To: Operating Record

From: Harold D. Register, Jr.
Risk Management

Date: October 10, 2025

Subject: DE Karn Bottom Ash Pond Coal Combustion Residual (CCR) Unit
40 CFR 257.97(a) Selection of Remedy Report

CC: Heather Prentice, Risk Management

WSP USA Inc. (WSP), on behalf of Consumers Energy (CE), has prepared the enclosed Final Selection of Remedy Report (Report) for the former DE Karn Bottom Ash Pond CCR Unit as a requirement of §257.97(a) of 40 CFR Parts 257 and 261, Disposal of Coal Combustion Residuals from Electric Utilities, under Subtitle D of the Resource Conservation and Recovery Act (RCRA), also known as the Coal Combustion Residuals (CCR) Rule. The Karn Bottom Ash Pond was formerly the primary settling/detention structure for the National Pollutant Discharge Elimination System (NPDES) Treatment System prior to discharge and temporary storage for CCRs prior to disposal in one of the on-site, licensed disposal facilities governed by Natural Resources and Environmental Protection Act, 1994 PA 451, Part 115, Solid Waste Management, MCL 324.11501 et seq. (Michigan Solid Waste Statute)

Per §257.97(a), the enclosed Report describes the remedy selected along with how the remedy meets the standards set forth in §257.97(b) for the former Karn Bottom Ash Pond, which had triggered an Assessment of Corrective Measures (ACM) under the CCR Rule. The ACM is required pursuant to §257.96 whenever an Appendix IV constituent has been detected at a statistically significant level exceeding the established federal groundwater protection standard (GWPS). CE reported statistically significant exceedances above the GWPS within the certified compliance well network for one Appendix IV constituent, arsenic, in the "*Notification of Appendix IV Constituent Exceeding Groundwater Protection Standard per §257.95(g)*" (Consumers Energy Company, January 2019).

Unit with GWPS Exceedance	Constituent	# of Downgradient Wells Observed
Karn Bottom Ash Pond	Arsenic	5 of 6

Subsequently, the "*Assessment of Corrective Measures Report*" (ACM) (TRC, September 2019) was completed on September 11, 2019, for the Karn Bottom Ash Pond. Five remedial approaches were evaluated and presented based on source control by removing CCR in the former bottom ash pond. Semi-annual progress reports have been prepared in accordance with §257.97(a) to describe progress toward selecting and designing remedies and are available on the CE CCR Rule Compliance Data and Information public-facing website.

Final Remedy Selection

The ACM Report identified source removal as the primary corrective action for the former Karn Bottom Ash Pond and retained five technically feasible groundwater management alternatives for further evaluation to address the potential for residual arsenic. Section 5.0 of the enclosed Report reviews the alternatives evaluated as follows:

- Source Removal with Post Remedy Monitoring
- Source Removal with Groundwater Capture/Control
- Source Removal with Impermeable Barrier
- Source Removal with Active Geochemical Sequestration
- Source Removal with Passive Geochemical Sequestration

Section 6.0 of the enclosed Report goes into detail of how each of the potential remedies align with the standards of §257.97(b), which specifies that remedies must:

- Be protective of human health and the environment;
- Attain the groundwater protection standard as specified pursuant to §257.95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with standards for management of wastes as specified in §257.98(d).

Conclusion

The enclosed Report was submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Materials Management Division (MMD) for review and discussion prior to scheduling a public meeting to discuss the evaluated remedies. A public meeting was conducted on September 2, 2025 at the Charter Township of Hampton Trustees Regular Meeting

where the results of the corrective measures assessment were discussed (Board Agenda and Presentation enclosed). In addition to responding to questions during the Board meeting, a period of 30-days was provided to take questions prior to the final remedy selection, as required under §257.96(e). No questions were received by Consumers Energy during the required 30-day period following the public meeting prior to selecting the final remedy.

Therefore, The Source Removal with Passive Geochemical Sequestration remedy for the former Karn Bottom Ash Pond has been formally selected per §257.97 to meet the performance standards set forth in §257.97(b). Further, the remedy evaluation factors set forth in §257.97(c) have been considered in the context of the "*DE Karn Generating Facility Bottom Ash Pond CCR Removal Documentation Report*" (Golder, 2019) that demonstrates CCR removal has been completed to prevent further releases of Appendix IV constituents into the environment. Additionally, post-excavation groundwater monitoring data demonstrates the effectiveness of the source removal towards initially making progression towards attaining the GWPS and being protective of human health and the environment. Therefore, the schedule for implementing and completing the remedy required by §257.97(d) has been presented in Section 9.0 of the enclosed Report.

The enclosed Report has been certified by a qualified professional engineer pursuant to §257.97(a). The report has been completed and placed in the operating record as required by § 257.105(h)(12).

Enclosures

Charter Township of Hampton Trustees. September 2025. Regular Board Meeting Agenda.

Consumers Energy Company. September 2025. Proposed Remedy Selection, Former DE Karn Bottom Ash Pond.

WSP USA Inc. July 2025. Remedy Selection Report - Bottom Ash Pond Alternatives Assessment for Groundwater Corrective Action, Consumers Energy - Karn Complex.

References

Consumers Energy Company. April 25, 2018. Initiation of Assessment Monitoring Program under §257.94(e)(3).

Consumers Energy Company. January 14, 2019. Notification of Appendix IV Constituent Exceeding Groundwater Protection Standard per §257.95(g), DE Karn Bottom Ash Pond CCR Unit.

EGLE. April 2018. Consumers Energy Company D.E. Karn Bottom Ash Closure Work Plan dated April 9, 2018.

EGLE. November 2020. Closure Certification, Consumers DE Karn Bottom Ash Pond, Bay County, Waste Data System No. 392503.

Golder Associates. January 2018. DE Karn Generating Facility Bottom Ash Ponds Closure Plan, Essexville, Michigan. Prepared for Consumers Energy Company.

Golder Associates Inc. April 2018. DE Karn Generating Facility Bottom Ash Pond Closure Work Plan, West Olive, Michigan. Prepared for Consumers Energy Company.

Golder Associates. October 2019. DE Karn Generating Facility Bottom Ash Pond CCR Removal Documentation Report. Prepared for Consumers Energy Company.

TRC. September 2019. Assessment of Corrective Measures, Consumers Energy Company DE Karn Bottom Ash Pond Coal Combustion Residual Unit. Prepared for Consumers Energy Company.

AGENDA
CHARTER TOWNSHIP OF HAMPTON
TUESDAY, SEPTEMBER 2, 2025
REGULAR MEETING
7:00 P.M.

CALL MEETING TO ORDER, PLEDGE TO THE FLAG & INVOCATION

ROLL CALL:

APPROVAL OF AGENDA/CHANGES TO AGENDA:

APPROVAL OF MINUTES: A. Regular Meeting Minutes 8.4.25

COMMUNICATIONS : A. DPW Report- August 2025
B. Public Safety Report- August 2025

AUDITOR'S REPORT : Foret & Klass

OPEN TO THE PUBLIC:

OLD BUSINESS:

NEW BUSINESS:
A. Consumer's Energy- DE Karn Bottom Ash Pond Remediation
B. Finn Road Improvement DNR Grant- Declaration & Notice
C. Officer Wheaton Resignation
D. Police Academy Cadet Sponsorship
E. USDA Reimbursement Request #12
F. Automatic Mutual Aid with City of Essexville

STANDING COMMITTEE REPORTS:

ATTORNEY'S REPORT:

OFFICER/TRUSTEE/DEPT. HEAD/COMMISSIONER REPORTS:

A. **CLERK:** A. August 2025 Revenue & Expenditure Report
B. **TREASURER:**
C. **TRUSTEES:**
D. **SUPERVISOR:**
E. **PUBLIC WORKS SUPERINTENDENT:**
F. **PUBLIC SAFETY DIRECTOR:**
G. **COUNTY COMMISSIONER:**

OPEN TO THE PUBLIC:

ADJOURNMENT:

In order to make sure everyone gets a chance to address the Board, we are limiting each person's time to speak for a total of 2 minutes.

Proposed Remedy Selection
Former DE Karn Bottom Ash Pond

September 2, 2025

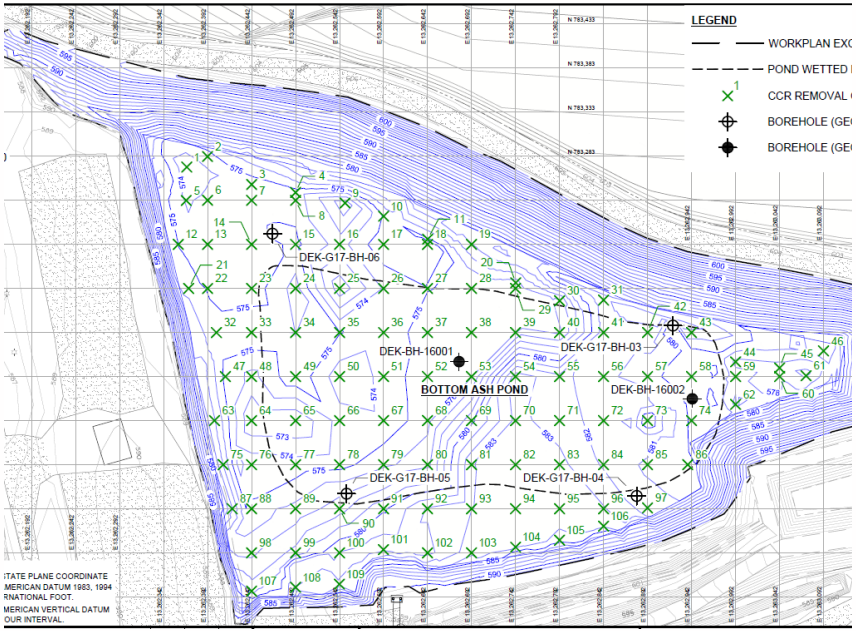
Consumers Energy
Count on Us®

Agenda

- Background and purpose
- Site features
- Remedial strategies evaluated
- Remedial strategies retained
- Remedial responses implemented
- Closing

Background and Purpose

- Consumers completed an Assessment of Corrective Measures focusing on excavation of coal combustion residuals (CCR) in 2019
- Consumers documented the removal of CCRs from the former bottom ash pond in a report submitted to EGLE in 2020
- Consumers is now proceeding with the next procedural step toward closing and remediating the former bottom ash pond



Removal of CCR from former Karn Bottom Ash Pond

Site features

What remedial strategies were evaluated?

Remedial Option	Example
1. Post CCR Removal Monitoring	Monitored Natural Attenuation
2. Groundwater Capture and Control	Pump & Treat
3. Impermeable Barrier	Soil-Bentonite Slurry Wall
4. Active Treatment	Air Sparge
5. Passive Treatment	Treatment Wall or In Situ Injection

How were the remedial strategies selected?

- Feasibility study completed to evaluate remedial options
  - Conducted groundwater and geochemical modeling
  - Considered factors:
    - Effectiveness,
    - Implementability,
    - Schedule, and
    - Cost

- Developing Pilot Study to evaluate:
  - Conditions for injecting iron to treat arsenic
  - Quantity of iron necessary to treat arsenic

- Results from the Pilot Study will be used to “scale-up” to a full-scale remedy

How are remedial responses being implemented?

- Primary remedial response – CCR Removal
  - CCR from former bottom ash pond removed in 2020
  - Three lines of evidence used to document that CCR has been removed
  - Documentation provided to EGLE

- Secondary remedial response – Passive Treatment
  - Pilot study (injection + monitoring) in 2026
  - Design and scale-up in 2027
  - Implement full-scale remedy upon Remedial Action Plan approval from EGLE

Thank you!

Madison Jarmon – Community Affairs Manager
Madison.Jarmon@cmsenergy.com

Dena Isabell – Stakeholder Engagement Manager
Dena.Isabell@cmsenergy.com

REPORT

Remedy Selection Report - Bottom Ash Pond Alternatives Assessment for Groundwater Corrective Action

Consumers Energy - Karn Complex

Submitted to:

Consumers Energy Company

Submitted by:

WSP USA Inc.
15851 South US 27 Suite 50 Lansing
Michigan 48906

517 482 2262

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July 2025

Executive Summary

This Remedy Selection Report (RSR) contains an Alternatives Analysis (AA) for groundwater at the former Bottom Ash Pond (BAP) at Consumers Energy Company's (Consumers') D.E. Karn Electrical Power Generating Facility (generating facility) was prepared to address arsenic-impacted groundwater at the BAP, a former treatment unit (settling basin) within the National Pollutant Discharge Elimination System (NPDES) permitted system that settled commingled plant process waters and bottom ash within a defined area (Golder, 2018). The BAP and generating facility are within the larger Karn Complex (Figure 1).

The materials collected in the BAP were defined as "other wastes regulated by statute" under state solid waste rules, exempting the management of liquid industrial waste from solid waste licensing in lieu of the NPDES Permit. However, sludges and residues generated from disposal would be subject to applicable solid waste requirements. Therefore, this treatment and storage area was closed in 2018 by excavating coal ash to an extent where health-based criteria were met, which was certified through multiple lines of evidence (Golder, 2019). EGLE accepted the closure of the Karn Bottom Ash Pond on November 30, 2020, (EGLE, 2020).

This RSR, describing the potential remedial groundwater activities at the former BAP in addition to removing the CCR source material, is being pursued to fulfill Consumer's obligations related to:

- Monitoring conducted in accordance with Hydrogeological Monitoring Plan Rev. 03 (Karn Landfill HMP, Consumer's, 2017) pursuant to Part 115 and Part 201 of the 1994, as amended (Parts 115 and 201, respectively, of Act 451)
- The administrative rules promulgated pursuant thereto, and
- The requirements under MCL 324.11519b(9)(b) in compliance with the provisions of section 20114b of Part 201.

Previous closure and response activities that Consumers has completed specific to the BAP have included ash removal and capping. The remedial response actions evaluated in this AA address potential migration of arsenic in groundwater from the former BAP to off-site surface water via the groundwater-surface water interface (GSI) exposure pathway. Currently there are no risk-based remediation standards being considered for the Site and therefore the drinking water exposure pathway for the BAP area is a relevant exposure pathway.

Using observations from site investigation and remediation activities performed at the BAP, a conceptual site model (CSM) was developed for site-specific post-closure conditions. The CSM includes a description of the current understanding of geologic, geotechnical, hydrologic, groundwater quality, fate and transport of constituents, and Site constraints. A list of eight (8) remedial alternatives were qualitatively screened against the CSM using implementability, effectiveness and source control/reduction as screening criteria to recommend specific alternatives to carry forward for further evaluation. Following the initial evaluation of potential remedial alternatives, two alternatives, 1) chemical approaches using in-situ injections (ISI) and 2) the presumptive remedy for groundwater remediation, hydraulic containment using pump and treatment (P&T) were selected for detailed evaluation following 40 CFR § 257.96 for use at the Site. The results of the detailed evaluation recommend employing an ISI program with zero-valent iron (ZVI) to sequester the mass and movement of arsenic towards potential receptors.

Table of Contents

Tables

Figures

Appendices

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a licensed Professional Engineer under the laws of the state of Michigan.

Gary Daniels
PE License No. 6201049144

Abbreviations

µg/L	micrograms per liter
µM	micrometer
3D	three-dimensional
Barr	Barr Engineering Co.
BAP	Bottom Ash Pond
bay	Saginaw Bay
CCR	coal combustion residuals
Consumers	Consumers Energy Company
CQA	construction quality assurance
CSBR	continuously stirred batch reactor
CSM	conceptual site model
EBCT	empty bed contact time
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EVS	Earth Volumetric Studio
feet/day	feet per day
FS	feasibility study
generating facility	D.E. Karn Electrical Power Generating Facility
Geosyntec	Geosyntec Consultants
Golder	Golder Associates Inc.
groundwater model	groundwater flow model
GSI	groundwater-surface water interface
Hach® Test	Hach® low-range arsenic field test
HMP	Hydrogeological Monitoring Plan
IFB	Issued-for-Bid
MDEQ	Michigan Department of Environmental Quality
MDOT	Michigan Department of Transportation
mg/kg	milligrams per kilogram
mL	milliliter
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PRB	permeable reactive barrier
psf	pounds per square foot
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RSR	Remedy Selection Report
river	Saginaw River
SESC	Soil Erosion and Sedimentation Control
s.u.	standard units
TOC	total organic carbon
ZVI	zero-valent iron

1.0 INTRODUCTION

On behalf of Consumers Energy Company (Consumers), WSP prepared this *Remedy Selection Report* (*RSR*) for groundwater corrective action at the former Bottom Ash Pond (BAP) at Consumers Energy Company's (Consumers') D.E. Karn Electrical Power Generating Facility (generating facility). This RSR was prepared to address arsenic-impacted groundwater at the BAP, a former treatment unit (settling basin) within the NPDES that settled commingled plant process waters and bottom ash within a defined area (Golder, 2018). The BAP and generating facility are within the larger Karn Complex (Figure 1).

As documented here, Consumers has completed a detailed evaluation of corrective measures to address a single constituent (arsenic) in groundwater at concentrations above the generic Groundwater Protection Standard (GWPS), set at the USEPA drinking water MCL of 10 ug/L). The evaluation was completed in accordance with the United States Environmental Protection Agency's (USEPA's) Coal Combustion Residuals (CCR) Rule, 40 Code of Federal Regulations (CFR) Parts 257 effective October 19, 2015 (CCR Rule).

This RSR includes an overview of ongoing geologic and hydrogeologic investigations to refine the conceptual site model (CSM), identifies the Appendix IV constituent detected in groundwater (arsenic) at a concentration above the generic GWPS, discusses the nature and extent of this inorganic constituent in groundwater, evaluates potential corrective measures to address arsenic in groundwater, and presents a proposed groundwater remedy for preliminary review by EGLE, consisting of geochemical approaches (in-situ injections, ISI) for treatment of arsenic in groundwater. Once an approved remedy is selected and implemented, the remediation will be monitored routinely and evaluated under the corrective action monitoring program. The selected remedy may require modification or adjustment based on monitoring results, as appropriate.

