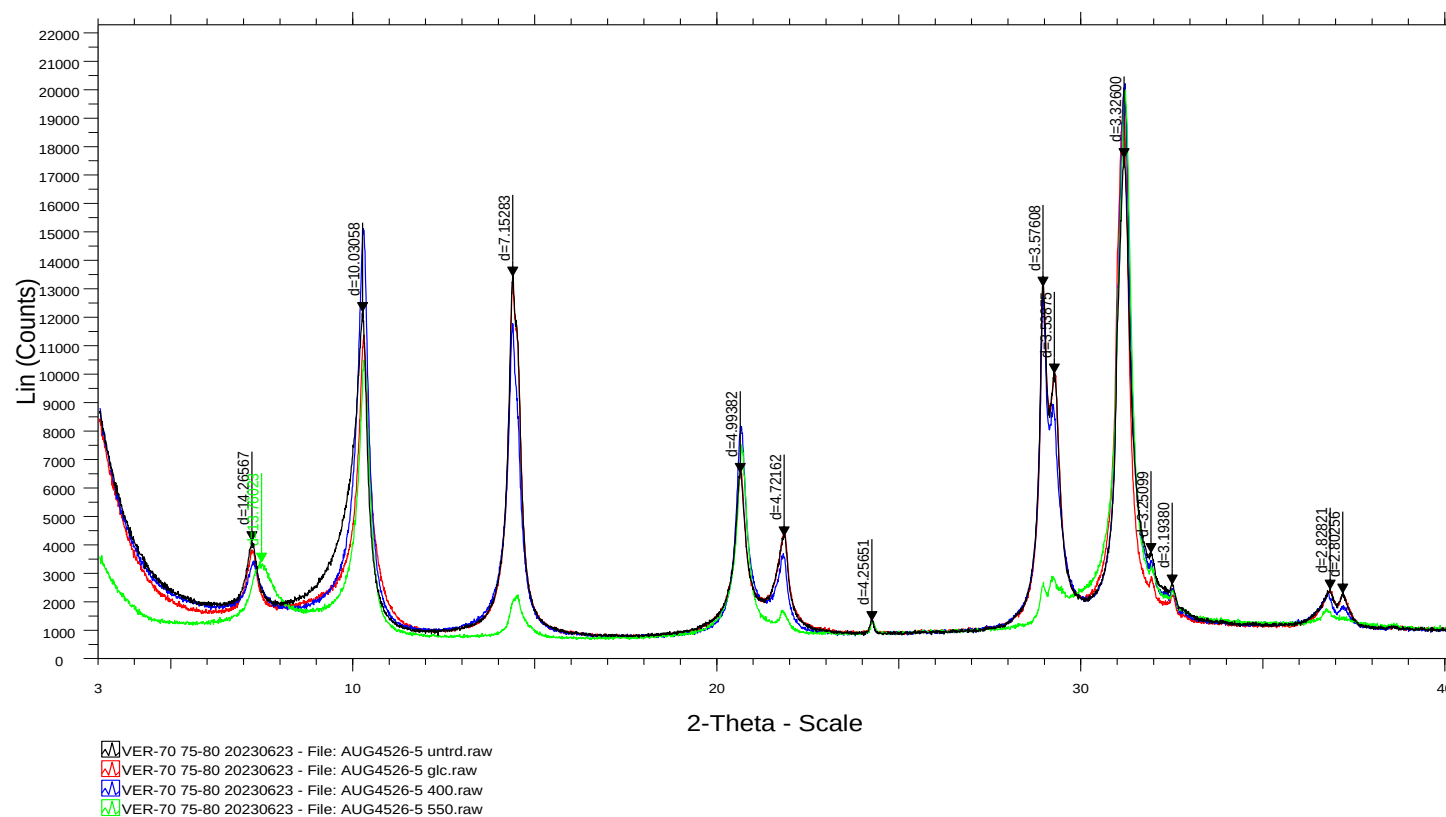
VER-70 41-42 20230623



VER-70 75-80 20230623



VER-70 75-80 20230623



ATTACHMENT 5

PCA Data Input Summary

ELECTRONIC PCA DATA FOR ATTACHMENT 4

35 I.A.C. § 845: ALTERNATIVE SOURCE DEMONSTRATION
VERMILION POWER PLANT
NEW EAST ASH POND
OAKWOOD, IL

Well	HSU	Date	Well Type	pH (SU)	Alkalinity, bicarbonate (mg/L)	Barium (mg/L)	Boron (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
16A	BCU	04/01/2021	Downgradient	7.50	390	0.261	0.675	40.8	131	0.77	31	662
16A	BCU	04/21/2021	Downgradient	7.20	407	0.335	0.613	71.1	106	0.64	78	692
16A	BCU	05/11/2021	Downgradient	7.40	361	0.245	0.807	36.6	139	0.78	16	582
16A	BCU	06/03/2021	Downgradient	7.26	405	0.272	0.716	51.6	128	0.68	47	680
16A	BCU	06/17/2021	Downgradient	7.40	406	0.251	0.746	42.2	144	0.78	30	630
16A	BCU	07/08/2021	Downgradient	7.31	404	0.249	0.768	38	151	0.77	24	688
16A	BCU	07/27/2021	Downgradient	7.45	390	0.248	0.794	35.3	163	0.84	16	662
16A	BCU	08/17/2021	Downgradient	7.50	393	0.261	0.755	33.3	176	0.84	11	654
16A	BCU	11/29/2023	Downgradient	7.66	400	0.33	0.76	37	160	0.82	4.1	770
16A	BCU	02/21/2024	Downgradient	7.68	380	0.34	0.62	30	140	0.87	5.2	650
35D	BCU	04/01/2021	Downgradient	8.20	707	0.111	2.0	112	529	0.76	1640	3830
35D	BCU	04/21/2021	Downgradient	7.76	533	0.0294	1.8	93.6	281	0.65	1220	2920
35D	BCU	06/03/2021	Downgradient	7.25	637	0.0546	2.5	98.1	461	0.75	1300	3240
35D	BCU	06/17/2021	Downgradient	7.25	603	0.1400	1.8	99.4	393	0.75	1320	3170
35D	BCU	07/08/2021	Downgradient	7.22	582	0.0297	1.9	86	372	0.74	1230	2910
35D	BCU	07/27/2021	Downgradient	7.37	507	0.0263	1.5	70.4	234	0.79	981	2320
35D	BCU	08/17/2021	Downgradient	7.30	491	0.0269	1.41	65.7	199	0.76	895	2090
35D	BCU	11/29/2023	Downgradient	7.34	680	0.029	2.4	120	470	0.65	1700	4300
35D	BCU	02/21/2024	Downgradient	7.42	630	0.026	2.1	110	440	0.7	1600	3900
70D	BCU	04/01/2021	Downgradient	7.60	262	0.336	0.712	39.6	317	0.76	53	792
70D	BCU	04/21/2021	Downgradient	7.28	334	0.5210	1.01	48.1	517	0.57	48	1150
70D	BCU	06/03/2021	Downgradient	7.03	416	0.687	1.56	68.6	665	0.47	48	1570
70D	BCU	06/17/2021	Downgradient	7.14	443	0.726	1.33	73.1	680	0.5	49	1600
70D	BCU	07/08/2021	Downgradient	6.85	527	0.954	1.58	82.5	735	0.41	49	1770