2.0 BACKGROUND

2.1 Unit Description

The BAP was a treatment unit (settling basin) within the NPDES that settled commingled plant process waters and bottom ash within a defined area (Golder, 2018). The materials collected in this unit were defined as "other wastes regulated by statute" under state solid waste rules, exempting the management of liquid industrial waste from solid waste licensing in lieu of the NPDES Permit. However, sludges and residues generated from disposal would be subject to applicable solid waste requirements. Therefore, this treatment and storage area was closed in 2018 by excavating coal ash to the extent where health-based criteria were met (Figure 2), which was certified through multiple lines of evidence and documented in a *Closure Certification Report* (Golder, 2019). EGLE accepted the closure of the Karn Bottom Ash Pond on November 30, 2020 (EGLE, 2020).

The BAP is part of the larger Karn Complex and is zoned for industrial use, and the applicable cleanup category for this RSR is limited non-residential following Michigan Part 201 Rule. However, the generic GWPS for the BAP will be the MCL for arsenic, 10 ug/L. The selected remedy, proposed herein, is intended to meet the requirements of 40 CFR § 257.97 and to fulfill Consumers' obligations related to monitoring conducted in accordance with *Hydrogeological Monitoring Plan, Rev. 04* (HMP-R4), submitted to EGLE (via email transmittal on November 4, 2025) under Parts 115 and 201 of the Michigan Natural Resources and Environmental Protection Act of 1994 (Michigan Public Act 451), as amended, and the administrative rules promulgated pursuant thereto.

The generating facility is located at 2742 N. Weadock Highway in Essexville, Michigan, east of the Saginaw River (river) on the south end of the bay. Adjacent to the BAP, but not evaluated for remedial responses for this report,

are the former Karn Landfill and the former Karn Lined Impoundment (KLI), and the former Karn 1&2 Chemical Treatment Ponds.

The materials collected in this unit were defined as “other wastes regulated by statute” under state solid waste rules, exempting the management of liquid industrial waste from solid waste licensing in lieu of the NPDES Permit. However, sludges and residues generated from disposal would be subject to applicable solid waste requirements. Therefore, this treatment and storage area was closed in 2018 by excavating coal ash to an extent where health-based criteria were met, which was certified through multiple lines of evidence (Golder, 2019). EGLE accepted the closure of the BAP on November 30, 2020 (EGLE, 2020).

2.2 Other Units

2.2.1 Karn Landfill

The Karn Landfill received sluiced bottom ash and fly ash from the coal-fired units at the generating facility starting in the late 1950s. Construction Permit No. 0195 (Construction Permit) formalized the Karn Landfill construction consisting of breakwater dikes from the shoreline at the plant lakeward to enclose shallow, submerged, bay-bottom land (Natural Resource Technology, Inc., 2002). The perimeter embankment dikes were constructed using native materials ranging from silty clay to coarse sand, were topped with materials to support light-duty road traffic, and are armored on the shoreward and channel side. The Construction Permit also established the engineering and operational conversion of hydraulic deposition to controlled moisture placement to achieve maximum density deposition. The conversion to dry fly ash handling operations was completed in February 2009 (AECOM, 2009).

Consumers started to close portions of the Karn Landfill in 2012 after EGLE approved revisions to the final closure plan incorporating a geomembrane cover (AECOM, 2012). Subsequent revisions of the closure plan were submitted in 2014 that included a revised final cover grading plan to optimize regrading of material within the Karn Landfill and the construction of a final cover system to promote positive drainage (Consumers, 2014). Consumers Energy certified the final phase of closure (Consumers, 2020) in 2019, culminating in approval of all phases of Karn Landfill closure by EGLE on June 24, 2020, and initiating the 30-year post-closure care period.

Groundwater remediation at the Karn Landfill was evaluated in a Remedial Action Plan (RAP) submitted to EGLE, and approved in July 2023 (Barr, 2023). The approved remedial response is to remove arsenic from groundwater by installing a permeable reaction barrier (PRB) comprised of zero-valent iron (ZVI) perpendicular to groundwater flow along the northern perimeter embankment dike. A Remedial Action Plan Issued-for-Bid Construction Package (IFB Package) was prepared to supplement the RAP and was submitted to EGLE on July 26, 2024 (WSP, 2024) and approved by EGLE on September 5, 2024.

2.2.2 Karn Lined Impoundment

The KLI was a double-lined, double-composite storage pond (TRC, 2018) that included a primary and secondary leachate collection system that went into service in June 2018 to replace the BAP. The KLI is licensed to receive coal ash materials after December 28, 2020, authorized by Solid Waste Operating License No. 9629. Bottom ash was periodically excavated, and then removed materials were stacked and allowed to dewater prior to being loaded and hauled for disposal at the JC Weadock Landfill.

2.2.3 Karn 1&2 Chemical Treatment Facility

The Karn 1&2 Chemical Treatment Facility consisted of two treatment basins: an equalization basin (south pond) and a treatment basin (north pond). This treatment facility was constructed in 1978 (Chas. T. Main of Michigan, Inc., 1976) based on changes in the NPDES system that required treatment and characterization of boiler chemical cleaning wastes prior to discharge. The materials collected in this unit were defined as “other wastes regulated by statute” under state solid waste rules, exempting the management of liquid industrial waste from solid waste licensing in lieu of the NPDES Permit. However, sludges and residues generated from treatment and disposal would be subject to applicable solid waste requirements. These ponds were closed in 2014 by removing all liquid and solid waste residues and documenting the excavation of the liner systems to native soil.

2.3 Groundwater Monitoring

Consumers performs routine groundwater monitoring pursuant to the HMP (Consumers, 2017). Groundwater monitoring at the Karn Complex commenced in 1983 when the first monitoring wells were installed. The Michigan Water Resources Commission issued a Determination of Permit Exemption No. GWE – 0005 on August 21, 1986 (State of Michigan Department of Natural Resources Water Resources Commission, 1986) that documented: 1) groundwater at the site overlies an unusable aquifer and 2) discharges were adequately regulated by the National Pollutant Discharge Elimination System (NPDES) permit and solid waste operating licenses issued under Act 641 of Public Act of 1978. Monitoring wells MW-18 and MW-19 (formerly MW-10 and MW-11) continue to be sampled on a quarterly basis to validate no change in discharge standard under the exemption.

In February 2002, the Michigan Department of Environmental Quality (MDEQ, now referred to as EGLE) issued a Letter of Warning raising concerns related to possible water quality issues associated with coal ash materials, including arsenic, venting into the bay. Consumers completed a detailed investigation and characterization in September 2005 of the discharge, culminating in a determination that the groundwater-surface water interface (GSI) pathway was relevant and could be protected through an authorized groundwater mixing zone monitored at alternative monitoring points. Consumers Energy applied for a groundwater mixing zone authorization in 2007 that was ultimately approved on August 26, 2009 (MDEQ, 2009). The approval of the groundwater mixing zone provided updated GSI criteria, accepted the GSI compliance monitoring approach to verify ongoing compliance with GSI criteria, and required a detailed HMP to be submitted as a condition of the solid waste operating license (MDEQ, 2009).

Consumers submitted a Karn Landfill HMP Rev. 01 that was approved by EGLE on March 1, 2010 (Michigan Department of Natural Resources and Environment, 2010). The Karn Landfill HMP Rev. 01 included a potentiometric monitoring program, a porewater monitoring program, a leachate monitoring program, and a GSI Compliance Monitoring Program consistent with the requirements set forth in a 2009 letter from EGLE (MDEQ, 2009). Updates to Karn Landfill HMP Rev. 01 were completed after the groundwater mixing zone reauthorization request was submitted in February 2014 (Consumers, 2014). Finally, the Karn Landfill HMP Rev. 02 was updated again in December 2017 to incorporate groundwater monitoring wells installed for the Karn Bottom Ash Pond into the potentiometric monitoring program and document the implementation of an interim system of six groundwater extraction wells on the northern border of the Karn Landfill. Revision 3 of the HMP (Consumers, 2017) was submitted and approved in December 19, 2017. Recently Revision 4 of the HMP was submitted for approval on November 4, 2024.

Results from BAP area wells within the GSI Compliance Monitoring Program documented since 2016 have reported arsenic, boron, chromium (based on the GSI criterion for hexavalent chromium), molybdenum, and selenium detected in groundwater above Part 201 generic GSI criteria from at least one sampling event.

Until final closure, the drinking water pathway is expected to be addressed through groundwater monitoring. Once a final remedy is approved by EGLE, additional site-specific administrative restrictions will be placed on the BAP to restrict the groundwater pathway..

2.4 Remedial Response Objectives

The remedial response objective is to meet and maintain long-term compliance during post-closure care of the BAP with criteria for USEPA drinking water MCL's for arsenic in groundwater of 10 micrograms per liter (µg/L). The proposed remedy will be selected to meet the EPA criteria throughout the BAP unit, and as required in the Site's HMP.

3.0 REMEDY SELECTION PROCESS

The remedy selection process involves assessment of potentially applicable groundwater remediation alternatives. For the BAP, an evaluation of groundwater corrective action alternatives has been performed, and results of this on-going assessment have been documented as required by 40 CFR § 257.96.

The remedy selected for the unit must meet the following required criteria:

§257.97 Selection of Remedy [Required Criteria]

(b) Remedies must:

(1) Be protective of human health and the environment.

(2) Attain the groundwater protection standard as specified pursuant to §257.95(h).

(3) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment.

(4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems.

(5) Comply with standards for management of wastes as specified in §257.98(d).

Technologies that meet the required criteria are then evaluated using the following comparative criteria:

§ 257.97 Selection of remedy [Comparative Criteria]

(c) In selecting a remedy that meets the standards of paragraph (b) of this section, the owner or operator of the CCR unit shall consider the following evaluation factors:

(1) The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful based on consideration of the following:

(i) magnitude of reduction of existing risks.

(ii) magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy.

(iii) the type and degree of long-term management required, including monitoring, operation, and maintenance.

(iv) short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant.

(v) time until full protection is achieved.

(vi) potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment.

(vii) long-term reliability of the engineering and institutional controls; and

(viii) potential need for replacement of the remedy.

(2) The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:

(i) the extent to which containment practices will reduce further releases; and

(ii) the extent to which treatment technologies may be used.

(3) The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:

(i) degree of difficulty associated with constructing the technology.

(ii) expected operational reliability of the technologies.

(iii) need to coordinate with and obtain necessary approvals and permits from other agencies.

(iv) availability of necessary equipment and specialists; and

(v) available capacity and location of needed treatment, storage, and disposal services.

(4) The degree to which community concerns are addressed by a potential remedy(s).

Using the above criteria, this document evaluates a selection of potential remedies appropriate for treating arsenic. Arsenic sequestration is significantly influenced by CCR constituent chemistry and characteristics of Appendix IV parameters, which are inorganic trace elements – metals and metalloids that have attenuation and remediation characteristics markedly different than organic constituents. Common chemical mechanisms of sequestration for CCR constituents include adsorption to, or coprecipitation with, oxides and hydrous oxides (oxyhydroxides) of iron and manganese; coprecipitation with, and adsorption to, iron sulfides such as pyrite (FeS_2); and precipitation as carbonates, sulfides, sulfates, and/or phosphates (USEPA 2007; EPRI 2018). The attenuation capacity can be evaluated through site-specific field and lab testing and geochemical modeling. Processes such as precipitation/co-precipitation, adsorption, and other methods such as groundwater extraction

and treatment and engineered plant uptake (phytoremediation) are also evaluated for the remediation of Appendix IV constituents. The selected remedy will meet the criteria of 40 CFR § 257.97(b) and the effectiveness criteria specified in § 257.97(c).

4.0 CONCEPTUAL SITE MODEL

This section provides a summary of the Conceptual Site Model (CSM) for the BAP. An initial CSM for the BAP was developed during BAP ash removal. For this report, brief summaries of the following CSM elements are provided in sub sections, below.

- geology
- geotechnical
- hydrology, and
- hydrogeology

Recently, a geochemical evaluation was performed, including new BAP groundwater and aquifer solids sampling used to describe current groundwater composition, chemistry and trends; aquifer solids mineralogy; constituents of concern (arsenic) and results of reactive transport modeling. A detailed presentation of the geochemical evaluation is provided in Section 4.5.

4.1 Geology

The primary geologic units under the Karn Complex are coal ash and other fill materials, sand, an intermediate silt/clay unit, and clay. The fill/native sand unit is the primary conduit of impacted groundwater flow. Native sands are present as two units separated by an intermediate silt/clay layer on the west side of the Karn Landfill, but the lower sand pinches out to zero thickness toward the east. The upper sand ranges in thickness from approximately 33 feet on the west side of the Karn Landfill to less than 10 feet on the east side. A continuous, native, hard silty clay unit, deposited as glacial till, exists beneath the sand and intermediate silt/clay units. The top of this unit is relatively flat throughout the eastern portion of the Karn Landfill, at an elevation of approximately 575 feet, but slopes downward to the west under the river to an elevation of 515 feet, and the unit extends to bedrock at an elevation of approximately 500 to 520 feet.

In preparation of this AA, six (6) additional borings were conducted at the BAP (see Figure 3 for boring locations). The boring logs from locations B-1 through B-6 are provided in Appendix A. The logs indicate that:

- The bottom of the BAP excavation and top of uppermost sand layer coincide at about 575-578 ft msl, an elevation below the groundwater table elevation and consistent with the dewatering required during ash removal from the BAP
- Within the BAP boundaries, the area appears to be clean of coal-ash or coal-ash derivatives
- Outside the BAP boundaries, buried ash is still present, primarily below grade in the former lined-impoundment area and along the transition area between the BAP and the Karn Landfill in the area of wells (e.g. perimeter embankment dike structure)

Overall, the local geologic conditions include limited residual source areas for infiltration of arsenic into groundwater and are the focus of remedial evaluation for the BAP area.

4.2 Geotechnical

Multiple geotechnical investigations have previously been completed at the Karn Complex based on this evaluation and previous recommendations, Consumers regraded the perimeter embankment dike slopes along the intake channel and installed a geotextile liner and riprap on the perimeter embankment dike slope bordering the discharge channel in 2011 (NTH Consultants, Ltd, 2011). Consumers also implemented a long-term monitoring plan for the perimeter embankment dike following the intake and discharge channel slope improvements (NTH Consultants, Ltd., 2011). Consumers Energy provide a request to cease the long-term perimeter dike monitoring slope monitoring program on December 20, 2024, which was approved by EGLE MMD on January 16, 2025.

4.3 Hydrology

Great Lake water levels fluctuated over a range of 3 to 6 feet since the nineteenth century and, in the future, more rapid fluctuations between extreme low and extreme high water levels are expected, due to increasingly volatile trends in regional precipitation and temperature attributed to climate change (Environmental Law & Policy Center, 2019). Flood control at the Karn Complex is maintained with the perimeter embankment dike system to prevent inflow from the river and bay, and a series of lined drainage ditches to control runoff from precipitation that falls within the closed area of the Karn Complex.

4.4 Hydrogeology

4.4.1 Groundwater Quantity

Groundwater flows radially outward towards the bay, river, intake channel, and discharge channel (see Figure 4). Following the closure of the Karn Bottom Ash Pond and the installation of final cover over the Karn Landfill, a reduction in hydraulic gradients and groundwater elevations has been observed in monitoring conducted under the Karn Landfill HMP. However, a groundwater potentiometric mound persists with the highest groundwater elevations near monitoring wells OW-11, DEK-MW-15003, and DEK-MW-18001. A former NPDES surface conveyance ditch located just south of the Karn Landfill appeared to be contributing to the groundwater mound. Groundwater elevations are expected to decrease once the Karn Generating Complex ceases operations and the unlined impoundment are remediated and closed, which is anticipated to occur in late 2024-early 2025. It is noted that even prior to full closure of the lined impoundment, groundwater elevations have further declined by 2-3 feet (since 2023) and continued declining of the mounding is expected due to decreased infiltration. In the very long-term, it is anticipated that the groundwater elevations in the entire Karn peninsula will be nearly flat and just higher than the Lake Huron water surface.

Hydraulic conductivity has been estimated based on site-specific slug testing and laboratory testing of soil samples from 62 locations at the Karn Landfill and 22 locations at the adjacent Weadock Landfill. Hydraulic conductivities are comparable for materials tested at both landfills; therefore, the presented values include data from both landfills. The horizontal hydraulic conductivity estimates for the upper native sand unit ranges from 7.1 x 10^{-2} to 28 feet per day (feet/day), combined with the anticipated long-term hydraulic gradient at the BAP (approxiimately 0.0008 ft/ft), estimated groundwater velocities are anticipated on the order of 0.02 ft/day or 7.9 ft/yr).

4.4.2 CCR Constituent Trends

Consumers Energy performs routine groundwater monitoring pursuant to the HMP and RCRA monitoring programs to monitor CCR-related constituents in groundwater at the site:

- Arsenic, the primary CCR parameter of interest at the site, has been above the generic GWPS of 10 ug/L in select wells at the BAP since sampling began in 2015. Arsenic concentrations in wells at the BAP have ranged from non-detect (<1 ug/L) to 1,080 ug/L. The arsenic concentrations have been variable in wells at the BAP with most wells not exhibiting any visual trends. However, wells DEK-MW-18001 and OW-11 both exhibit visually increasing trends and well OW-11 had the highest arsenic concentration at the BAP of 1,080 ug/L measured during the March 2025 sampling event (Figure 5).
- Boron (a widely recognized near-conservative tracer of CCR) concentrations in groundwater at the BAP have generally remained stable except at well OW-11 which exhibits a visually increasing trend (Figure 6). Boron concentrations at well OW-11 have been consistently higher than at other wells ranging from 2,370 ug/L to 3,690 ug/L.
- Chromium concentrations in groundwater at the BAP have remained low (<35 ug/L) since sampling began in 2015 and do not exhibit any visual trends (Figure 7).
- Molybdenum concentrations in groundwater at wells in the BAP have remained below the GWPS of 100 ug/L since sampling began in 2015, except at well OW-11 (Figure 8). Well OW-11 has consistently had the highest concentrations of molybdenum at the BAP ranging from 151 ug/L (03/2024) to 640 ug/L (02-2017) but exhibits a visually decreasing trend in molybdenum concentrations.
- Selenium concentrations in groundwater at the BAP have remained below 15 ug/L and do not exhibit a visual trend since sampling began in 2015 (Figure 9).

4.5 BAP Site Geochemistry

This section summarizes the geochemical evaluation of BAP groundwater and aquifer solids. Groundwater chemistry and trends, aquifer solids composition and mineralogy, trends in constituents of concern, and results of reactive transport modeling, are provided to help define the conceptual site model (CSM).

Under the RCRA monitoring programs for the Karn BAP and Karn Lined Impoundment, semiannual groundwater samples are collected from onsite monitoring wells and 4 offsite background monitoring wells. The monitoring locations used for this evaluation are as follows:

DEK Wells	Monitoring Wells	
DEK-MW-15002	DEK-MW-22001	OW-10
DEK-MW-15003	DEK-MW-22002	OW-11
DEK-MW-15004	DEK-MW-22003	OW-12
DEK-MW-15005	DEK-MW-22004	OW-13
DEK-MW-15006	DEK-MW-22005	MW-18
DEK-MW-18001	DEK-MW-22006	MW-19

Groundwater quality data collected between December 2015 and March 2025 were evaluated as part of this CSM at various monitoring well locations (Figure 1). Aquifer and bedrock solids samples taken from boreholes at the BAP were also evaluated to better understand the geochemical controls on groundwater at borehole locations shown on Figure 3. The flow of groundwater and evaluation of the groundwater chemistry data used for geochemical modeling is further described in Section 4.5.2.

Laboratory results evaluating aquifer solids for major mineralogy, acid-base accounting (ABA), and the selective sequential extraction procedure (SEP) of metals from solids are provided in Appendix B.

4.5.1 General Groundwater Chemistry

4.5.1.1 pH and redox

Since December 2015, the pH and redox of groundwater in wells at the former BAP has ranged from 7.0 to 9.8 (as field pH in standard units [SU]; Figure 10) and -268 to +200 mV (reported as field Oxidation Reduction Potential [ORP]; Figure 11), respectively. Historically, the pH of groundwater at the BAP has generally ranged from 7.0 to 8.0 with the exception of at wells DEK-MW-15003, MW-18, MW-19, and OW-1, where groundwater pH has been elevated (> 8.0). The pH of groundwater at well OW-11 has consistently been measured above 9.5 since October 2021.

A Pourbaix diagram for arsenic for the Karn BAP was developed with iron stability overlain (Figure 12). Groundwater pH and redox values from the March 2024 sampling events were plotted on the diagram. Based on the Pourbaix diagram all wells in the BAP fall within the stability field of ferrous iron (Fe^{2+}) except well OW-11, which plots within the stability field of ferrihydrite (Figure 12).

4.5.1.2 Other CCR Constituent Trends

The total alkalinity (as $CaCO_3$) at wells at the Karn BAP has generally ranged from 44,400 ug/L to 768,000 ug/L since December 2015. The highest concentration of 768,000 ug/L at well DEK-MW-15006 (February 2017) persisted for only one sampling event and has since remained below 250,000 ug/L (Figure 13).

Calcium concentrations at the BAP wells have ranged from 5,000 ug/L to 356,000 ug/L since December of 2015 (Figure 14. At well OW-11, where arsenic concentrations in groundwater at the BAP are highest, calcium concentrations are lower than any other well at the BAP since 2020.

Sulfate concentrations at the BAP wells have been variable since sampling began in December of 2015, ranging from non-detect (less than 1,000 ug/L) to 1,320,000 ug/L. When sampling began, sulfate concentrations at wells DEK-MW-15006 and DEK-MW-22006 were over 900,000 ug/L (1,320,000 ug/L in December 2015 and 965,000 ug/L in March 2022 respectively) but have since decreased to less than 600,000 ug/L during the first quarter 2025 sampling event (Figure 15).

4.5.1.3 Major Ion Abundance and Mineral Saturation

Based on the relative abundance of major ions in groundwater at the site, groundwater can be characterized by a variety of the following water types: calcium bicarbonate, calcium sulfate, sodium bicarbonate, magnesium sulfate, sodium chloride, and sodium sulfate. A visual plot depicting the various water types with corresponding wells is provided in the form of a Piper diagram (Figure 16). An evaluation of charge balances indicated that all groundwater samples had less than 5% error except for DEK-MW-15003, OW-10, and OW-11. However, these

samples were still used in evaluation and consideration was given to potential misbalance causes, as described in the modeling assumptions.

The potential for mineral precipitation was assessed in PHREEQC using a saturation index (SI) calculated according to Equation 1.

$$SI = \log (IAP/Ksp) \quad \text{(Eq. 1)}$$

The saturation index is the ratio of the ion activity product (IAP) of a mineral to the solubility product (Ksp). An SI value greater than zero indicates that the solution is supersaturated with respect to a particular mineral phase and, therefore, precipitation of this mineral may occur. An evaluation of precipitation kinetics is then required to determine whether the supersaturated mineral will indeed form. An SI value less than zero indicates the solution is undersaturated with respect to a particular mineral phase. An SI value close to zero indicates equilibrium conditions exist between the mineral and the solution. SI values between -0.5 and 0.5 are considered to represent ‘equilibrium’ in this report to account for the uncertainties inherent in the analytical methods and geochemical modeling. Results of evaluation of mineral SI are presented in Table 1.

Table 1. Saturation Indices of Select Minerals at the Karn BAP

Well ID		DEK-MW-15002	DEK-MW-15003	DEK-MW-15004	DEK-MW-15005	DEK-MW-15006	DEK-MW-18001	DEK-MW-22001	DEK-MW-22002	DEK-MW-22003
Charge Balance Error (%)		-2.95	-5.33	-2.61	-4.47	-2.63	-4.54	-2.81	-0.38	-3.23
Ionic Strength (mol/L)		1.48E-02	6.82E-03	1.29E-02	2.10E-02	2.22E-02	1.18E-02	2.64E-02	2.31E-02	3.81E-02
Cr(OH)3(am)	$Cr(OH)_3$(am)	**1.50**	**0.93**	**0.48**	**0.71**	**0.47**	**0.58**	**1.32**	**0.25**	**0.19**
Halite	NaCl	-6.70	-7.08	-6.82	-6.51	-6.99	-6.69	-6.91	-6.55	-6.19
Ferrihydrite	$Fe(OH)_3$	-3.51	-0.83	**-0.46**	-2.37	-1.89	-1.37	-1.79	-1.39	-1.61
Siderite	$FeCO_3$	-0.80	**-0.40**	**0.40**	**-0.36**	**-0.09**	**-0.37**	**0.37**	**0.42**	**0.16**
Hematite	Fe2O3	**0.95**	**6.24**	**7.01**	**3.22**	**4.18**	**5.21**	**4.38**	**5.19**	**4.74**
Goethite	FeO(OH)	-0.69	**1.94**	**2.33**	**0.44**	**0.93**	**1.43**	**1.03**	**1.43**	**1.21**
Rhodochrosite	MnCO3	**-0.32**	**-0.23**	**-0.28**	**-0.15**	**0.06**	-0.65	**-0.03**	**0.04**	**-0.02**
Dolomite(disordered)	CaMg(CO3)2	-0.56	-0.53	-0.97	**-0.37**	**-0.43**	-1.32	-1.13	-0.64	-0.57
Dolomite(ordered)	CaMg(CO3)2	**0.19**	**0.22**	**-0.22**	**0.39**	**0.33**	-0.56	**-0.38**	**0.11**	**0.19**
Gypsum	CaSO4:2H2O	-1.64	-2.03	-1.33	-0.94	-0.70	-1.44	-0.54	-0.83	**-0.45**
Calcite	CaCO3	**0.31**	**0.38**	**0.12**	**0.46**	**0.52**	**0.00**	**0.19**	**0.27**	**0.25**
Magnesite	MgCO3	-0.76	-1.03	-1.13	-0.74	-0.89	-1.31	-1.27	-0.82	-0.73
Barite	BaSO4	**0.56**	**0.08**	**1.00**	**1.37**	**1.32**	**1.09**	**1.44**	**1.34**	**1.51**
Witherite	BaCO3	-2.87	-2.85	-2.90	-2.61	-2.82	-2.84	-3.20	-2.94	-3.17
Fluorite	CaF2	-1.02	-1.28	-1.13	-0.92	-0.83	-1.25	-0.78	-0.91	-0.85
CoCO3	CoCO3	-2.72	-2.26	-2.76	-2.75	-2.79	-2.73	-3.20	-2.98	-3.22
Cerrusite	PbCO3	-1.57	-1.63	-1.64	-1.58	-1.59	-1.61	-1.72	-1.63	-1.70
Carbon Dioxide	pCO2(g) (b)	-1.89	-2.98	-2.34	-2.15	-2.29	-2.53	-2.07	-2.09	-2.20

Well ID		DEK-MW-22004	DEK-MW-22005	DEK-MW-22006	OW-10	OW-11	OW-12	OW-13	MW-18	MW-19
Charge Balance Error (%)		-3.05	-3.71	-2.70	-15.28	-12.32	-2.24	-1.38	-2.11	-2.54
Ionic Strength (mol/L)		1.08E-02	1.50E-02	3.69E-02	1.71E-02	4.31E-03	2.44E-02	2.33E-02	9.13E-03	8.96E-03
Cr(OH)3(am)	$Cr(OH)_3$(am)	**0.65**	**0.78**	**0.24**	**0.29**	**0.75**	**-0.03**	**-0.30**	**1.13**	**0.39**
Halite	NaCl	-6.75	-6.79	-7.15	-6.84	-7.00	-7.30	-5.98	-6.98	-7.22
Ferrihydrite	$Fe(OH)_3$	-0.89	-1.67	-1.34	-2.33	**2.48**	-1.68	-2.06	-1.39	-2.16
Siderite	$FeCO_3$	**0.17**	**0.17**	**0.71**	**0.35**	-1.87	**0.52**	**0.46**	**-0.37**	-0.73
Hematite	Fe2O3	**6.19**	**4.63**	**5.33**	**3.29**	**12.91**	**4.59**	**3.87**	**5.15**	**3.61**
Goethite	FeO(OH)	**1.93**	**1.15**	**1.51**	**0.48**	**5.29**	**1.13**	**0.78**	**1.41**	**0.63**
Rhodochrosite	MnCO3	-0.51	**-0.07**	**0.37**	**0.06**	**-0.47**	**-0.19**	**-0.43**	**0.37**	**-0.46**
Dolomite(disordered)	CaMg(CO3)2	-0.78	**0.25**	**0.21**	**-0.47**	**0.14**	**-0.04**	-1.10	**1.06**	-1.14
Dolomite(ordered)	CaMg(CO3)2	**-0.02**	**1.00**	**0.96**	**0.28**	**0.89**	**0.72**	**-0.35**	**1.82**	**-0.38**
Gypsum	CaSO4:2H2O	-1.72	-1.33	-0.54	-3.45	-2.97	-1.10	-1.51	-2.13	-1.84
Calcite	CaCO3	**0.38**	**0.81**	**0.55**	**0.44**	**0.83**	**0.43**	**0.22**	**1.15**	**0.10**
Magnesite	MgCO3	-1.05	**-0.47**	**-0.15**	-0.85	-0.64	**-0.41**	-1.15	**-0.08**	-1.27
Barite	BaSO4	**0.48**	**0.78**	**1.32**	-1.29	**-0.43**	**1.10**	**0.64**	**0.17**	**0.18**
Witherite	BaCO3	-2.80	-2.46	-2.98	-2.77	-2.00	-2.73	-3.02	-1.90	-3.23
Fluorite	CaF2	-1.09	-0.97	-0.93	-0.91	-0.75	-0.96	-0.83	-1.15	-1.11
CoCO3	CoCO3	-2.49	-2.30	-2.88	-2.77	-1.85	-2.86	-3.08	-1.82	-2.73
Cerrusite	PbCO3	-1.53	-1.53	-1.55	-1.63	-1.79	-1.65	-1.66	-1.61	-1.63
Carbon Dioxide	pCO2(g) (b)	-2.42	-2.47	-1.94	-1.41	-4.89	-1.45	-1.36	-3.26	-2.15

Notes:

1. Saturation indices > -0.5 identified by bold type and grey shading
2. Charge balances >5% or < -5% shown in red

Based on that evaluation, generally groundwater at the BAP was identified to be at equilibrium (or supersaturated) with respect to barite, calcite, chromium hydroxide (amorphous), dolomite (ordered), goethite, hematite, rhodochrosite, and siderite, with a few exceptions. Notably, due to the reducing conditions of groundwater, samples were undersaturated with respect to ferrihydrite. However, ferrihydrite is well recognized to age to goethite rapidly after precipitation and crystallization. The ubiquitous SI>0 for chromium hydroxide in samples indicates mineral precipitation strongly controls dissolved concentration of chromium at the pH and redox conditions of the site.

4.5.1.4 Arsenic

In groundwater, arsenic can be present in two valence states, as arsenite species with the valence state arsenic(III) and as arsenate species with the valence state arsenic(V) (Hem, 1985). Arsenite species have a lower affinity for sorption (attenuation) on metal (hydr)oxide surfaces than arsenate species and are regarded to be more mobile in natural environments (Campbell and Nordstrom, 2014; Smith and Huyck, 1999). The sorption of arsenic onto ferrihydrite under varying pH and redox conditions (Dzombak and Morel, 1990) and gibbsite (Karamalidis and Dzombak, 2011) has been well studied, as well as arsenic adsorption onto clay minerals (Manning and Goldberg, 1996). Under oxidizing conditions, arsenic is ten times less mobile at a pH range typically found in groundwater (5 to 9) than at higher pH due to desorption from metal surfaces (Strenge and Peterson, 1989). At low pH (<5), arsenic will also become more mobile, as metal (hydr)oxides begin to dissolve (Campbell and Nordstrom, 2014). Arsenic occurs naturally across the United States in soils at a range of <0.10 to 97 mg/kg with an average concentration of 5 mg/kg (Smith and Huyck, 1999). Arsenic precipitation as a sulfide mineral under strong reducing conditions is also a well-established method of attenuation (Nordstrom et al., 2014).

Based on the pH and redox conditions of groundwater measured at the wells at the BAP, arsenic is likely present predominantly as an arsenite species (As^{+3}), which has a lower affinity for sorption (Figure 12).

4.5.1.5 Site Mineralogy

The mineralogical composition of twelve samples from borings at the BAP were assessed using quantitative X-ray diffraction (XRD) with Rietveld refinement. The purpose of this analysis was to identify and quantify the major crystalline mineral phases and the clay mineral content of the underlying materials at the Site. This effort aided in understanding the influence the underlying site geology has on groundwater quality, potential for attenuation, and influences on dissolved arsenic concentrations. The results of mineralogical evaluation are summarized in Table 2 and the laboratory report is provided in Appendix B.

Table 2. Summary of Mineralogical Testing at the BAP

Mineral/Compound	Mineral Formula	Sample Location											
		B-1		B-2		B-3		B-4	B-5			B-6	
		Sampling Interval											
		12'-13' (wt %)	16'-18' (wt %)	8'-9' (wt %)	13'-15' (wt %)	11'-13' (wt %)	17'-19' (wt %)	10'-12' (wt %)	10'-15' (wt %)	18'-20' (wt %)	21 1/2'- 22 1/2' (wt %)	6'"-18'" (wt %)	5'-7' (wt %)
Quartz	SiO_2	5.8	69.6	32.5	69.0	23.3	76.4	36.0	54.6	77.2	68.9	28.4	59.4
Pyrite	FeS_2	8.3	-	-	-	0.2	-	-	-	-	-	-	-
Magnetite	Fe_3O_4	24.6	-	-	-	3.4	-	3.9	1.6	-	-	4.6	-
Hematite	Fe_2O_3	22.1	-	-	-	4.6	0.5	6.1	3.7	-	-	5.7	-
Mullite	$\sim Al_8Si_3O_{15}$	21.3	-	-	-	67.2	-	32.3	17.2	-	-	33.6	-
Gypsum	$CaSO_4{\cdot}2H_2O$	6.8	-	-	-	-	-	-	-	-	-	-	-
Cristobalite	SiO_2	5.8	-	-	-	-	-	-	-	-	-	-	-
Marcasite	FeS_2	1.5	-	-	-	-	-	-	-	-	-	-	-
Kaolinite	$Al_2Si_2O_5(OH)_4$	3.8	-	-	-	-	-	-	-	-	-	-	-
Albite	$NaAlSi_3O_8$	-	8.4	9.3	11.1	-	9.4	10.4	10.3	8.1	7.3	3.9	7.6
Dolomite	$CaMg(CO_3)_2$	-	1.6	23.8	3.1	-	1.3	1.1	2.0	1.3	7.1	5.9	4.5
Ankerite	$CaFe(CO_3)_2$	-	1.0	-	-	-	-	1.6	-	-	-	2.1	-
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$	-	0.1	4.4	0.7	-	0.7	-	-	1.3	3.1	-	1.6
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	-	1.4	2.4	-	-	0.3	-	-	1.3	-	-	0.8
Calcite	$CaCO_3$	-	0.7	11.7	-	1.1	-	0.7	2.4	-	5.7	13.7	19.7
Hornblende	$(Ca,Na)_{2\text{-}3}(Mg,Fe,Al)_5Si_6(Si,Al)_2O_{22}(OH)_2$	-	1.3	0.7	1.4	-	1.2	-	-	1.5	2.7	-	1.0
Microcline	$KAlSi_3O_8$	-	15.9	5.5	12.2	0.3	7.8	6.6	6.3	5.6	3.2	2.1	5.5
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	-	-	9.8	2.3	-	-	-	-	-	-	-	-
Diopside	$CaMgSi_2O_6$	-	-	-	-	-	2.4	-	1.8	3.7	-	-	-
Rutile	TiO_2	-	-	-	-	-	-	1.4	-	-	-	-	-
Phlogopite	$KMg_3(AlSi_3O_{10})(OH)_2$	-	-	-	-	-	-	-	-	-	1.9	-	-
TOTAL		100	100	100	100	100	100	100	100	100	100	100	100

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.