70D	BCU	07/27/2021	Downgradient	6.96	540	0.734	1.54	78.1	745	0.44	48	1830
70D	BCU	08/17/2021	Downgradient	6.84	610	0.761	1.54	91.5	716	0.36	50	1940
70D	BCU	11/29/2023	Downgradient	6.98	580	0.42	1.4	84	550	0.43	47	1800
70D	BCU	02/21/2024	Downgradient	6.91	490	0.68	1.5	84	730	0.4	43	1900
71D	BCU	04/01/2021	Downgradient	7.60	258	0.299	0.58	37.7	172	0.92	44	896
71D	BCU	06/17/2021	Downgradient	7.15	475	0.4	1.1	28.7	563	0.73	72	1640
71D	BCU	08/17/2021	Downgradient	6.95	628	0.677	1.3	34.9	674	0.56	63	1900
71D	BCU	11/29/2023	Downgradient	7.09	770	0.7800	1.5	45.0	800	0.47	53	2400
22	BCU	04/01/2021	Upgradient	7.40	390	0.0723	0.41	41.5	23	0.43	34	484
22	BCU	04/20/2021	Upgradient	7.58	407	0.0798	0.418	37.5	11	0.4	27	476
22	BCU	05/10/2021	Upgradient	7.29	395	0.0795	0.433	45.7	11	0.42	30	494
22	BCU	06/03/2021	Upgradient	7.26	390	0.0787	0.361	48.3	7	0.38	29	450
22	BCU	06/17/2021	Upgradient	7.23	406	0.079	0.377	50.3	7	0.39	30	468
22	BCU	07/08/2021	Upgradient	7.20	412	0.082	0.3	47.7	7	0.37	30	476
22	BCU	07/27/2021	Upgradient	7.34	401	0.0795	0.311	48.2	7	0.39	30	486
22	BCU	08/17/2021	Upgradient	7.26	402	0.0785	0.34	47.1	7	0.38	29	474
22	BCU	11/28/2023	Upgradient	7.51	400	0.084	0.3	44	6.4	0.36	26	490
22	BCU	02/21/2024	Upgradient	7.40	410	0.084	0.4	46	7.7	0.37	29	490
10	UCU	04/01/2021	Upgradient	6.80	550	0.079	0.0587	182	6	0.13	292	942
10	UCU	04/21/2021	Upgradient	6.80	546	0.047	0.0587	193	6	0.14	309	1080
10	UCU	05/10/2021	Upgradient	6.76	476	0.068	0.053	160	4	0.14	224	850
10	UCU	06/03/2021	Upgradient	6.74	579	0.0795	0.0835	186	5	0.14	317	980
10	UCU	06/17/2021	Upgradient	6.76	550	0.0625	0.111	186	6	0.14	272	946
10	UCU	07/08/2021	Upgradient	6.69	561	0.068	0.0499	166	5	0.13	328	988
10	UCU	07/27/2021	Upgradient	6.80	550	0.0712	0.237	182	4	0.14	338	1010
10	UCU	08/17/2021	Upgradient	6.69	582	0.0772	0.0695	192	5	0.13	296	970
10	UCU	11/28/2023	Upgradient	7.03	510	0.11	0.059	160	4.6	0.15	230	890
10	UCU	02/20/2024	Upgradient	6.82	540	0.076	0.068	180	3.5	0.13	300	1100
70S	UU	04/01/2021	Downgradient	7.00	310	0.02	0.457	253	19	0.14	760	1450
70S	UU	04/21/2021	Downgradient	6.94	270	0.0205	0.403	281	17	0.14	840	1580
70S	UU	05/10/2021	Downgradient	6.99	262	0.0185	0.382	270	16	0.14	779	1480
70S	UU	06/03/2021	Downgradient	6.91	272	0.0165	0.424	245	15	0.14	673	1350
70S	UU	06/17/2021	Downgradient	6.85	278	0.0187	0.363	250	15	0.15	730	1340
70S	UU	07/08/2021	Downgradient	6.80	305	0.0172	0.253	220	14	0.16	589	1220
70S	UU	07/27/2021	Downgradient	7.01	287	0.0148	0.556	229	11	0.17	541	1140
70S	UU	08/17/2021	Downgradient	6.87	272	0.0195	0.538	232	15	0.16	638	1250
70S	UU	11/29/2023	Downgradient	7.16	280	0.02	0.63	220	20	0.17	670	1500
70S	UU	02/21/2024	Downgradient	6.93	310	0.024	0.43	210	11	0.13	600	1200
71S	UU	04/01/2021	Downgradient	6.90	422	0.05	0.18	115	2	0.18	68	486
71S	UU	04/21/2021	Downgradient	6.73	419	0.05	0.22	116	3	0.17	68	500
71S	UU	05/12/2021	Downgradient	6.84	403	0.05	0.23	124	3	0.18	69	474
71S	UU	06/03/2021	Downgradient	6.71	419	0.04	0.23	116	2	0.18	60	484
71S	UU	06/17/2021	Downgradient	6.76	422	0.04	0.22	117	2	0.19	65	502
71S	UU	07/08/2021	Downgradient	6.60	462	0.05	0.17	128	2	0.19	46	490
71S	UU	07/27/2021	Downgradient	6.83	421	0.05	0.25	132	2	0.20	60	538
71S	UU	08/17/2021	Downgradient	6.73	442	0.07	0.27	122	3	0.19	69	534
NED1	CCR	04/01/2021	CCR	9.20	1.5	0.0324	18.6	497	44	0.32	1340	2340
NED1	CCR	04/21/2021	CCR	8.86	4	0.029	19.3	472	32	0.38	1230	2130
NED1	CCR	05/11/2021	CCR	7.88	132	0.029	14	674	18	0.2	1300	2170
NED1	CCR	06/04/2021	CCR	7.55	117	0.0319	13.5	532	18	0.24	1400	2340
NED1	CCR	08/17/2021	CCR	8.73	18	0.0314	18.3	531	25	0.29	1510	2350
NED1	CCR	11/29/2023	CCR	8.04	210	0.230	10	470	11	0.15	1300	2500
NED1	CCR	02/21/2024	CCR	7.78	100	0.130	10	470	13	0.099	1300	2200
ND3	CCR	03/31/2021	CCR	8.70	99	0.060	32	291	10	0.2	953	1680
ND3	CCR	04/21/2021	CCR	8.38	65	0.059	30.3	310	9	0.16	984	1740
ND3	CCR	05/11/2021	CCR	8.35	68	0.038	31	332	8	0.15	970	1720
ND3	CCR	06/03/2021	CCR	7.93	115	0.027	28.5	333	7	0.15	1040	1790
ND3	CCR	08/17/2021	CCR	7.94	120	0.064	29.4	344	6	0.17	1050	1680
ND3	CCR	06/20/2023	CCR	8.40	71	0.023	29	303	9	0.24	933	1500
ND3	CCR	02/20/2024	CCR	8.25	93	0.025	28	330	6.5	0.14	1100	1700
OED1	CCR	06/03/2021	CCR	10.00	1.5	0.039	45.5	886	5	0.1	1890	3240
OED1	CCR	06/16/2021	CCR	10.20	1.5	0.034	46.7	838	4	0.1	1930	3170
OED1	CCR	07/08/2021	CCR	10.30	1.5	0.031	46.7	810	3	0.1	1960	3170
OED1	CCR	07/27/2021	CCR	10.30	1.5	0.026	35	886	3	0.1	1950	3220
OED1	CCR	08/17/2021	CCR	10.10	1.5	0.039	39.5	828	2	0.1	1910	3060
OED1	CCR	06/20/2023	CCR	10.10	1.5	0.038	49.2	834	2	0.04	1860	3130