Samples collected of aquifer solids at the BAP consisted primarily of quartz, dolomite, calcite, and albite minerals reflecting the weathering of underlying bedrock lithology. Various amounts of reduced ferrous iron minerals pyrite and marcasite were identified in some samples, up to 9.8% by weight percent. The ferric iron minerals hematite and magnetite were also identified in samples, in some cases representing up to nearly 47% of the sample by weight percent.

4.5.1.6 Acid Base Accounting

The acid base accounting (ABA) test is conducted to predict the acid generation characteristics of a material through determination of the acid neutralizing and generation potentials. The ABA included determination of the following:

- Carbonate neutralization potential (Ca NP) from total carbon (CT), and inorganic carbon (TIC) analysis
- Acid generation potential (AP) by determination of sulfur speciation, including total sulfur (S [T]), sulfide sulfur (S [S^{2-}]), and sulfate sulfur (S [SO_4^{2-}]).
- Organic carbon (C Org), and insoluble S are determined by calculations

The Ca NP of a sample is determined from its total inorganic carbon (TIC) content. The TIC is determined by measuring the amount of carbon dioxide (CO_2) released from an acidified sample. The Ca NP is a measure of the neutralization capacity of a sample afforded by carbonate minerals only, assuming all carbonates react like calcite. While calcium and magnesium carbonates are generally the main neutralizing minerals in lithological materials, iron carbonates (such as ankerite and siderite) do not contribute to buffering capacity and tend to generate acidity due to the subsequent hydrolysis of the iron. Therefore, if iron carbonates are present, Ca NP will overestimate the neutralizing capacity of a material. The potential for overestimation can be addressed explicitly through careful mineralogical evaluations and determination of NP using methods specifically designed to isolate any potential effects from iron carbonates. For this evaluation, both the NP and the Ca NP are used for evaluations of neutralization potential (INAP, 2009). Organic carbon is calculated by subtraction using total carbon and subtracting the inorganic carbon measurement.

The AP of a material is derived from a sulfur determination. The most environmentally conservative approach to calculate AP is to assume that all sulfur in a sample is potentially reactive and, therefore, capable of generating acid. However, this ignores the fact that not all sulfur will contribute acidity (e.g., sulfur in gypsum, barite, or chalcocite). For this evaluation, the AP is calculated using total sulfur concentration due to the near equivalent content in most samples. By convention in ABA studies, one assumes that the sulfide sulfur is present entirely as pyrite (FeS_2) to use the stoichiometry of pyrite to calculate a theoretical amount of sulfuric acid that could be generated. As for NP, the AP is expressed in kg $CaCO_3$/ton. Insoluble sulfur is determined by subtraction. The results of ABA testing are provided in Table 3 and Appendix B.

Table 3. Acid Base Accounting Results for the Karn BAP

Test	S(T)	S(SO4)	S(S-2)	Insoluble S	C(T)	TIC	C (Org)	Ca NP	AP
Units	%	%	%	%	%	%		kg CaCO3/t	kg CaCO3/t
Method Code LOD	CSA06V 0.005	CSA07C1 0.010	CSA08C1 0.010	Calc.	CSA06V 0.005	CSB02V 0.010	Calc.	Calc.	Calc.
Sample ID									
B-1 12'-13'	2.48	0.22	2.06	0.20	4.00	<0.01	4.00	<0.8	64.40
B-4 10'-12'	0.11	0.02	0.03	0.06	4.95	0.18	4.77	15.00	0.90
B-6 6"-18"	0.11	0.07	0.02	0.02	4.37	0.91	3.46	75.80	0.60
B-3 11'-13'	0.14	0.04	0.03	0.07	7.42	0.09	7.33	7.50	0.90
B-5 10'-15'	0.20	0.03	0.11	0.06	6.59	0.51	6.08	42.50	3.40
B-2 8'-9'	0.08	0.02	0.05	0.01	4.17	4.16	0.01	346.70	1.60
B-1 16'-18'	0.03	0.01	0.01	0.01	0.38	0.24	0.14	20.00	0.30
B-2 13'-15'	0.04	0.02	0.02	0.00	0.61	0.39	0.22	32.50	0.60
B-3 17'-19'	0.07	0.01	0.04	0.02	0.52	0.22	0.30	18.30	1.30
B-5 18'-20'	0.06	0.02	0.03	0.01	0.47	0.19	0.28	15.80	0.90
B-5 21 1/2'-22 1/2'	0.03	<0.01	0.01	0.02	2.14	1.84	0.30	153.30	0.30
B-6 5'-7'	0.02	0.01	<0.01	0.01	2.58	2.28	0.30	190.00	<0.3

The results of ABA testing indicate that some samples have the capacity for acid generation, but sample B1 (12'-13') had a much higher AP than NP. All other samples had a higher NP than AP. Sample B1 also had the highest concentration of pyrite as determined by both the mineralogical evaluation and sulfur speciation. Generally, while there is some minor potential for acid generation in some localized spots, it is outweighed by the neutralization potential of samples and the identified presence of calcite in the aquifer solids and presence of carbonate alkalinity in groundwater.

4.5.1.7 Sequential Extraction

Chemical analysis by sequential extraction of metals from overburden materials was conducted on 12 samples (up to three sample depths per borehole) at locations in the BAP. The analytical results are summarized in Table 4 and presented in Appendix B.

Table 4. Summary of Sequential Extraction Results for the Karn BAP

Analyte	SEP Step	Sample Location											
		B-1		B-2		B-3		B-4	B-5			B-6	
		Sample Interval											
		12'-13'	16'-18'	8'-9'	13'-15'	11'-13'	17'-19'	10'-12'	10'-15'	18'-20'	21 1/2'- 22 1/2	6"-18"	5'-7'
Aluminum	SEP Step 1	12.91	11.43	14.59	13.29	56.06	17.03	54.96	23.52	20.03	3.53	51.32	3.21
Aluminum	SEP Step 2	17.52	3.23	7.92	4.17	30.58	3.71	30.23	15.71	4.15	5.10	24.04	2.75
Aluminum	SEP Step 3	149.88	70.07	109.97	150.08	1996.85	67.75	167.61	237.04	124.62	112.31	310.71	71.06
Aluminum	SEP Step 4	1918.47	318.52	422.65	518.81	3891.77	360.56	1822.68	1802.05	553.86	434.38	2196.23	325.48
Aluminum	SEP Step 5	977.68	113.40	801.49	163.52	1816.16	126.22	668.62	1326.13	198.93	314.18	1474.94	186.58
Aluminum	Residual Fraction	82180.05	19014.56	36757.65	19024.74	130836.42	20969.16	91215.36	65431.92	20357.70	16777.49	88858.02	15547.74
Environmentally Available		3076.46	516.64	1356.62	849.87	7791.42	575.27	2744.09	3404.45	901.60	869.50	4057.24	589.07
Environmentally Available (%)		4%	3%	4%	4%	6%	3%	3%	5%	4%	5%	4%	4%
SEP SUM		85256.51	19531.20	38114.27	19874.61	138627.84	21544.43	93959.45	68836.37	21259.30	17646.99	92915.26	16136.81
Arsenic	SEP Step 1	0.10	0.06	0.02	0.06	0.35	0.08	0.22	0.37	0.09	0.08	0.14	0.01
Arsenic	SEP Step 2	0.18	0.14	0.14	0.14	0.79	<DL	0.18	0.18	<DL	0.19	0.09	0.09
Arsenic	SEP Step 3	0.32	0.60	0.19	0.74	6.21	0.42	1.33	6.01	0.42	1.11	0.55	0.14
Arsenic	SEP Step 4	2.03	1.24	0.65	1.25	19.41	1.11	3.07	12.75	1.11	1.21	0.51	0.37
Arsenic	SEP Step 5	9.59	1.06	0.89	1.11	16.54	0.84	1.92	12.85	0.69	1.11	1.62	0.55
Arsenic	Residual Fraction	10.00	1.00	5.00	1.00	26.00	<1	3.00	11.00	<1	4.00	10.00	3.00
Environmentally Available		12.23	3.10	1.88	3.30	43.30	2.45	6.72	32.16	2.30	3.70	2.92	1.16
Environmentally Available (%)		55%	76%	27%	77%	62%	100%	69%	75%	100%	48%	23%	28%
SEP SUM		22.23	4.10	6.88	4.30	69.30	2.45	9.72	43.16	2.30	7.70	12.92	4.16
Iron	SEP Step 1	191.39	37.48	16.12	26.64	25.53	29.74	49.92	15.53	23.91	6.82	94.78	7.24
Iron	SEP Step 2	202.45	6.45	6.99	7.87	9.73	5.10	27.48	5.54	5.54	10.21	32.37	7.79
Iron	SEP Step 3	996.13	1682.49	512.58	3455.62	926.61	1113.69	386.52	1108.95	3498.57	3109.34	1530.42	1136.88
Iron	SEP Step 4	8162.70	1521.16	2432.43	2056.70	2793.74	1457.08	2532.52	3359.21	1730.82	2014.11	5872.02	3016.41
Iron	SEP Step 5	17155.51	156.26	1025.16	232.07	685.69	408.82	636.56	1178.26	291.70	205.12	1012.58	198.50
Iron	Residual Fraction	146925.00	3616.90	16975.60	4932.34	45388.20	2980.91	84538.56	37958.28	3375.90	8345.28	82198.23	5182.58
Environmentally Available		26708.17	3403.84	3993.29	5778.90	4441.30	3014.43	3632.99	5667.50	5550.54	5345.60	8542.17	4366.83
Environmentally Available (%)		15%	48%	19%	54%	9%	50%	4%	13%	62%	39%	9%	46%
SEP SUM		173633.17	7020.74	20968.89	10711.24	49829.50	5995.34	88171.55	43625.78	8926.44	13690.88	90740.40	9549.41

Notes:
All Results displayed in milligram per kilogram mg/kg.
Environmentally Available = Sum of SEP steps 1-5
SEP SUM = sum of steps and may not equal the SEP_TOT_Prep reported in lab reports

SEP Steps:
Step 1 - Water Soluble Fraction: This extraction targets metals that are readily dissolved into the aqueous phase from a soil or sediment sample
Step 2 - Exchangable Fraction: This extraction includes trace elements that are reversibly adsorbed to aquifer minerals, amorphous solids, and/or organic material by electrostatic forces.
Step 3 - Carbonate Fraction: This extraction targets trace elements that are adsorbed or otherwise bound to carbonate minerals.
Step 4 - Metals bound to Fe and Mn Oxides: This extraction targets trace elements that are complexed by amorphous minerals and (hydr)oxides of iron, manganese, and/or aluminium.
Step 5 - Organic Fraction: This extraction targets trace elements strongly bound via chemisorption to organic material.
Step 6 - Residual Fraction: Trace elements remaining in the soil aftrer the previous extractions will be distributed between silicates, phosphates, and refractory oxides.

The sequential extraction procedure (SEP) consists of a six-step metals extraction from solids to determine the potential environmental stability of those metals. The six-step SEP is defined by specific extraction steps as follows (based on a modified Tessier et al. [1979] method):

SEQUENTIAL EXTRACTION PROCEDURE				
ENVIRONMENTALLY AVAILABLE / ACID/SULFIDE AND RESIDUAL (Increasing Availability)	Step 1	Increasing Extraction Strength	Water Soluble Fraction:	This extraction targets metals that are readily dissolved into the aqueous phase from a soil or sediment sample
	Step 2		Exchangeable Fraction:	This extraction includes trace elements that are reversibly adsorbed to aquifer minerals, amorphous solids, and/or organic material by electrostatic forces
	Step 3		Carbonate Fraction:	This extraction targets trace elements that are adsorbed or otherwise bound to carbonate minerals
	Step 4		Metals bound to Fe and Mn Oxides:	This extraction targets trace elements that are complexed by amorphous minerals and (hydr)oxides of iron, manganese, and/or aluminum
	Step 5		Organic Fraction:	This extraction targets trace elements strongly bound via chemisorption to organic material
	Step 6		Residual Fraction:	Trace elements remaining in the overburden after the previous extractions will be distributed between silicates, phosphates, and refractory oxides

Steps 1 through 6 represent an increasing amount of target metals that can be removed into solution from the solid phase. For instance, metals bound in the carbonate fraction, or that are exchangeable, are much more likely to become mobile due to changes in groundwater chemistry than metals bound within the residual fraction. The total concentration of a metal measured from all six steps can be compared to the concentration determined from the total metal analysis for compositional accountability. Metals extracted in Steps 1 through 5 are considered environmentally available, whereas metals extracted in Step 6 represent the residual fraction and are not expected to be released under conditions typically encountered in aquifers. The exception to this is in the case of strong acidification or other major excursions from typical groundwater conditions (Tessier et al., 1979).

Arsenic (Figure 17): Total arsenic measured in aquifer solids collected from the six boreholes ranged from 2.3 to 69.3 mg/kg. The environmentally available fraction ranged from 1.16 to 43.3 mg/kg. Samples B-1 (12’-13’), B-3 (11’-13’), and B-5 (10’-15’) had the highest concentrations of total arsenic and the portion of arsenic in the environmentally available fraction, which ranged from 22.23 to 69.3 mg/kg and 12.23 to 43.3 mg/kg, respectively. Sample B-5 (18’-20’) had the lowest total arsenic concentration measured at 2.3 mg/kg and sample B-6 (5’-7’) had the lowest environmentally available fraction of arsenic measured at 1.16 mg/kg.

Generally, the majority of arsenic in samples resided in the iron and manganese oxides or organics fractions. The presence of environmentally available arsenic indicates that arsenic could be released to groundwater if substantial changes occur causing the reductive dissolution of metal hydr(oxide) surfaces or the oxidation of natural organic matter, potentially due to significant acidification, change in redox conditions of the aquifer, or other substantial changes from equilibrium conditions. However historical groundwater data gives no indication that changes to groundwater conditions of a magnitude needed to liberate arsenic would be expected.

Iron (Figure 18): Iron minerals commonly represent one of most abundant reservoirs for metal/metalloid attenuation in soils (Dzombak and Morel, 1990; Smith, 1999). Iron was present in all samples analyzed, with the total iron ranging from approximately 6,000 to 173,600 mg/kg and the environmentally available fraction ranging

from approximately 3,000 to 26,700 mg/kg. Sample B-1 (12'-13') had the highest total and environmentally available concentrations of iron measured at 173,633 and 26,708 mg/kg, respectively.

The largest proportion of iron was present in the iron and manganese oxides and residual fractions. The iron and manganese oxides fraction are part of the environmentally available fraction and can generally be considered representative of the amount of iron in soil that may be available as a sorbing medium. Iron is generally regarded as the strongest attenuating agent for arsenic in the subsurface environment (Campbell and Nordstrom, 2014).

Summary of Section 4.5.1

- Arsenic is the primary CCR parameter of interest at the site, has been above the generic GWPS of 10 ug/L in select wells at the BAP since sampling began in 2015. Arsenic concentrations in wells at the BAP have ranged from non-detect (<1 ug/L) to 1,080 ug/L. (Figure 5)
- Groundwater at the BAP was identified to be at equilibrium (or supersaturated) with respect to barite, calcite, chromium hydroxide (amorphous), dolomite (ordered), goethite, hematite, rhodochrosite, and siderite and undersaturated with respect to ferrihydrite due to reducing conditions. (Table 1)
- Based on the pH and redox conditions of groundwater measured at the wells at the BAP, arsenic is likely present predominantly as an arsenite species (As^{+3}), which has a lower affinity for sorption (Figure 12).
- Aquifer solids at the BAP consisted primarily of quartz, dolomite, calcite, and albite minerals reflecting the weathering of underlying bedrock lithology. (Table 2)
- There is the minor potential for acid generation in some localized spots. But that potential is outweighed by the neutralization potential of samples and the identified presence of calcite in the aquifer solids and abundant carbonate alkalinity in groundwater. (Table 3)
- The majority of arsenic in samples resided in the iron and manganese oxides or organics fractions, susceptible to release. However historical groundwater data gives no indication that changes to groundwater conditions of a magnitude needed to liberate arsenic would be expected. (Table 4)
- The largest proportion of iron was present in the iron and manganese oxides and residual fractions, generally regarded as the strongest attenuating agent for arsenic in the subsurface environment. (Table 4)

4.5.2 Reactive Transport Modeling

WSP performed geochemical reactive transport modeling to evaluate the time to reduce dissolved arsenic concentrations at the BAP to below the generic GWPS. Four active remediation strategies and monitored natural attenuation (MNA) were evaluated for long-term effectiveness. The different model scenarios are outlined in Table 5.