Notes:
mg/L = milligrams per liter
TDS= Total Dissolved Solids
SU= standard units
HSU = hydrostratigraphic unit
CCR = coal combustion residual
BCU = Bedrock Confining Unit
UCU = Upper Confining Unit
UU = Upper Unit
Non-detect values were replaced with half of detection limit.

ATTACHMENT 6
PCA Analyses - Well 35D Results Excluded

ATTACHMENT 6 – ADDITIONAL PCA ANALYSES

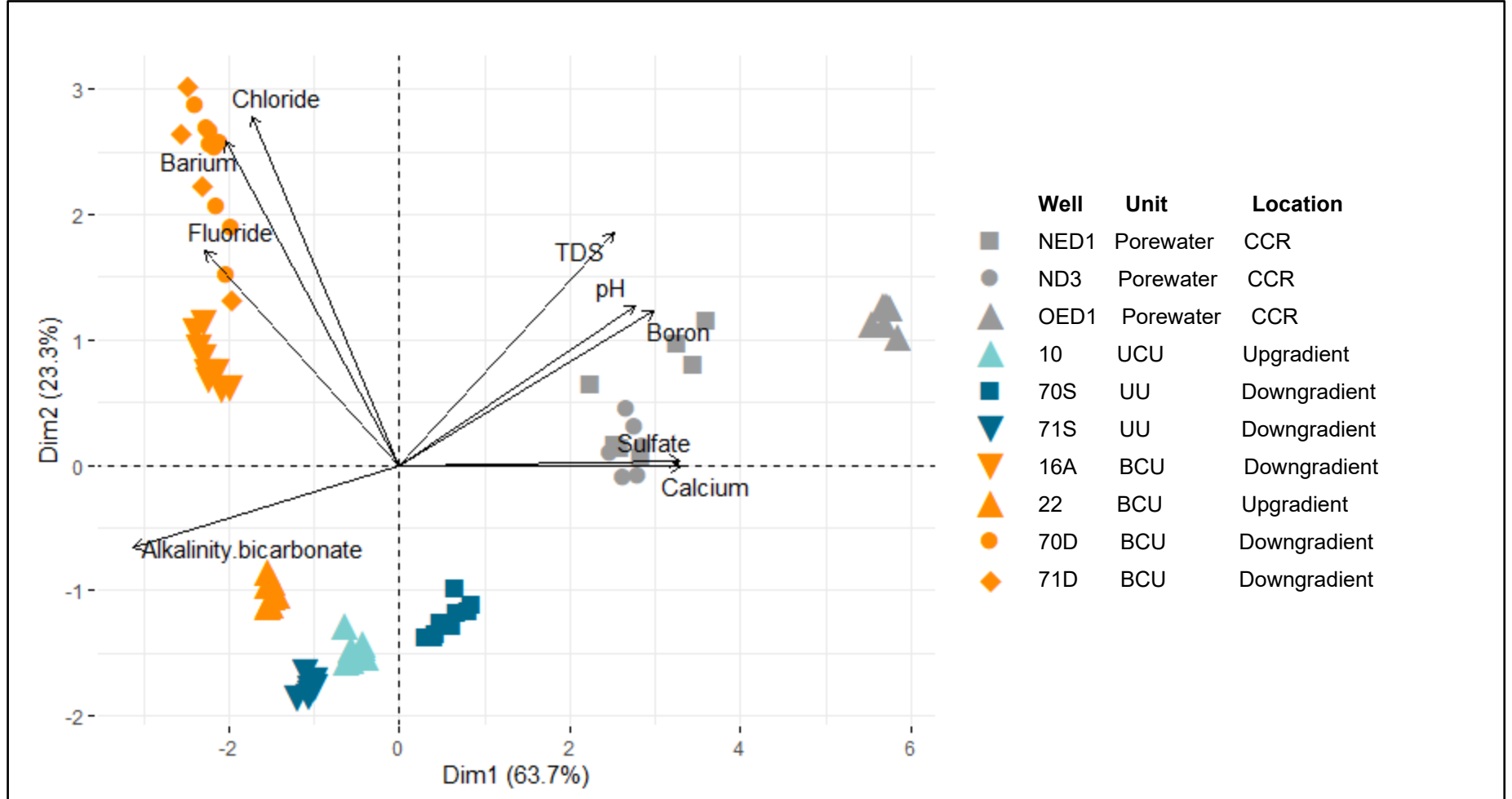
Due to anomalously high sulfate concentrations in well 35D¹, sulfate and TDS were excluded from both multivariate analyses described in the July 2024 *Evaluation of Alternative Sources for Total Dissolved Solids within Bedrock Solids* technical memorandum prepared by Geosyntec. Two additional scenarios which included sulfate and TDS but exclude 35D samples are presented herein. The evaluation included one analysis with porewater samples and one without porewater samples included.

The biplot for the scenario with porewater samples included is shown on **Attachment 6a** indicating that the porewater samples are clustered separately from the BCU, UCU, and UU samples. This finding is consistent with the scenario where both 35D and porewater samples were included (**Figure 3** of main text). As before, constituents such as boron and sulfate are responsible for the chemical signature of the porewater samples. The results of clustering analysis confirmed one cluster of porewater samples distinct from the combined BCU, UCU and UU groundwater sample cluster (**Attachment 6b**).

The biplot for the scenario without porewater samples is shown on **Attachment 6c** indicating that BCU samples cluster separately from the combined UCU and UU samples. This finding is consistent with the previous scenario where 35D samples were included and porewater was excluded (**Figure 6** of main text). Clustering, as shown in **Attachment 6d**, also confirmed distinct clustering of BCU samples from the UCU and UU samples.

These findings are consistent with the scenarios described in the main document, in which lithology is the main driver for the chemistry of the groundwater samples.

¹ Ramboll. 2023. *35 I.A.C. § 845.650(E): Alternative Source Demonstration – New East Ash Pond*. Vermilion Power Plant, Oakwood, Illinois. Ramboll Americas Engineering Solutions, Inc. December.



Notes:

- The arrows signify the correlations between the constituents and the principal components.
- Datapoints are colored based on hydrostratigraphic unit of sampling locations as follows:
 - Bedrock Confining Unit (BCU) wells: 16A, 22, 70D, 71D.
 - Upper Confining Unit (UCU) well: 10.
 - Upper Unit (UU) wells: 70S, 71S.
 - Coal Combustion Residual (CCR) well: NED1, ND3, OED1.

**Principal Components Analysis Biplot
(35D Excluded)**

Vermilion Power Plant – New East Ash Pond

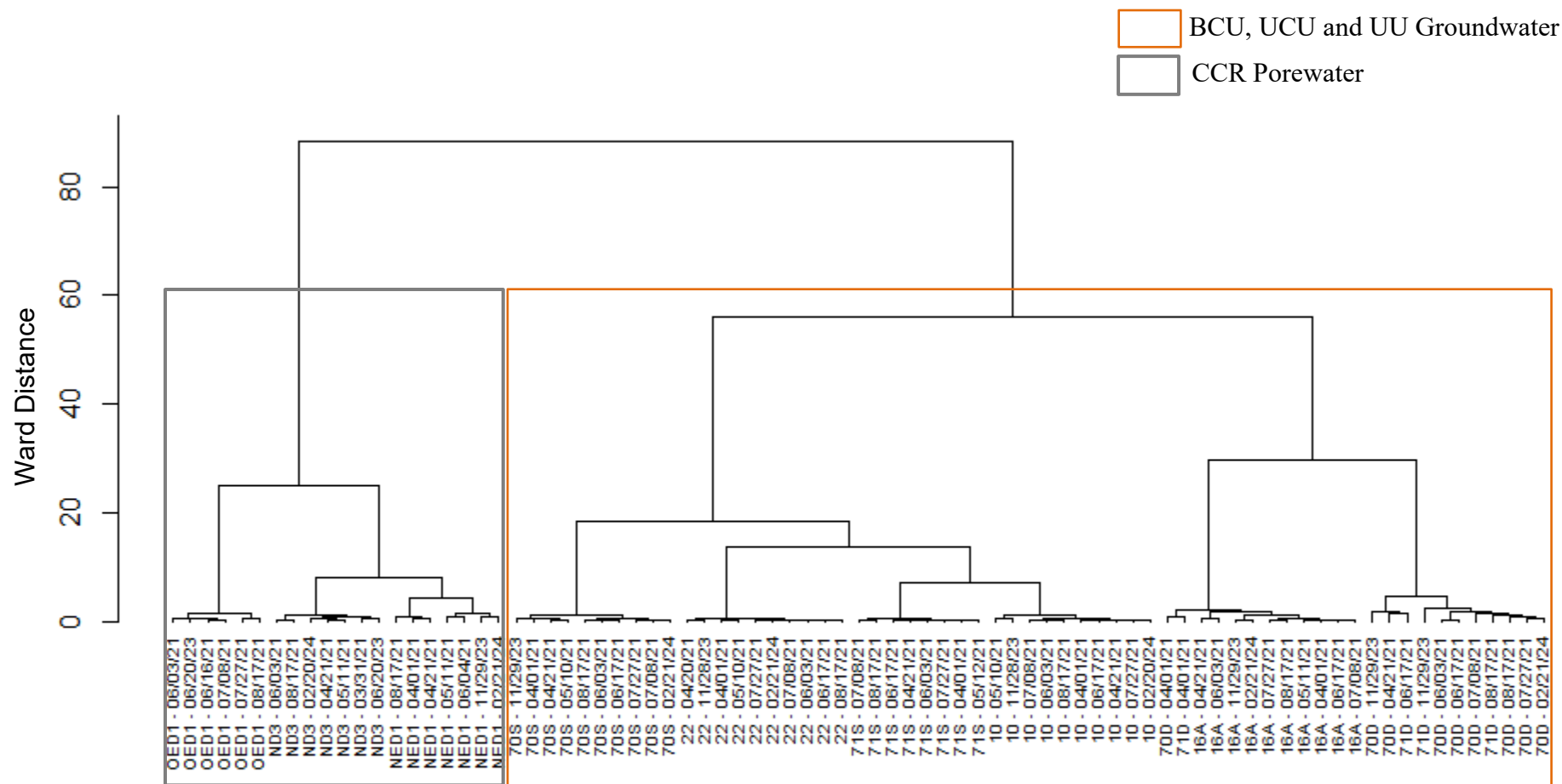
Geosyntec
consultants

Attachment

6a

Columbus, Ohio

July 2024



Notes:

1. The cluster analysis used Euclidean distances, and Ward's method as the clustering algorithm.
2. In the dendrogram, samples on the same branch are more similar to each other. The samples with the highest similarity are on the closest branches.
3. The boxes around the branches represent the two clusters into which samples from each source grouped.
4. BCU, UCU, UU and CCR refer to Bedrock Confining Unit, Upper Confining Unit, Upper Unit, and Coal Combustion Residual, respectively.