Table 5. Summary of Remediation Strategies Modeled at the Karn BAP

Scenario	Remediation Strategy	Model Strategy
Scenario 1	MNA	No active remedy implemented
Scenario 2	In-situ injection of zero valent iron (ZVI)	Injection of a groundwater solution mixed with solid ZVI at multiple locations
Scenario 3	In-situ injection of ferric sulfate	Injection of a groundwater solution that has been mixed with solid ferric sulfate ($Fe_2[SO4]_3$)
Scenario 4	In-situ injection of ferrous sulfate heptahydrate	Injection of a groundwater solution that has been mixed with solid ferrous sulfate (FeSO4:7H2O)
Scenario 5	Pump and treat with reinjection	Removal of groundwater from the BAP using 7 extraction wells and simultaneous injection background groundwater using 10 Injection wells

Following completion of the initial modeling scenarios, model sensitivity was evaluated using two different additional scenarios to further evaluate the ZVI remediation strategy. These included:

- Sensitivity Analysis 1: Groundwater with elevated arsenic north of the BAP to evaluate long-term attenuation of arsenic by ZVI with potential contributions from the Ash Pond.
- Sensitivity Analysis 2: A minimal background adsorption scenario. This sensitivity analysis used the lowest measured adsorption potential (from SEP results) for aquifer materials at and around the BAP to ensure the efficacy of the ZVI treatment.

Specific details of each model scenario are presented in section 4.5.2.4.

4.5.2.1 PHAST

The geochemical model PHAST V.3 is a computer program developed by the U.S. Geological Survey that simulates multicomponent reactive solute transport in a 3-D saturated groundwater flow system (Parkhurst et al., 2010). PHAST is a versatile groundwater flow and solute transport simulator with capabilities to model a wide range of equilibrium and kinetic geochemical reactions. The flow and transport calculations are based on a modified version of the Heat and Solute Transport Program (HST3D) that is restricted to constant fluid density and constant temperature. The geochemical reactions are simulated with the geochemical model PHREEQC-RM, which is embedded in PHAST.

In this application, results of groundwater modeling for the Site using MODFLOW 6 were directly incorporated into PHAST for seamless model coordination. Groundwater model results were exported from groundwater model developed by BARR Engineering using the “2019 Conditions” model. The results of that modeling effort are summarized in the “Feasibility Study” (Barr, 2021). Thus, groundwater flow was not solved independently in the PHAST software so that groundwater chemical reactions could be the primary focus of the evaluation.

4.5.2.2 Surface Complexation

Surface complexation can be described using a mechanistic model to account for adsorption onto metal oxide surfaces. The theory is based on Dzombak and Morel (1990) utilizing iron (hydrous ferric oxide [Hfo]) as ferrihydrite $Fe(OH)_3$ as adsorbing surfaces based on the concentrations measured in representative solids. Surface site densities are then calculated from these values using formulas for Hfo based on Dzombak and Morel (1990). Surface sites are allowed and assumed to obtain equilibrium with ambient groundwater to establish a pre-loaded background condition. The surface complexation model for ferrihydrite includes both strong sites (Hfo_strong) and weak sites (Hfo_weak), which are treated as different surface sites in PHREEQC based on the Dzombak and Morel (1990) model.

To calculate initial adsorption sites for surface complexation, the mass of iron in sediment/soil samples was converted using methods described by Dzombak and Morel (1990). This was used in combination with the calculation methodology of Appelo and Postma (2005) to calculate the specific quantity of sites on ferrihydrite surface type as well as the amount of each mineral available to participate in the reactions. Briefly, the methodology assumes the number of surface sites (sites) equals the product of the moles of iron ([Fe]) and moles of surface sites per moles of iron ([sites]/[Fe]) (i.e., sites = [Fe] x [sites]/[Fe] or $5.5x10^{-4}$ mol = $2.75x10^{-3}$ mol iron x 0.2 mol sites/mol iron). For the amount of ferrihydrite available for sorption, the Appelo and Postma methodology assumes the mass of ferrihydrite ($_{M}$HFO) in grams (g) available equals the product of [Fe] and the molecular weight of ferrihydrite ($_{MW}$HFO) (i.e., $_{M}$HFO = [Fe] x $_{MW}$HFO; or 0.24 g = 2.75x10-3 mol x 88.85 g/mol).

The geochemical thermodynamic database (TDB) Minteq v.4 is a widely accepted database compiled from numerous sources by the United States Environmental Protection Agency (Allison et al., 1991). However, the Minteq v.4 database does not include partitioning coefficients for iron adsorption constants on carbonate (Van Geen et al., 1994), and uranium and iron constants (Liger et al., 1999). Due to the need for these constants to more accurately model attenuation they were included in the standard Minteq v.4 database to supplement the existing thermodynamic data. The thermodynamics of zero valent iron corrosion was also included in the TBD based on those values determined by Liang et al. (2003) and Wilkin et al. (2009). The values for ZVI corrosion and oxidation to ferric hydroxide from Liang et al. (2003) and Wilkin et al. (2009) were also in good agreement with previous bench-scale testing conducted for the Site as part of the “Final Design Report; D.E. Karn Permeable Reactive Barrier Wall.” (WSP, 2024).

4.5.2.3 Modeling Assumptions

The assumptions inherent to the reactive transport geochemical modeling effort and limitations of those modeling results can be summarized as follows:

- Groundwater “total” values were used rather than dissolved due to the lack of dissolved data for the Site. The use of total as opposed to dissolved values may not recognize the effects of colloids in groundwater quality.
- All reactions occur at thermodynamic equilibrium (i.e., no kinetics or other time-dependent expressions were used to describe the chemical reactions). Kinetic expressions developed as part of the previous Karn modeling effort were not included due to the rapid nature of reactions when using ISI.
- All sorption reactions occur on Hfo, Hao, in the form of naturally occurring metal (hydr)oxide minerals. In addition, other aquifer materials such as clays may play a role in metal attenuation but are not included in this modelling effort.

- The attenuation modeling accounts for competitive adsorption from major cations, anions (specifically including sulfate and carbonate), and metal species where thermodynamic data were available from Dzombak and Morel (1990)
- All chemical reactions in the system are described using the equilibrium constants published by the USEPA Minteq v.4 thermodynamic database (Allison et al., 1991) as well as the additional thermodynamic data included in files from Dzombak and Morel (1990) and Karamalidis and Dzombak (2011).
- Dispersivity was set to maintain a Peclet number of <2.0 and generally set to between one half to one cell length in accordance with Parkhurst et. al (2010).
- Model calibration occurs during the initial conditions model design phase. The initial model calibration is further described in subsequent sections using site-specific groundwater and aquifer solids data.

Injectates were allowed to equilibrate with a background groundwater at various concentrations prior to the simulated injection. Using this approach more resembles the typical ISI procedure of creating an injectable slurry or liquid material as opposed to modeling direct additions of solids phases to groundwater.

4.5.2.4 Reactive Transport Model Scenarios

Each reactive transport model scenario was created using the same model domain and initial calibration. The initial arsenic concentration was assigned to each zone by interpolating (by inverse difference weighting) the measured groundwater concentrations in GIS. This resulted in the creation of five distinct zones based on the interpolated arsenic concentrations to best represent existing conditions (Figure 19). Arsenic concentrations were assumed to be homogenous vertically in the BAP to present a conservative approach. The aquifer outside of the BAP was represented using groundwater quality from well OW-10. Using this approach, the geochemical conditions of the model best represent a calibrated re-creation of actual site geochemical conditions. The concentration target for solutions containing iron was 20 to 30 g/L except where solubility limits were reached.

After initial model calibration, each model scenario was setup to best represent each potential corrective action option. The MNA model had no changes after initial calibration. All model scenarios were run forward in time for 30-years with each remediation strategy starting after an initial two-year period that allowed for initial model stabilization and equalization. The MNA model was run forward for a total of 50-years. The details of each model scenario are further described as follows:

Scenario 1: Scenario one evaluated if MNA would be a viable strategy to reduce dissolved arsenic concentrations at the BAP to below the generic GWPS. The groundwater in the BAP with arsenic over the generic GWPS was recharged with simulated rainwater that equilibrates in the vadose zone to mimic the water quality measured at OW-10. The BAP and the surrounding aquifer with recharge were modeled forward for 50-years to evaluate if MNA would result in a decrease of arsenic concentrations to below the generic GWPS at the BAP.

Scenario 2: This scenario evaluated the effectiveness of in-situ injections of ZVI to reduce the dissolved arsenic concentrations at the BAP to below the generic GWPS. To model this approach, 0.5 moles of solid phase ZVI was dissolved in an electrolyte balanced clean water to create an injectate for the PHAST model. PHAST does not allow the injection of solids. The resulting water consisted of approximately 28 g/L dissolved iron with small amounts of sodium and chloride, that was then allowed to air equilibrate to simulate physical solution creation on-site prior to injection. The injectate had an approximate pH of 8.3. The ZVI mixture was then injected at 29 random, generally equally placed locations across the BAP. Two different rates of injection were used based on

the magnitude of the arsenic exceedance proximal to each simulated injection location. Areas of higher concentrations of arsenic received injectate at 8 gallons per minute (gpm), whereas areas of lower arsenic concentrations only received injectate at 5 gpm. The modeled injections occurred over a 30-day period and after the 30-days of injection only simulated recharge was applied to the model, similar to that of the MNA model until the end of the 30-year simulation.

Scenario 3: The next scenario evaluated the effectiveness of an in-situ injection of ferric sulfate to reduce the dissolved arsenic concentrations at the BAP. To model this approach, a basic groundwater solution (same as ZVI electrolyte clean water) was equilibrated with 0.18 moles of solid phase ferric sulfate ($Fe_2[SO4]_3$) to simulate the creation of the injectate (the highest concentration that could be dissolved in the simulation). During the mixing phase, precipitation of iron generated acid, decreasing the resulting solutions pH. To increase pH of the solution, 1.05 moles per liter of strong base [sodium hydroxide (NaOH)] was used to increase the pH to encourage solid phase iron formation. The resulting water chemistry of the injectate consisted of approximately 19.5 g/L iron with a pH of 8.9. The injectate solution was then injected at the same locations at the ZVI scenario. The injections were simulated over a 30-day period and two injection rates (5 or 8 gpm) were again used based on the magnitude of the arsenic exceedance at each location.

Scenario 4: This scenario evaluated the effectiveness of an in-situ injection of ferrous sulfate heptahydrate to reduce the dissolved arsenic concentrations at the BAP. For this approach, a clean water with balanced electrolyte was again used, combined with 0.1 moles of solid phase ferrous sulfate heptahydrate for creation of the injectate. Mixing of ferrous sulfate also generates acid due to oxidation and precipitation of the iron and 0.15 moles per liter of sodium hydroxide was again used to raise the pH of the injectate. The resulting water chemistry of the injectate consisted of approximately 5.5 g/L iron with a pH of 8.0. This is the approximate solubility limit of ferric sulfate heptahydrate at 15°C, which leads to less dissolved iron in the injectate than the 20-30 g/L target used for the other solutions. The equilibrated water is then injected at the same simulated locations at the other scenarios. The injections also occurred over a 30-day period and two injection rates (5 or 8 gpm) were used based on the magnitude of the arsenic exceedance at that location.

Scenario 5: The last scenario evaluated the effectiveness of pump and treat with reinjection at the BAP to reduce the dissolved arsenic concentrations to below its respective generic GWPS. In this approach, groundwater from the BAP was removed through seven extraction wells that operated at a rate of 3 gpm for the duration of the entire 30-year modeled timeframe. Simultaneously, water was injected back into the BAP at 10 locations also at a rate of 3 gpm. Groundwater quality from well OW-10 was used to represent water that was treated and arsenic removed to below detection limits. Injections also continued at a constant rate for the duration of the 30-year timeframe.

Sensitivity Analysis 1: This simulation evaluated if the effect of groundwater with elevated arsenic concentration from the ash landfill north of the BAP would decrease the efficiency of the ZVI remedy at the BAP. Groundwater quality from well DEK-MW-15004 was used to simulate the effect of the ash landfill on the BAP and arsenic concentrations from that unit were modeled at 160 ug/L.

Sensitivity Analysis 2: The next sensitivity analysis evaluated the effect of decreased initial adsorption capacity (based on SEP results) for aquifer materials in and surrounding the BAP. This scenario evaluates the efficiency of ZVI as a remedy with a lowered (or lowest) likely attenuation capacity other than the addition of ZVI to the aquifer. All other scenarios used the geometric mean of SEP results to establish the baseline adsorptive capacity of the aquifer.

4.5.2.5 Reactive Transport Modeling Results

WSP modeled the time to achieve the generic GWPS for arsenic at the BAP using four different remedial approaches and MNA as outlined in Table 5. The following conclusions can be reached from the different model scenarios.

- Scenario 1, MNA: Modeling indicates that MNA would likely not be effective in reducing the groundwater arsenic concentrations at the BAP to below the generic GWPS within 50-years (Figure 20). Results of modeling further indicate that arsenic concentrations above the generic GWPS would likely persist beyond the 50-year timeframe that was modeled with little to no decrease.
- Scenario 2, In-situ Injection of ZVI: Modeling indicates that the in-situ injection of ZVI could be effective in reducing the dissolved concentration of arsenic at the BAP to below the generic GWPS in a reasonable timeframe (Figure 21). Based on the location of the injections and the injection rate, results indicate that there may be some areas where arsenic could persist above the generic GWPS after 30 days of injections. These areas may need to be addressed with additional ISI. However, injection placement differing from the model scenario could also minimize any arsenic persisting above the generic GWPS.
- Scenario 3, In-situ Injection of Ferric Sulfate: Modeling results indicate that the injection of ferric sulfate would likely not be effective at reducing dissolved concentrations of arsenic to below the generic GWPS at the BAP within 30-years (Figure 22). The modeling indicates that these injections could cause groundwater arsenic concentrations to increase from desorption and oxidation of reduced arsenic present at the BAP.
- Scenario 4, In-situ Injection of Ferrous Sulfate Heptahydrate: Modeling results indicate that the injection of ferrous sulfate heptahydrate would likely not be effective at reducing dissolved concentrations of arsenic to below the generic GWPS at the BAP within 30-years (Figure 23). The modeling indicates that injections could cause groundwater arsenic concentrations to increase at the BAP due to arsenic desorption and oxidation of reduced arsenic.
- Scenario 5, Pump and Treat with Reinjection (P&T): Modeling indicates that pump and treat with reinjection would likely not result in a decrease in arsenic concentrations to below the generic GWPS at the BAP within 30-years (Figure 24). Results also indicated that groundwater arsenic concentrations would slowly increase as reinjection occurs likely due to the desorption of arsenic as equilibrium conditions change due to water incompatibility (e.g. oxidation of groundwater during treatment and potential pH changes). Based on the chemical changes in groundwater expected during treatment, additional mobilization of reduced arsenic from the aquifer could be released into groundwater.

4.5.2.6 Sensitivity Analysis Results

Sensitivity Analysis 1: Sensitivity analysis indicates that the higher arsenic concentrations measured in the northward ash landfill would likely not adversely affect the efficiency of the ISI of ZVI at the BAP (Figure 25). The simulated injections of ZVI at the BAP adequately address any additional arsenic entering the BAP from the ash landfill.

Sensitivity Analysis 2: The results of the next sensitivity analysis indicated that the efficiency of the ZVI injections are adequate to attenuate arsenic with minimal attenuation from the native aquifer materials (Figure 26).

4.5.2.7 In-Situ Injection Compound Equivalency

WSP utilized geochemical modeling in PHREEQC to also evaluate the equivalency of comparable ISI compounds to ZVI. The two additional compounds that were evaluated were iron sulfide (FeS), and Mackinawite (FeS). Both are active compounds in numerous commercially designed ISI mediums that are commonly used for the remediation of metals and other compounds.

Results of the equivalency evaluation demonstrated that both polymorphs of iron sulfide would be effective at attenuating arsenic to below the generic GWPS under the geochemical conditions found at the BAP (Figures 27 and 28). Both forms can be deployed under reducing conditions leading to the sequestration of arsenic through precipitation or co-precipitation of arsenic sulfide minerals or under oxidizing conditions provide adequate adsorption surfaces from the conversion to iron hydroxides. At varying concentrations, both were evaluated to be as effective as ZVI for attenuation of arsenic at the BAP. Groundwater at well OW-10 was used for this simulated comparison as the sample contained arsenic at levels comparable to the highest observed at the BAP and contained a generally elevated concentration of TDS.

4.5.2.8 Reactive Transport Modeling Conclusion

Based on the results of modeling described in section 4.5.2, it is concluded that MNA and P&T are not recommended at the BAP as concentration of arsenic are likely not to decrease to below the generic GWPS within 50 years and 30 years, respectively. Modeling indicates that the in-situ injection of ZVI would be most effective to meet the generic GWPS for arsenic. However, it should be noted that the injection volume, injection timeframe, and injection locations used in this modeling evaluation should be further evaluated with a pilot test. Pilot testing will help determine the zone of influence of injections, ideal injection rates and volumes, refine injection locations, and help maximize efficiency of the proposed ZVI remediation strategy, minimizing the potential for localized arsenic generic GWPS exceedances or the need for additional future injections.

5.0 OPTIONS ASSESSMENT AND FEASIBILITY STUDY SUMMARY

The following corrective measures (listed alphabetically) were identified as potentially applicable to remediate arsenic in groundwater at the Site:

- Geochemical Approaches using In-Situ Injection (ISI)
- Hydraulic Containment using Pump and Treatment (P&T) with Re-Injection
- In-Situ Solidification/Stabilization (ISSS)
- Monitored Natural Attenuation (MNA)
- Permeable Reactive Barrier (PRB)
- Air Sparge Oxygenation (ASO)
- Phytoremediation (Phyto)
- Subsurface Vertical Barrier Walls (Slurry Wall)

Consumers also plans to utilize adaptive site management to support the remedial strategy and address potential changes in Site conditions as appropriate. Under an adaptive site management strategy, a remedial approach will be selected whereby: (1) a remedy will be installed or implemented to address current conditions; (2) the

performance of the remedy will be monitored, evaluated, and reported annually; (3) the CSM will be updated as more data are collected; and (4) adjustments and augmentations will be made to the remedy, as warranted, to achieve Site objectives.