**Dendrogram Graph from Cluster Analysis
(35D Excluded)**

Vermilion Power Plant – New East Ash Pond

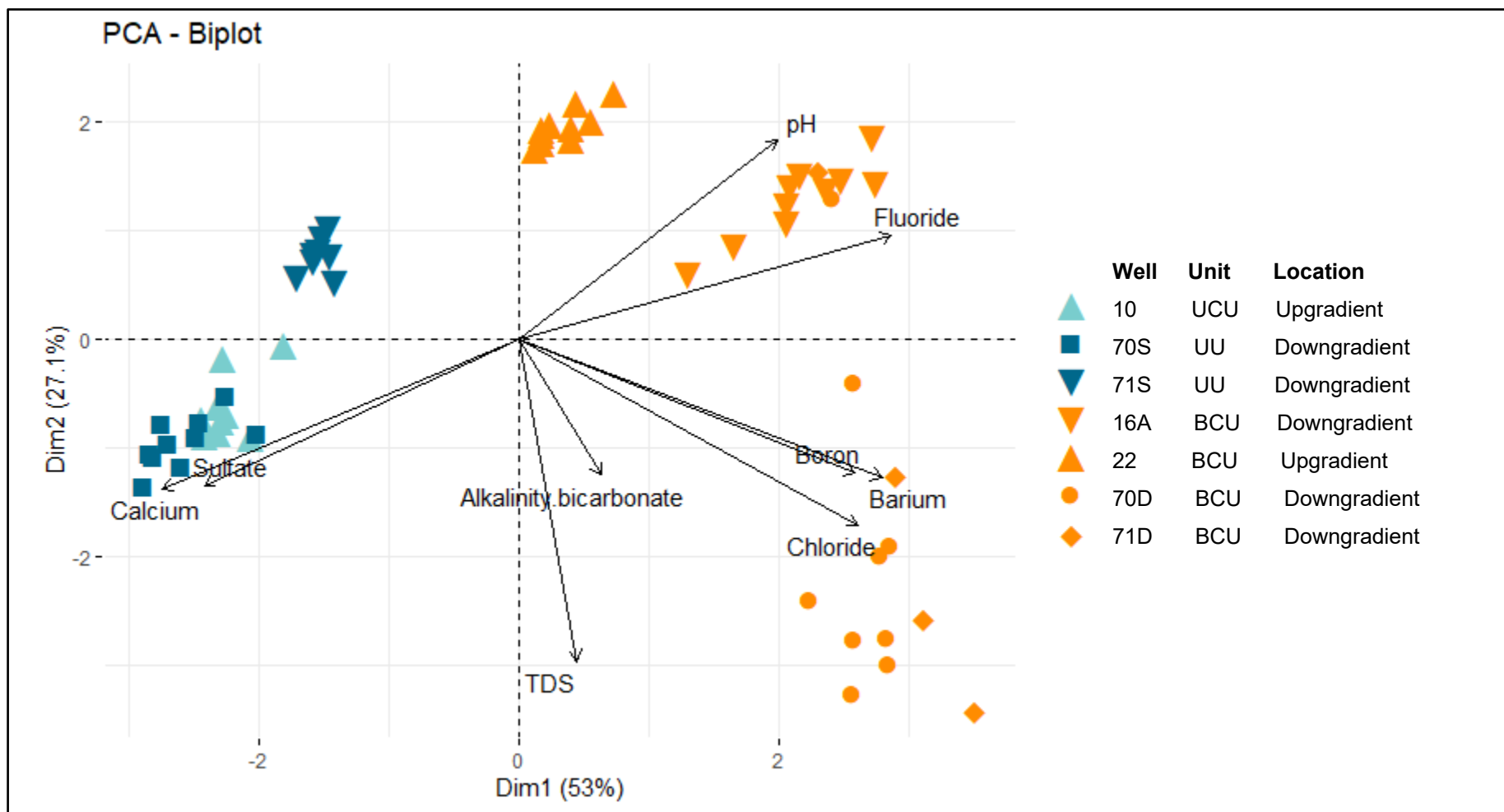
Geosyntec
consultants

Attachment

6b

Columbus, Ohio

July 2024



Notes:

1. The arrows signify the correlations between the constituents and the principal components.
2. Datapoints are colored based on hydrostratigraphic unit of sampling locations as follows:
 - Bedrock Confining Unit (BCU) wells: 16A, 22, 70D, 71D.
 - Upper Confining Unit (UCU) well: 10.
 - Upper Unit (UU) wells: 70S, 71S.

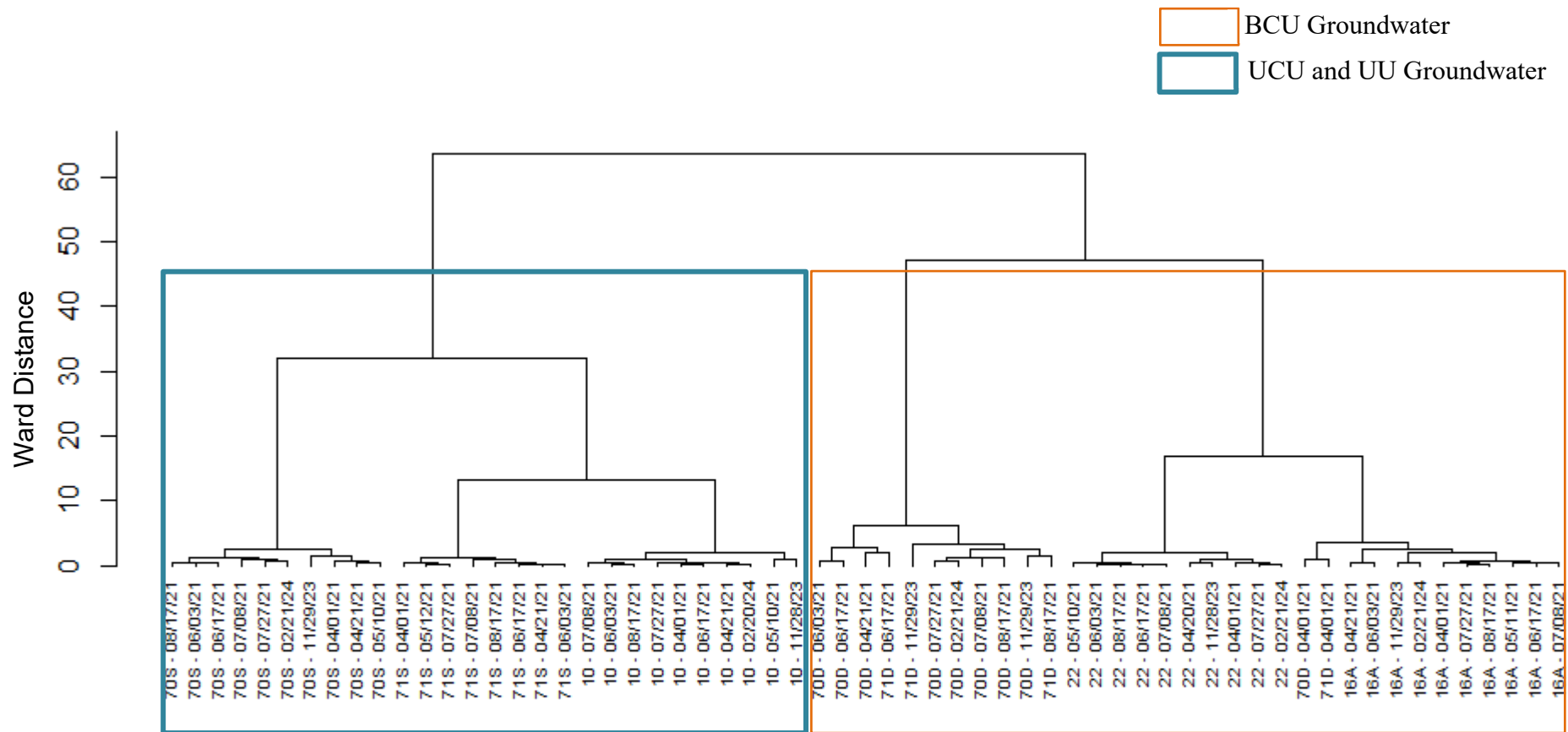
**Principal Components Analysis Biplot
(Porewater Wells and 35D are Excluded)**
Vermilion Power Plant – New East Ash Pond

Geosyntec
consultants

Columbus, Ohio

July 2024

Attachment
6c



Notes:

1. The cluster analysis used Euclidean distances, and Ward's method as the clustering algorithm.
2. In the dendrogram, samples on the same branch are more similar to each other. The samples with the highest similarity are on the closest branches.
3. The boxes around the branches represent the two clusters into which samples from each source grouped.
4. BCU, UCU and UU refer to Bedrock Confining Unit, Upper Confining Unit, and Upper Unit, respectively.

**Dendrogram Graph from Cluster Analysis
(Porewater Wells and 35D Excluded)
Vermilion Power Plant – New East Ash Pond**

Geosyntec
consultants

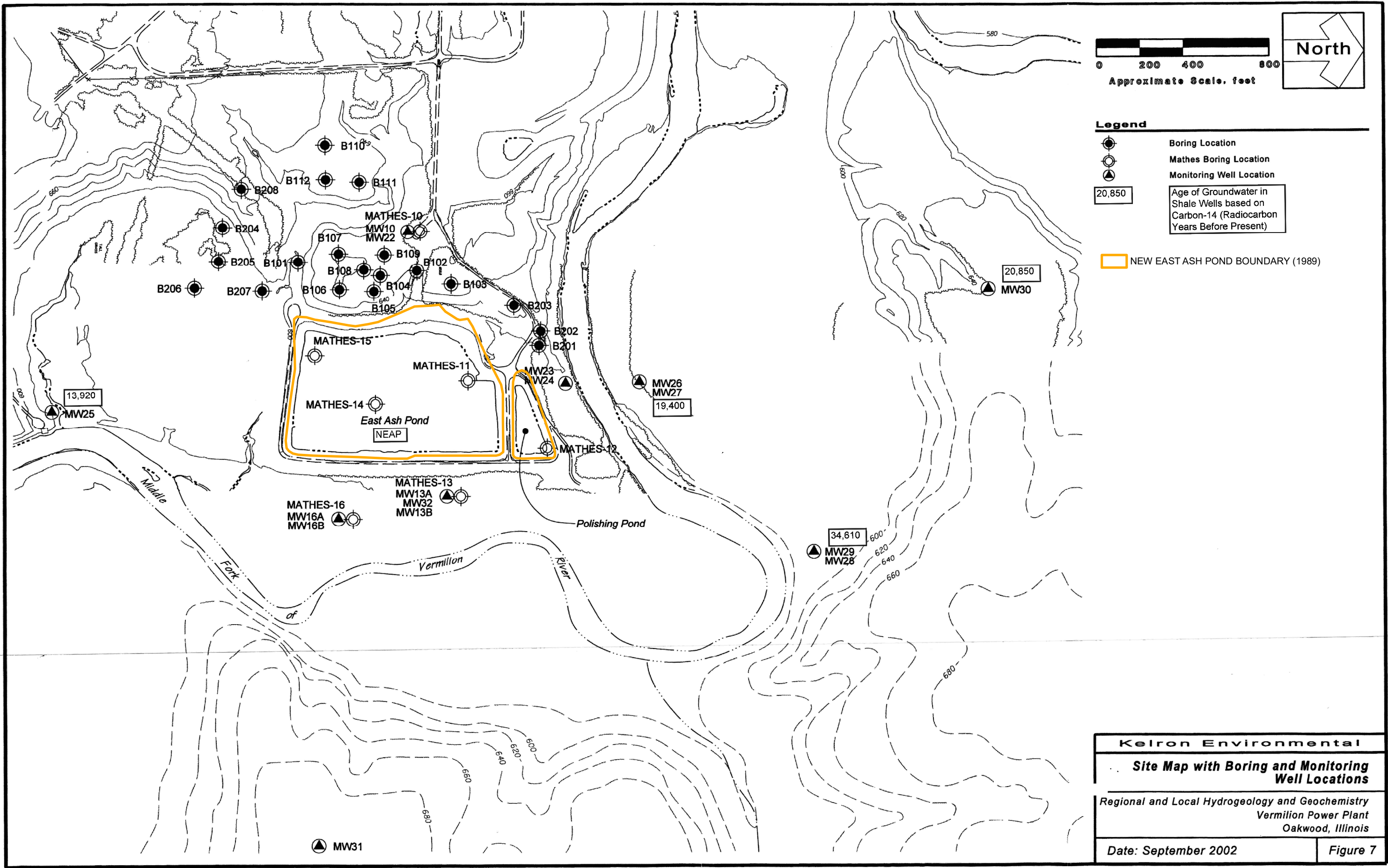
Columbus, Ohio

July 2024

Attachment

6d

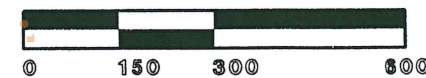
APPENDIX D
FIGURES 7, 9, AND 28 AND TABLE 6 FROM KELRON, 2003



A
West

A'
East

Boring:
MW31



Approximate Horizontal Scale: 1 in = 300 ft.
Approximate Vertical Scale: 1 in = 25 ft.
Vertical Exaggeration: 12x