The potential remedial measures identified were initially screened against the 'comparative criteria' using the known site-specific setting. The results of this process of evaluating potential remedies for ease of implementation, performance (source control) and effectiveness indicated:

- phytoremediation implementation is limited by the shallow depth that plants can access (Site groundwater is too deep, typical screen sections for shallow groundwater at the Site are on the order of 30 ft bgs or greater), effectiveness is limited, and source control/reduction is low.
- permeable reactive barriers (e.g., zero-valent iron barrier) are challenged by the orientation of existing structures in relationship to residual sources and the long-term hydraulic gradient and groundwater flow direction and velocity across the BAP. The uncertainty in long-term groundwater flow direction and velocity makes this remedial measure difficult to implement (in the correct location with correct width), effectiveness is high for that groundwater that flows through the PRB, and source control/reduction is low.
- subsurface vertical barrier walls (e.g., soil/bentonite slurry walls) are challenged by both the depth to a clay layer to tie into (approximately 50 ft in some areas) and the significant alterations to the groundwater flow field at the Site. Potential perturbations from the anticipated conditions could be contrary to the construction of the Karn Landfill PRB. Implementability is high (slurry walls are easy to construct), source control/reduction is low, effectiveness is uncertain due to variation in groundwater flow field in relationship to the impermeable walls' sections.
- chemical oxidation has the potential for the release of naturally occurring arsenic that is bound in natural soil and sediments. The area of the BAP is overwhelmingly reducing and the presence of natural organic matter and other reduced metals could potentially become oxidized, releasing acidity at the site and mobilizing arsenic and potentially other naturally occurring metals and/or metalloids.
- in-situ stabilization/solidification (fully mixing and cementing all soil/sediment/CCR residual materials) is difficult, but not impractical to implement at the Karn BAP scale of the arsenic impacts. However, because the impacts are relatively small in areal extent and some of which is already beneath the final Karn Landfill cap. Implementation of ISS is a significant project, certainly effective at source control/reduction, but difficult to implement in certain areas of the Site.
- MNA, described as monitoring groundwater conditions to establish plume containment and decline without 'enhancing' the attenuation mechanisms naturally present in the aquifer. Modeling MNA (Section 5.2.5) indicated the attainment of generic GWPS in excess of 50 years.

The two retained corrective measure alternatives (P&T and ISI) are discussed in further detail below for evaluation against the remedy selection criteria specified in 40 CFR § 257.97(b, c).

- **Alternative 1 – P&T:** Alternative 1 (Reactive Transport Model Scenario 5) relies on hydraulic containment, described as localized pumping with ex-situ treatment and re-injection to control arsenic migration and treat arsenic ex-situ (with an above grade water treatment system) followed by re-injection. Reactive transport modeling indicated arsenic concentrations are unlikely to below the generic GWPS within a reasonable time frame (30 years). P&T is however retained as the presumptive remedy for groundwater to be used in the

detailed comparisons. Additionally, P&T is identified as a contingency measure, and its use may be considered during adaptive management over the course of remedy implementation should the enacted remedy fail.

- **Alternative 2 - ISI:** Alternative 2 (Reactive Transport Model Scenario 2) relies on arsenic sequestration/immobilization under different combinations of redox and pH conditions (potentially with the addition of zero-valent iron (ZVI) or similar compounds known to sequester arsenic (e.g. iron sulfide). ISI with ZVI would create an in-situ reactive zone in the groundwater plume, creating conditions for reduction-oxidation and adsorption reactions resulting in the chemical attenuation of constituents in groundwater. For evaluating ISI, a conceptual design was considered using injections of ZVI injected in transmissive intervals within the saturated sand layer beneath the BAP, using direct push injection technology and applying in an array of injection locations.

6.0 CORRECTIVE MEASURES EVALUATION

The purpose of this section is to evaluate the corrective measures alternatives using the required criteria described in 40 CFR § 257.97(b) and the comparative criteria described in 40 CFR § 257.97(c).

6.1 REQUIRED CRITERIA (§257.97(b))

As described in 40 CFR § 257.97(b), for a groundwater corrective measure to be selected it must meet the following criteria:

1. Be protective of human health and the environment.
2. Attain the GWPS as specified pursuant to 40 CFR § 257.95(h).
3. Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment.
4. Remove from the environment as much of the contaminated material that was released from the CCR Unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards for management of wastes as specified in 40 CFR § 257.98(d).

The corrective measures alternatives are evaluated against the required criteria in the following subsections. As shown below, both alternatives evaluated meet or exceed the required criteria.

6.1.1 Protective of Human Health and the Environment (§257.97(b)(1))

Arsenic has been delineated to concentrations not exceeding health-protective screening criteria on Site, and constituents evaluated from the BAP are not expected to pose a risk to human health or the environment. Accordingly, no further risk evaluation of groundwater or surface water is warranted in connection with the remedy selection process. Because no adverse human health or environmental risk currently exists, human health and the environment will be protected through closure and implementation of either of the remedies being evaluated. Consequently, each of the remedies being evaluated would meet this criterion.

6.1.2 Attain the Groundwater Protection Standards (§257.97(b)(2))

Both proposed remedies can attain the generic GWPS at the compliance network and in the area of arsenic exceedances. For each of the remedies retained, attainment of the generic GWPS is expected based on constituent transport evaluations included in Appendix B.

Alternative 1 (P&T) was evaluated for ability to reach groundwater protection standards. Modeling indicates that pump and treat with reinjection would likely not result in a decrease in arsenic concentrations to below the generic GWPS at the BAP within 30-years (Figure 24).

Alternative 2 (ISI) can be applied in strategically areas of higher arsenic concentrations as well as broadly across some or all of the footprint of the BAP. Laboratory testing of groundwater from monitoring wells just to the north of the BAP at the Karn Landfill unit confirms that arsenic can be removed from groundwater using ZVI (WSP, 2024). Additionally, geochemical modeling supports these findings (Appendix B) and indicates that initial applications of ZVI using ISI reduces the arsenic concentration to below generic GWPS within one year. Monitoring will indicate any need for additional applications.

6.1.3 Control the Source of Release (§257.97(b)(3))

In connection with a remedy, the source of the contamination must be controlled to reduce or eliminate, to the maximum extent feasible, further releases by identifying and locating the cause of the release. The following section describes how the source control required criterion is met in connection with each evaluated alternative.

Alternative 1 (P&T) treats arsenic in groundwater ex-situ, while returning treated water to the aquifer using injection wells. The system is hydraulically designed to control the migration of arsenic. The system does not, however, treat source areas actively, only extracting and treating the material being released from the source at some distance away from the source.

Alternative 2 (ISI) can be applied in plume and source areas, with rapid treatment. The potential for re-applications exist, but primarily to finish off source areas, thus controlling and eliminating the source.

6.1.4 Removal of Contaminated Material from the Environment (§257.97(b)(4))

The corrective measures retained for further consideration can be effective at removing arsenic from groundwater, either through processes of immobilization or chemical attenuation in groundwater, either externally (P&T) or enhanced in-situ (ISI). The remedies considered herein remove contaminated material from the environment as follows:

Alternative 1 (P&T) can remove arsenic from the plume at an above-ground (ex-situ) groundwater treatment plant. Removal requires multiple processes (pre-filtration, chemical addition, flocculation/separation, waste handling) and the mechanical nature of these 24/7 systems usually requires significant operation, maintenance and monitoring (OM&M).

Alternative 2 (ISI) can immobilize arsenic under different combinations of redox and pH conditions and with the addition of surface reactive compounds such as ZVI. ISI would create an in-situ reactive zone in the groundwater plume and source areas, creating conditions for reduction-oxidation and adsorption reactions resulting in the chemical attenuation of arsenic in groundwater, without waste generated.

Each of the remedies can comply with Waste Management Standards (§257.97(b)(5)), and in accordance with 40 CFR § 257.98(d), any waste generated during the implementation of any of the remedies under consideration

would be managed in a manner that complies with applicable requirements of the Resource Conservation and Recovery Act and the Georgia Comprehensive Solid Waste Management Act. Consequently, each of the remedies being evaluated would meet this criterion.

Required Criteria	Alternative 1 (P&T)	Alternative 2 (ISI)
Be protective human health and the environment	✓	✓
Attain the groundwater protection standards	✓	✓
Control the sources of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents to the environment	✓	✓
Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems	✓	✓
Management of waste to comply with all applicable RCRA requirements	✓	✓

6.2 COMPARATIVE CRITERIA (§257.97(c))

This section compares the alternatives using the comparative criteria listed in 40 CFR § 257.97(c). Each of the comparative criteria consist of several sub-criteria listed in the CCR Rule that are considered below. The goal of this analysis is to further evaluate the alternatives that meet the required criteria to support remedy selection. Consistent with 40 CFR § 257.98(b), the selected and implemented remedy will be continually evaluated and, if warranted, modified consistent with adaptive management practices.

A graphic is provided within each subsection to provide a visual depiction of the favorability of each alternative, where dark green represents that the “option’s performance under this criterion is highly favorable”, medium green represents that the “option performs favorably under this criterion,” and light green represents that the “option performs less favorably under this criterion.”

Color Legend:

	Option’s performance under this criterion is *highly favorable*
	Option performs *favorably* under this criterion
	Option performs *less favorably* under this criterion

6.2.1 Category 1: Long- and Short-Term Effectiveness and Protectiveness

This comparative criterion takes into consideration the following sub-criteria relative to the long-term and short-term effectiveness of each corrective measure alternative. Long-term effectiveness and protectiveness mean that the remedy will protect human health and the environment after the remedial objectives have been met.

The short-term effectiveness of a potential remedy is related to the protectiveness of human health and the environment during construction and implementation. The degree of protection and the time period to achieve remedial action objectives are also considered.

Sub Criterion 1: Magnitude of Reduction of Existing Risks

As indicated by the nature and extent evaluation, the most recent groundwater sampling results, arsenic in groundwater from the BAP is not expected to pose a risk to human health or the environment. Therefore, this criterion is considered favorable for both corrective measure alternatives. In addition, each groundwater remedy retained for this comparative analysis will be effective at reducing concentrations, though at different rates, to levels below the generic GWPS.

Sub Criterion 2: Magnitude of Residual Risks in Terms of Likelihood of Further Releases Due to CCR Remaining Following Implementation of a Remedy

Unit closure through closure via excavation has already significantly reduced CCR releases with at least 90% removal of CCR materials. As noted in the groundwater modeling report (Appendix B), Alternative 2 (ISI) can access and treat residual CCR materials (source reduction) while Alternative 1 cannot.

Sub Criterion 3: The Type and Degree of Long-Term Management Required, Including Monitoring, Operations, and Maintenance

In accordance with 40 CFR § 257.97(c)(1)(iii), this sub-criterion considers the long-term management of each groundwater remedy.

Both Alternative 1 (P&T) and Alternative 2 (ISI) will require monitoring during the corrective action period and during subsequent long-term performance monitoring to confirm that GWPS are met. Alternative 1 (P&T) has high OM&M, requiring 24/7 attention. ISI is relatively low OM&M, ISI being slightly more intensive only during applications. Beyond monitoring required to verify performance of the groundwater remedy, per CCR rule requirements, post closure care monitoring, including groundwater sampling and reporting, will continue for no less than 30 years following closure.

Sub Criterion 4: Short-term risks that might be posed to the community or the environment during implementation of such a remedy

In accordance with 40 CFR § 257.97(c)(1)(iv), this sub-criterion relates to the potential for threats to human health (including without limitation worker safety and the community) and the environment associated with remedy implementation.

Community impacts include increased truck traffic on public roads during construction of the remedies, as well as increased vehicle emissions, resource consumption, and noise. Although Alternative 2 (ISI) will require active injection for a period of months, Alternative 1 (P&T , a 24/7 operation requiring truck traffic, etc. will have an impact on the community.

Sub Criterion 5: Time until full protection is achieved

Timeframes to achieve GWPS at the BAP were evaluated using a predictive 1-D reactive transport model (Appendix B). For Alternative 1 (P&T), is predicted to achieve the GWPS in greater than 40-50 years and is therefore considered less favorable overall. With implementation of ISI, the time to achievement of generic GWPS would be less than 1 year, but with potential re-applications.

Sub Criterion 6: Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment

In accordance with 40 CFR § 257.97(c)(1)(vi), this sub-criterion considers elements such as the generation and handling of wastes or potentially impacted media encountered during construction and operation of the remedy. Alternative 1 (P&T) is considered not favorable, and Alternative 2 (ISI) is considered favorable since potential exposure through contact with groundwater is minimal.

Sub Criterion 7: Long-term reliability of the engineering and institutional controls

The following describes the overall long-term reliability for each of the proposed groundwater remedial alternatives for purposes of comparison. Of note, the reliability of all alternatives is bolstered by the long-term reliability of the closure method and its expected positive effect on groundwater conditions.

Alternative 1 (P&T) is expected to have high long-term reliability but requiring the high OM&M. Alternative 2 (ISI), is also considered favorable because it reduces the long-term OM&M and the need for institutional controls.

Sub Criterion 8: Potential need for replacement of the remedy

Any need to replace a remedy would be based on a systematic Site review during the remedy implementation process if warranted to improve remedy protectiveness, effectiveness or facilitate progress toward meeting Site goals. In accordance with 40 CFR § 257.98(b), adaptive site management practices will be used to modify or replace the remedy if the requirements of 40 CFR § 257.97(b) are not achieved.

Alternative 1 (P&T) is considered the corrective measure with a low likelihood of requiring replacement but a high likelihood of extended operation. The technology is proven and available but requires significant OM&M. Alternative 2 (ISI), which relies on in-situ treatment to address high arsenic concentrations is considered favorable since the treatment efficacy of Site groundwater with ZVI is relatively certain. ISI is dependent upon the uniform distribution of in-situ reagents within targeted area of interest, and additional ISI applications may be required to avoid geochemical conditions that promote the mobilization or remobilization of arsenic, but a change to a different remedial technology is deemed low.

Category 1 Summary: Long- and Short-Term Effectiveness

Overall, Alternative 1 (P&T) is less favorable relative to Alternative 2 - ISI which is considered favorable with respect to long- and short- term effectiveness and protectiveness. While Alternative 2 - ISI is projected to reach generic GWPS at the waste boundary more quickly than Alternative 1 - P&T, both achieve GWPS within a reasonable timeframe. Alternative 2 (ISI) requires post-application monitoring data to evaluate short and long-term effectiveness and reliability and could result in a greater degree of long-term management if re-injections are required. ISI is considered favorable because it rapidly reduces constituent concentrations.

Category 1 – Long and Short-Term Effectiveness, Protectiveness, and Certainty of Success Summary	**Alternative 1: P&T**	**Alternative 2: ISI**
Sub-criterion 1 Magnitude of reduction of existing risks	Less Favorable	Favorable
Sub-criterion 2 Magnitude of residual risk in terms of likelihood of further release	Favorable	Favorable

Sub-criterion 3 Type and degree of long-term management required	Less Favorable	Favorable
Sub-criterion 4 Short-term risk to community or environment during implementation	Favorable	Favorable
Sub-criterion 5 Time until full protection is achieved	Less Favorable	Highly Favorable
Sub-criterion 6 Potential for exposure of humans and environmental receptors to remaining wastes	Less Favorable	Favorable
Sub-criterion 7 Long-term reliability of engineering and institutional controls	Less Favorable	Favorable
Sub-criterion 8 Potential need for replacement of the remedy	Favorable	Favorable
Category 1 Summary:	Less Favorable	Favorable

Note: Refer to Section 6.2 for Color Legend

6.2.2 Category 2: Source Control Effectiveness

As described in Section 6.2.1 above, the source control required criterion is satisfied in connection with both of the corrective measure alternatives being evaluated. Specifically, in connection with closure, CCR material has already been principally controlled through engineering methods including dewatering and excavation.

This comparative criterion takes into consideration the ability of the remedy to control a future release and the extensiveness of treatment technologies that will be required. Neither of the corrective measures under consideration would interfere with or diminish the benefits of the closure method.

Sub-Criterion 1: The extent to which containment practices will reduce further releases

Arsenic that is present in groundwater currently within the unit boundary will be controlled by the selected corrective measure. Therefore, all groundwater remedy alternatives are considered favorable for this sub-criterion.

Sub-Criterion 2: The extent to which treatment technologies may be used

This section evaluates 40 CFR § 257.97(c)(2)(ii) regarding the extent to which treatment technologies may be used. Alternatives that include more limited treatment approaches may be considered less favorable. Alternatives that rely on more extensive treatment approaches may be considered more favorable.

Alternative 1 (P&T), relies on a mechanical above-ground treatment plant, effective at reducing arsenic concentrations at the unit boundary through groundwater extractions, would be considered less favorable with respect to this criterion. Alternative 2 (ISI) relies on in-situ treatment with active injections to reduce concentrations of arsenic to GWPS at the unit boundary and in source areas, preventing further releases. Alternative 2's ability to treat in source areas makes it more favorable than Alternative 1.

Source control effectiveness summary

Given that source control measures will be used and are the main driver to control additional releases overall both alternatives are favorable for the category of source control. However, Alternative 1 is less favorable because it does not include an active treatment technology.