Legend

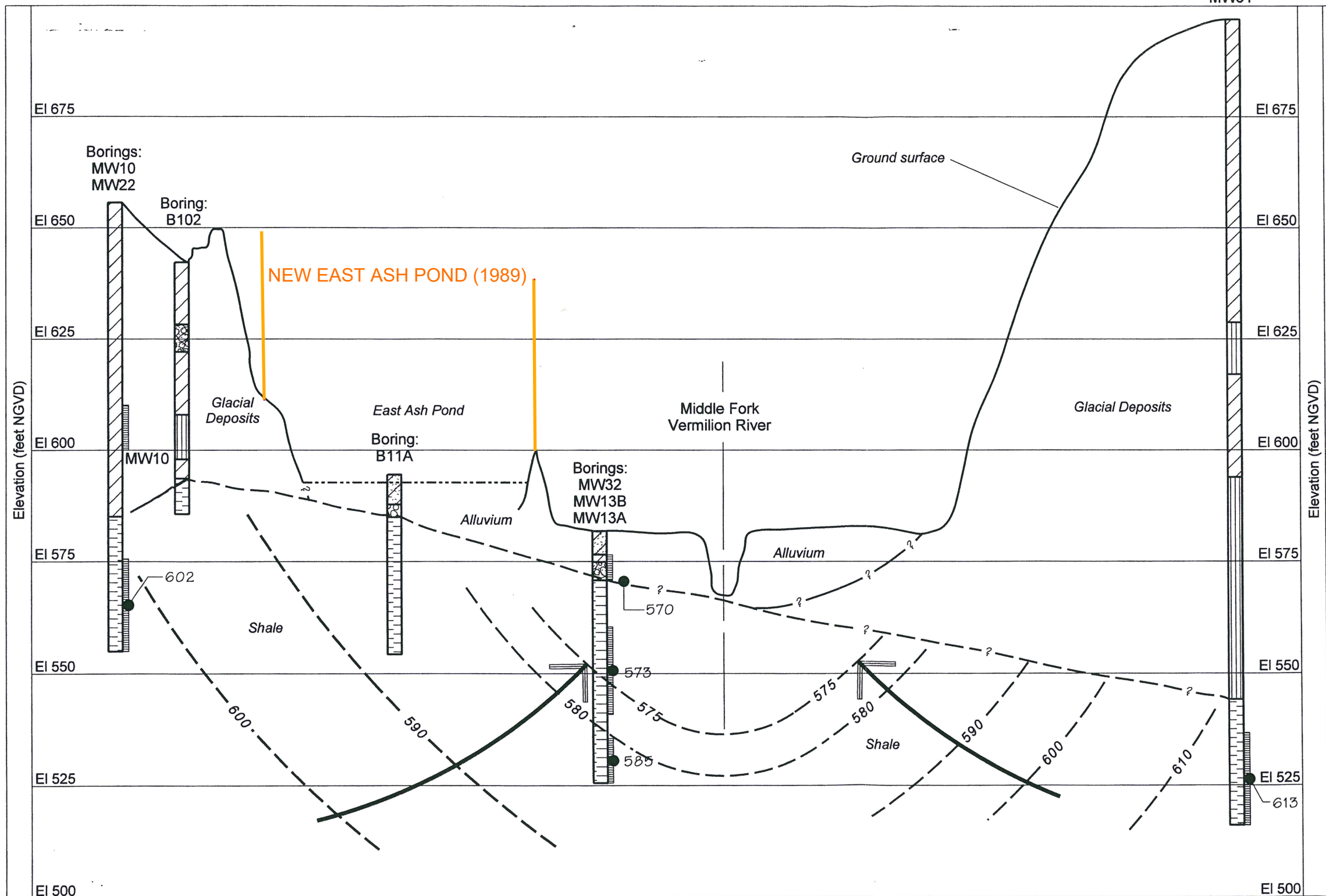
Geology

CL		Clay, silty clay, sandy clay, gravelly clay
ML		Silts, clayey silts
SC-SM		Clayey to silty sand
SP-SW		Sand, gravelly sand
GC-GM		Gravel with silt and/or clay
GP-GW		Gravel; gravel-sand mix
SH		Shale



Monitoring Well Screen Interval

Estimated Equipotential Lines
(Lines of Equivalent Head)



Kelron Environmental

**Equipotential Lines and Flowlines for
Groundwater in the Shale Based on
Observed Hydraulic Head in January 2002**

Regional and Local Hydrogeology and Geochemistry
Vermilion Power Plant
Oakwood, Illinois

Date: September 2002

Figure 28

Table 6. Vertical Groundwater Gradients in Shale and Between Shale and Alluvium

Regional and Local Hydrogeology and Geochemistry
Vermilion Power Plant, Illinois

Monitoring Wells for Gradient Calculations with Screened Formations		Groundwater Level Measurement Date During 2002								8-month Average
		22-23 Jan	18-Feb	19-21 March	16-17 April	22-May	18-Jun	16-Jul	27-Aug	
MW13B alluvial	MW13A shale	alluvial dry	-0.048	-0.048	-0.041	0.003	-0.044	-0.061	-0.064	-0.043
MW13A shale	MW32 shale	-0.615	-0.605	-0.598	-0.612	-0.588	-0.619	-0.524	-0.523	-0.585
MW16B alluvial	MW16A shale	alluvial dry	alluvial dry	0.031	0.040	alluvial dry	-0.012	alluvial dry	alluvial dry	0.020
MW23 alluvial	MW24 shale	0.317	0.386	0.351	0.355	0.346	0.294	0.284	0.275	0.326
MW26 alluvial	MW27 shale	-0.053	-0.020	0.001	0.008	0.032	-0.010	-0.048	-0.052	-0.018
MW28 alluvial	MW29 shale	-0.240	-0.231	-0.222	-0.223	-0.213	-0.240	-0.251	-0.204	-0.228

Notes: **-0.615** Vertical gradient is upwards between the screened well intervals and formations indicated.
 0.386 Vertical gradient is downwards between the screened well intervals and formations indicated.
 alluvial dry Shallow alluvial monitoring well did not have a measurable water level on the date indicated.