Category 2 – Source Control Effectiveness Summary	Alternative 1: P&T	Alternative 2: ISI
Sub-criterion 1 Extend to which containment practices will reduce further releases	Favorable	Favorable
Sub-criterion 2 Extent to which treatment technologies may be used	Less Favorable	Favorable
Category 2 Summary:	Less Favorable	Favorable

Note: Refer to Section 6.2 for Color Legend

6.2.3 Category 3: Ease of Implementation

This comparative criterion takes into consideration technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

Sub-Criterion 1: Degree of Difficulty Associated with Constructing the Technology

This sub-criterion considers the relative technical difficulty between implementing each of the remedies.

Alternative 1 (P&T) is considered less favorable since implementation of a groundwater treatment plant system is not easy. Alternative 2 (ISI) is considered favorable as there is no construction component. ISI technology is well established and relatively easy to implement and site-specific laboratory studies confirm its use.

Sub-Criterion 2: Expected Operational Reliability of the Technologies

This section compares the operational reliability of each of the proposed remedies in accordance with 40 CFR § 257.97(c)(3)(ii). Typically, simple remedies that do not require the installation of significant infrastructure are generally more reliable and do not require significant OMM; however, more complex remedies that rely on groundwater flow or geochemical manipulation or mechanical systems would be considered less favorable.

Alternative 1 (P&T) is considered less favorable from an operational perspective because P&T requires significant long-term OM&M. Alternative 2 (ISI) will include the short-term OM&M (principally monitoring) and is, therefore, considered favorable.

Sub-Criterion 3: Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies

Section 40 CFR § 257.97(c)(3)(iii) requires consideration be given and compared between remedies regarding the various agencies and type of permits that would be required for implementation of the groundwater remedy. A remedial alternative that could require several permits (for example, a pump and treatment system) would be considered less favorable when compared to a remedial alternative that would require fewer permits (for example, P&T).

Alternative 1 (P&T) is considered favorable since the implementation of a presumptive remedy for groundwater (P&T) is well established. Alternative 2 (ISI) requires minimal permitting (e.g., permit for pilot testing; and full-scale underground injection (UIC) permit), and is therefore considered favorable. Neither is considered to have significant permitting issues.

Sub-Criterion 4: Availability of Necessary Equipment and Specialists

Remedies that could be implemented by local contractors and without specialty contractors or experts may be considered more favorable. Consideration should be given to specialty contractor/consultant proximity to the CCR Unit, contractor or equipment availability, and the effectiveness of the proposed remedy on similar sites.

Alternative 1 (P&T) and Alternative 2 (ISI) are both considered favorable since the equipment, supplies, technical specialists, contractors, etc. for conducting either corrective measure are common in the remediation industry.

Sub-Criterion 5: Available Capacity and Location of Needed Treatment, Storage, and Disposal Services

This sub criterion (40 CFR § 257.97(c)(3)(v)) considers disposal options for materials generated by the groundwater remedy and land area that is available for implementation of the remedy.

Alternative 1 (P&T) has a need for treatment, storage and disposal services. Materials generated include spent filters and filter cake from chemical precipitation processes. On-Site, materials needing storage include treatment chemicals, cleaning products, machinery lubricants, etc. Unit processes need buildings and ancillary structures.

Alternative 2 (ISI) would not produce waste necessitating treatment-storage-disposal (TSD) services and is considered favorable. Alternative 2 (ISI) would produce relatively small quantities of soil cuttings and ancillary wastes/debris from well installation and chemical injection activities that are negligible and is also considered favorable.

Ease of implementation Summary

The various sub-criteria were evaluated, and relative comparisons were made between the corrective measure alternatives to determine which remedy, or remedies would be expected to be the most and least favorable regarding the certainty of success. The results of this comparison are included in the following table for each of the Comparison Criteria.

Category 3 – Ease of Implementation Summary	**Alternative 1: P&T**	**Alternative 2: ISI**
Sub-criterion 1 Degree of Difficulty Associated with Constructing the Technology	Less Favorable	Favorable
Sub-criterion 2 Expected Operational Reliability of the Technologies	Less Favorable	Favorable
Sub-criterion 3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies	Favorable	Favorable
Sub-criterion 4 Availability of Necessary Equipment and Specialists	Favorable	Favorable
Sub-criterion 5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services	Less Favorable	Favorable
Category 3 Summary:	Less Favorable	Favorable

Note: Refer to Section 6.2 for Color Legend

6.2.4 Evaluation of Comparison Criteria

The various sub-criteria were evaluated, and relative comparisons were made between the remedial alternatives to determine which remedy, or remedies would be expected to be the most and least favorable regarding the certainty of success. The results of this comparison are summarized in the table below.

Summary of Comparison Criteria	Alternative 1: P&T	Alternative 2: ISI
Category 1 Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success	Less Favorable	Favorable
Category 2 Effectiveness in Controlling the Source to Reduce Further Releases	Less Favorable	Favorable
Category 3 Ease of Implementation	Less Favorable	Favorable

Note: Refer to Section 6.2 for Color Legend

7.0 DESIGN AND IMPLEMENTATION SUMMARY

The remedial response strategy is to apply ISI at the BAP to remove arsenic from groundwater by installing an array of injection locations that acting as a coalesced unit treat a significant area of the BAP, particularly in areas of known high arsenic concentrations. Granular ZVI material is injected in a top-down approach, pressure injecting ZVI slurry every 2 feet from the top of the sand unit down to the underlaying clay (approximately 15-20 feet of saturated thickness) using hydraulic push technology. Design details will be finalized at a later date and detailed in a separate work plan, and the final design (e.g., number of injection locations, volume and reactant concentration of injectant) may differ from the concepts presented in this RSR.

Following approval by EGLE for the recommended remedy, a Final RSR with sections providing a summary of the design and implementation plan, including permit requirements and approvals that will be obtained prior to construction; site preparation activities and general requirements; the design and construction of an ISI program; and site restoration.

8.0 OPERATION, MAINTENANCE AND MONITORING PLAN

An operation, maintenance and monitoring plan (OM&M) inclusive of additional monitoring locations and requirements will be further developed during final design and will describe the groundwater monitoring program that will be implemented to evaluate ISI performance, plans to maintain the effectiveness and integrity of the remedial response after construction, and contingency planning. The detailed OM&M Plan will be incorporated into the Karn Landfill HMP and update the existing plan.

8.1 ISI Performance Monitoring

Groundwater conditions will be monitored before, during, and after implementation to assess ISI performance. A monitoring well network consisting of monitoring locations approved in the Karn Landfill HMP, monitoring wells installed during the FS, and new monitoring wells that will be installed within the constructed ISI program will form the basis of a corrective action monitoring program to assess progress towards the Site cleanup goals. The placement of the monitoring wells within the BAP is expected to cover areas of highest arsenic concentrations. Additional

monitoring locations for assessment of exposure control mechanisms will likely include points of compliance and monitoring wells along the intake channel.

Groundwater samples collected to assess the performance of ISI will be analyzed for select constituents consistent with the sampling program parameters and analytical methods tabulated in Appendix A and sampling standard operating procedures in the HMP-R4 and will be further developed in the corrective action monitoring plan. Since the primary constituent of interest is arsenic and the tools most suitable for visualizing redox trends are field-measured parameters of dissolved oxygen, oxygen reduction potential (ORP), and pH, these parameters will be key measurements in monitoring events and corrective action effectiveness evaluations. However, constituents monitored in addition to arsenic for the purposes of evaluating the remedy's effectiveness will be determined by the results of the pilot study evaluation of the effectiveness of the ISI program and will be further developed in the final RSR. The detailed corrective action monitoring plan will be incorporated into a revised HMP and provided to EGLE for review and approval. The HMP will be updated to include the OM&M Plan for the operation and monitoring of the ISI remedy.

In addition to analytical results, groundwater elevations will be used to evaluate the hydraulic gradient across the BAP to monitor for changes to the hydraulic characteristics in the remedial response area. Water level elevations and gradients will also be evaluated in the initial Annual RAER. Recommendations for water level monitoring and any changes to that program will be presented in that initial report and assessed for trends in subsequent reports.

Initially, the corrective action monitoring program that will consist of measuring water elevation and collecting samples for analysis from a groundwater monitoring well network will be conducted on a quarterly basis, pursuant to the Karn Landfill HMP and consistent with ISI performance monitoring frequency recommended by the Interstate Technology and Regulatory Council (ITRC, 2011).

Should monitoring indicate plugging/fouling may be occurring, which may be indicated by changes to groundwater flow patterns in the vicinity of the ISI injections or increasing arsenic concentrations downgradient of the ISI injections may be conducted to evaluate mineral buildup within the aquifer.

8.2 ISI Maintenance

ISI performance will be monitored in accordance with the OM&M Plan developed during final design, and the ISI supplemental injections will be performed as needed to mitigate groundwater flow with arsenic concentrations above GWPS criteria. An estimated replacement interval and the engineering decision matrix and performance criteria that triggers replacement will be evaluated during the final design.

8.3 Contingency Planning

General contingency plans will be further developed and incorporated as part of the OM&M Plan and implemented as needed if the remedial response does not meet the remedial response objectives. The estimate of the time to achieve remedial response objectives once ISI has been implemented is very rapid and less than one year (the chemical reactions are relatively instantaneous but mixing and contact does take time). The potential for supplemental applications of ISI based on monitoring data will extend the life of the remedy. It is unlikely that supplemental applications will continue beyond a 30-year closure period.

The timing for implementing contingency plans will be further developed during final design and included in the OM&M Plan. In general, if monitoring activities indicate that groundwater quality is not meeting the remedial response objectives within the expected amount of time following construction, additional evaluation will be

completed to identify potential contingency actions. Bench-scale testing conducted as part of a PRB remedy at the adjacent Karn Landfill indicated that ZVI arsenic treatment capacity is not expected to rapidly degrade in Site groundwater (WSP, 2024). Finally, groundwater hydraulic gradients are very shallow and groundwater migration slow, anticipated to be on the order of 8 ft/year. Therefore, semi-annual monitoring is sufficient to identify performance deficiencies within a reasonable amount of time to evaluate and remedy deficiencies.

9.0 IMPLEMENTATION SCHEDULE

The schedule for implementing the remedial response is dependent on timing of approval of this RSR and successor activities that include EGLE concurrence with the IFB construction package and approval of a revised HMP that defines the corrective action monitoring program and includes monitoring, maintenance, and contingency plans for the ISI operation and ISI program data collection. While the schedule is subject to change based on these known constraints, the anticipated schedule based on the best available information is:

Implementation Component	**Anticipated Timeframe**
Pilot Test Workplan Submittal & EGLE Approval	Through 4Q2025
Pilot Study Implementation	1Q2026 – 3Q2026/1Q2027
Pilot Study Monitoring	3Q2026 – 3Q2027
RAP/Final Remedy Selection	4Q2027 – 1Q2029
Final Design and Implementation	2Q2029
Contractor Procurement	Within 90 days after EGLE concurrence with Construction Package
Site preparation; begin remedial response implementation	Within 180 days after EGLE concurrence with Construction Package
Remedial response implementation for initial in situ treatment followed by site restoration and demobilization	Within 1 years after remedial response implementation
Remedial response implementation for subsequent in situ treatment followed by site restoration and demobilization	Within 1 year of initial application results report
Certified Quality Assurance Construction Report will be prepared and submitted to EGLE for review and acceptance	Within 180 days of final application results report

Remedial response construction is expected to take approximately up to two years to complete, including final design and contractor selection and mobilization. As this schedule is further refined during final design and contractor selection, and throughout the project, EGLE will be notified of changes.

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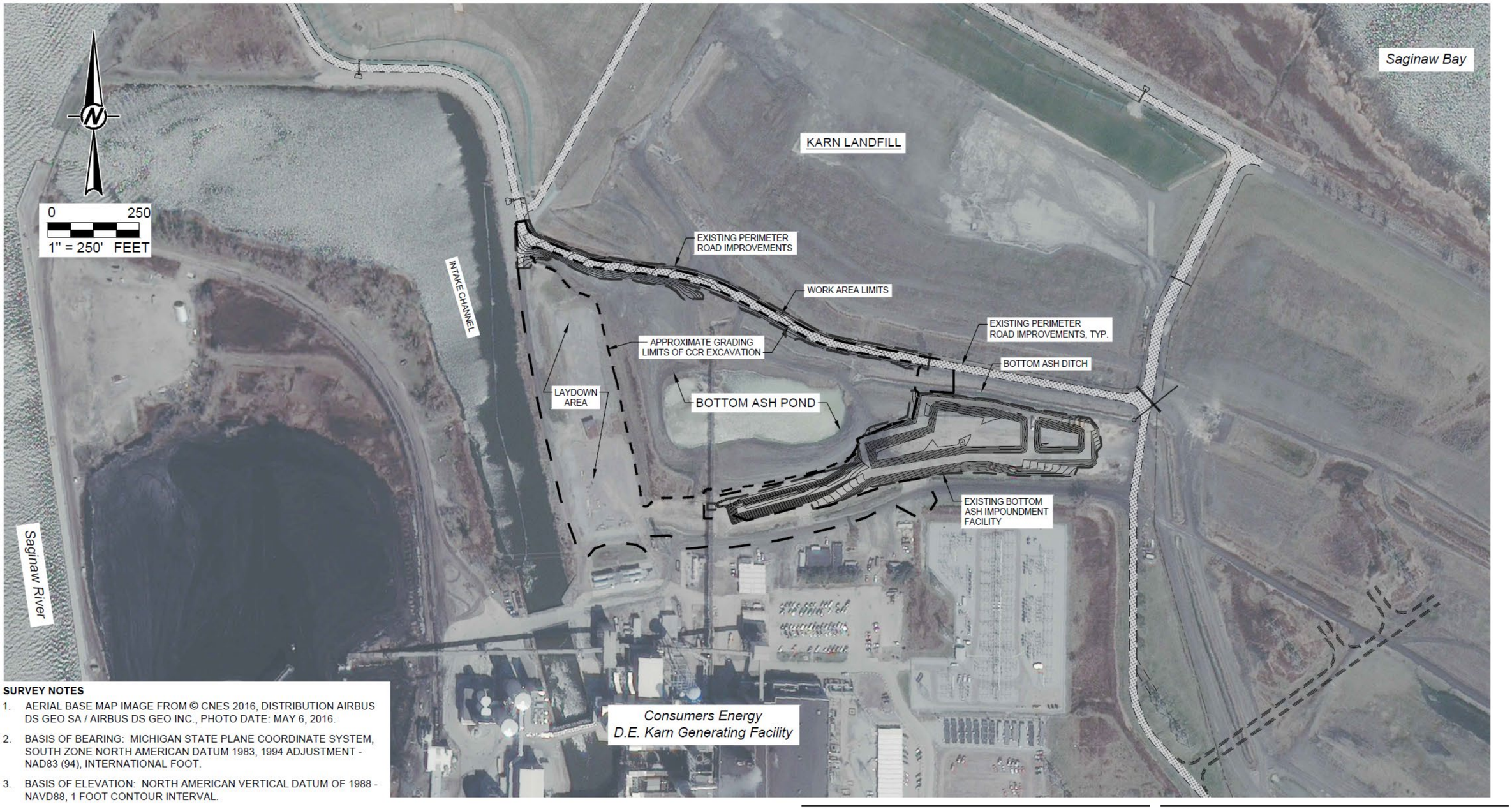
FIGURES



SURVEY NOTES

1. AERIAL BASE MAP IMAGE FROM © CNES 2016, DISTRIBUTION AIRBUS DS GEO SA / AIRBUS DS GEO INC., PHOTO DATE: MAY 6, 2016.
2. BASIS OF BEARING: MICHIGAN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE NORTH AMERICAN DATUM 1983, 1994 ADJUSTMENT - NAD83 (94), INTERNATIONAL FOOT.
3. BASIS OF ELEVATION: NORTH AMERICAN VERTICAL DATUM OF 1988 - NAVD88, 1 FOOT CONTOUR INTERVAL.

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REVIEWED	PJN
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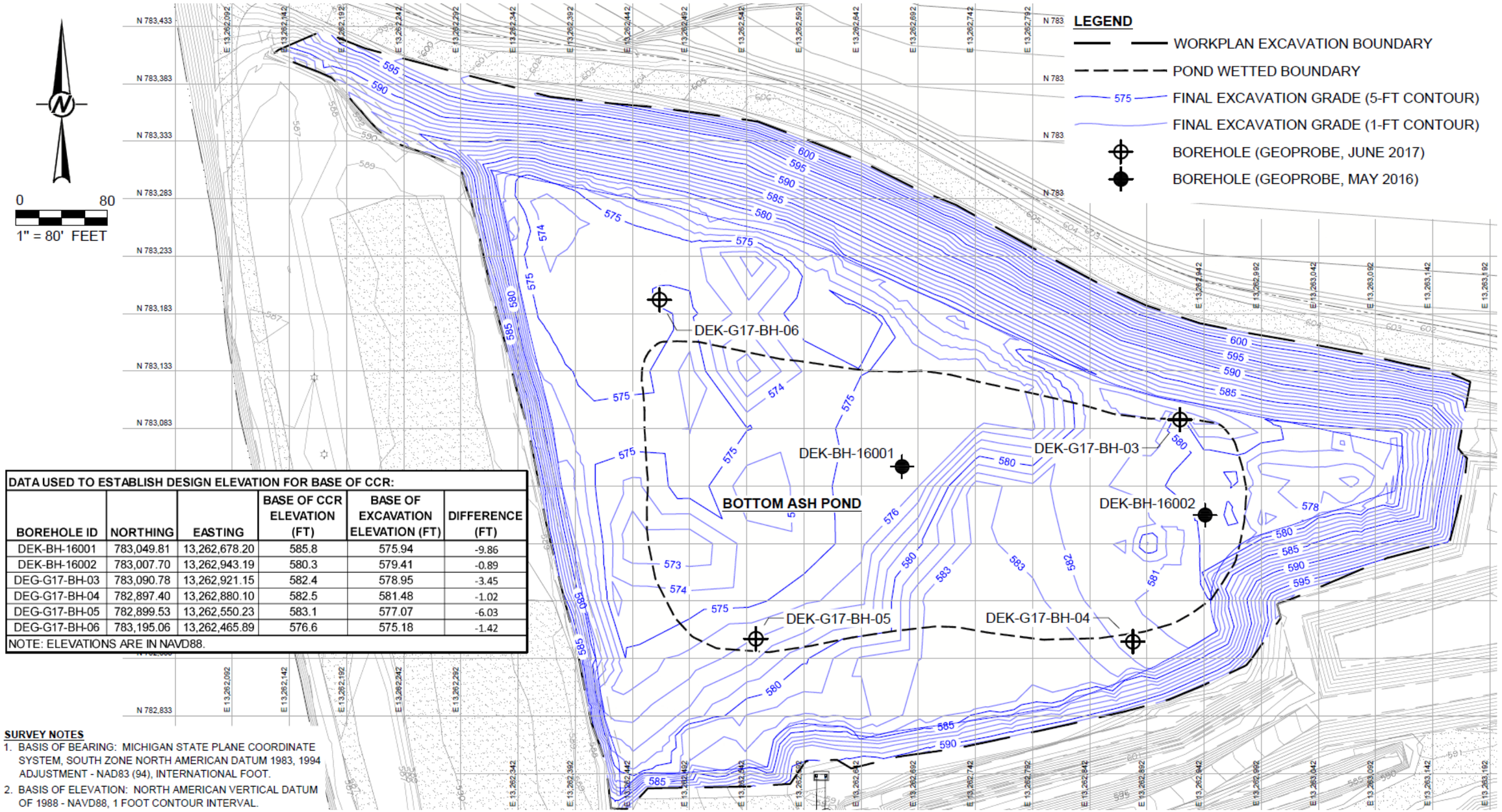
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SITE OVERVIEW

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 1in



DATA USED TO ESTABLISH DESIGN ELEVATION FOR BASE OF CCR:

BOREHOLE ID	NORTHING	EASTING	BASE OF CCR ELEVATION (FT)	BASE OF EXCAVATION ELEVATION (FT)	DIFFERENCE (FT)
DEK-BH-16001	783,049.81	13,262,678.20	585.8	575.94	-9.86
DEK-BH-16002	783,007.70	13,262,943.19	580.3	579.41	-0.89
DEG-G17-BH-03	783,090.78	13,262,921.15	582.4	578.95	-3.45
DEG-G17-BH-04	782,897.40	13,262,880.10	582.5	581.48	-1.02
DEG-G17-BH-05	782,899.53	13,262,550.23	583.1	577.07	-6.03
DEG-G17-BH-06	783,195.06	13,262,465.89	576.6	575.18	-1.42

NOTE: ELEVATIONS ARE IN NAVD88.

SURVEY NOTES

1. BASIS OF BEARING: MICHIGAN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE NORTH AMERICAN DATUM 1983, 1994 ADJUSTMENT - NAD83 (94), INTERNATIONAL FOOT.
2. BASIS OF ELEVATION: NORTH AMERICAN VERTICAL DATUM OF 1988 - NAVD88, 1 FOOT CONTOUR INTERVAL.

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TITLE
BAP EXCAVATION SURFACE

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 1in

LOCATION MAP
NOT TO SCALE

LEGEND

PROPOSED BORING LOCATION

PORPOSED BORING LOCATIONS		
DESIGNATION	LATITIUDE	LONGITUDE
BORING 1	43.6480370	-83.8405089
BORING 2	43.6469691	-83.8411412
BORING 3	43.6475024	-83.8385365
BORING 4	43.6468980	-83.8391403
BORING 5	43.6471316	-83.8363062
BORING 6	43.6466313	-83.8364384

0 200 400
SCALE: 1"=200'

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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
BOREHOLE LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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NOTE(S)

1. WATER LEVELS WERE MEASURED ON SEPTEMBER 30, 2024

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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SEPTEMBER 2024 SITE POTENTIOMETRIC SURFACE MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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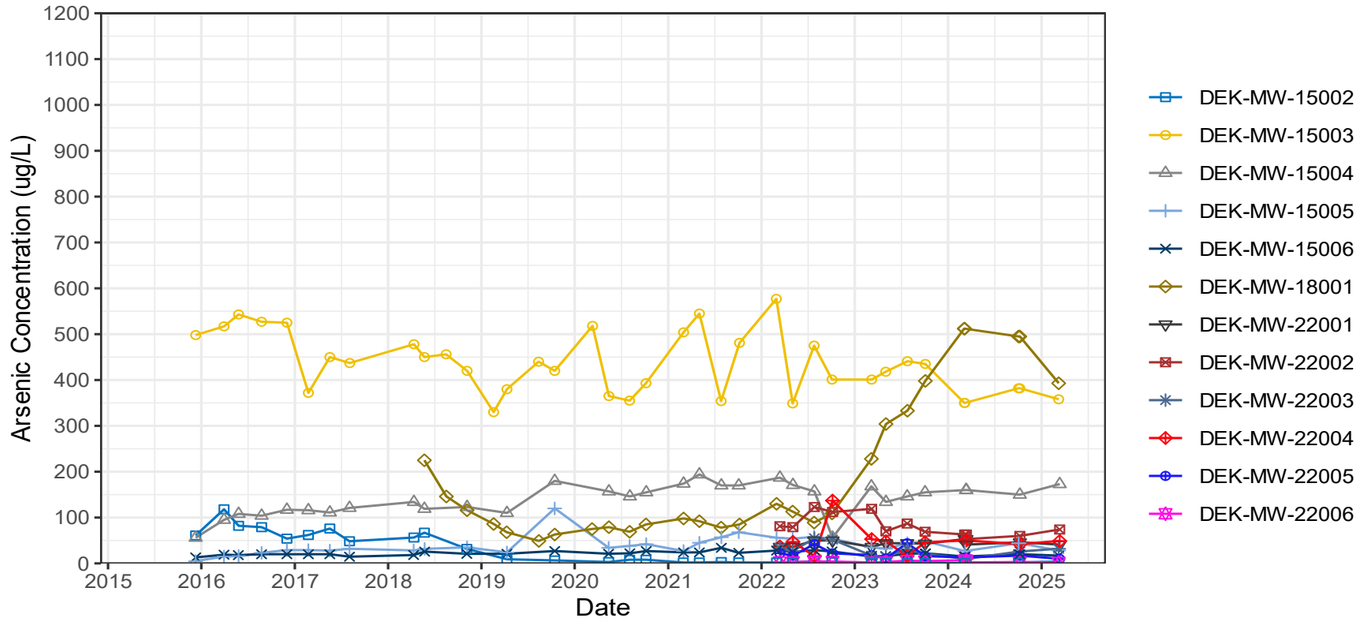

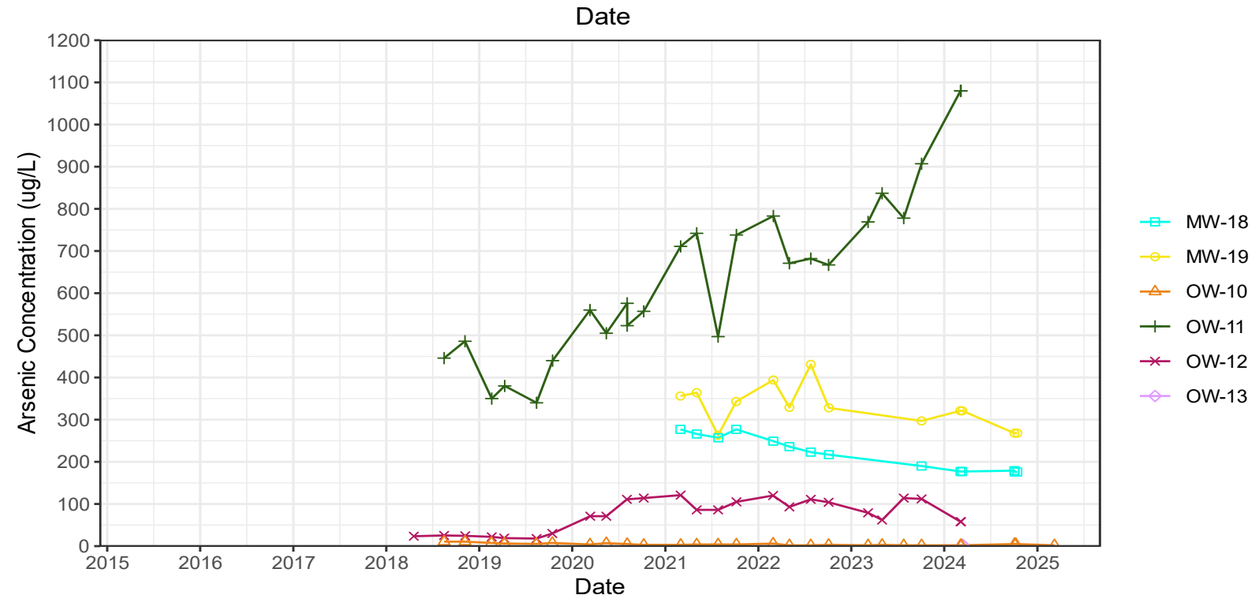

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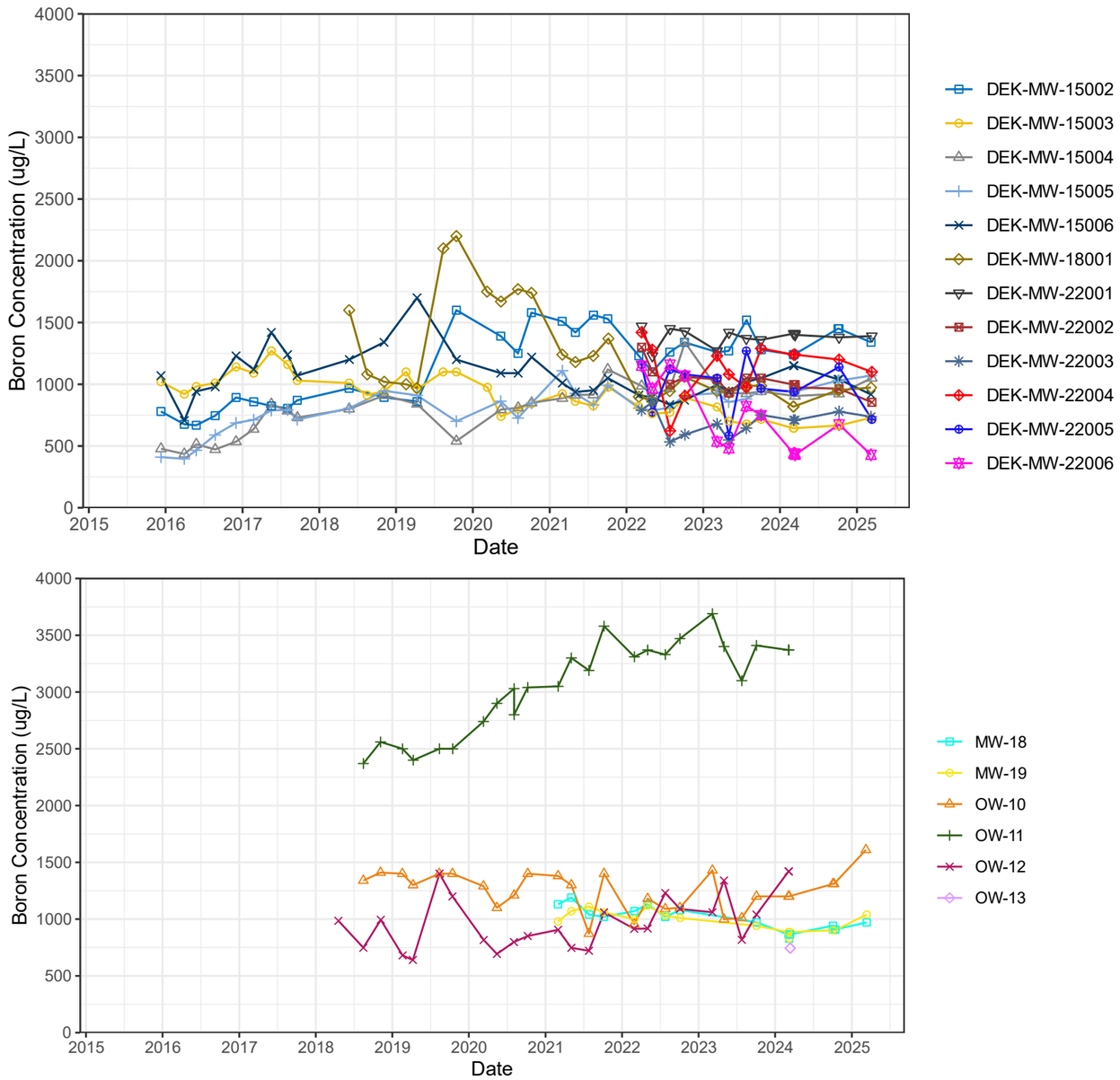
TITLE
TOTAL ARSENIC CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	5



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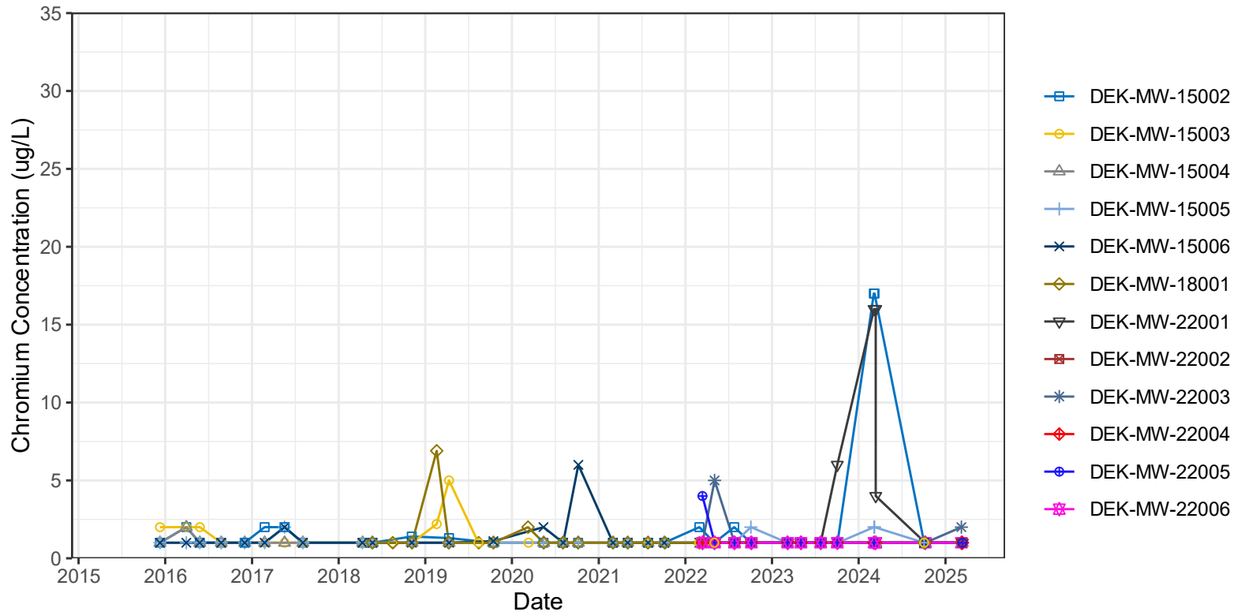
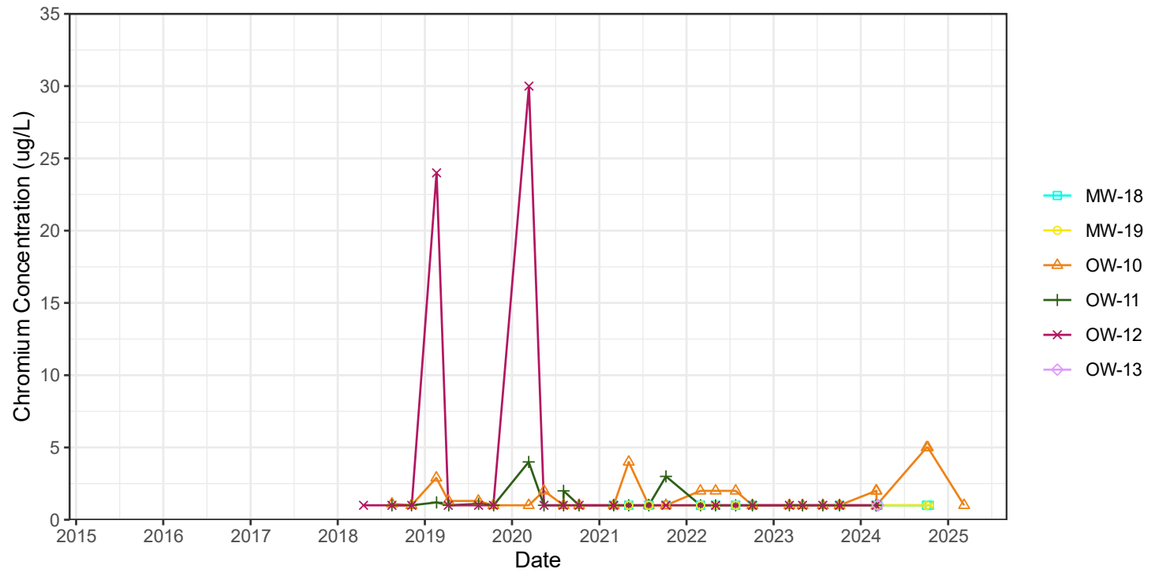
TITLE
TOTAL BORON CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	6





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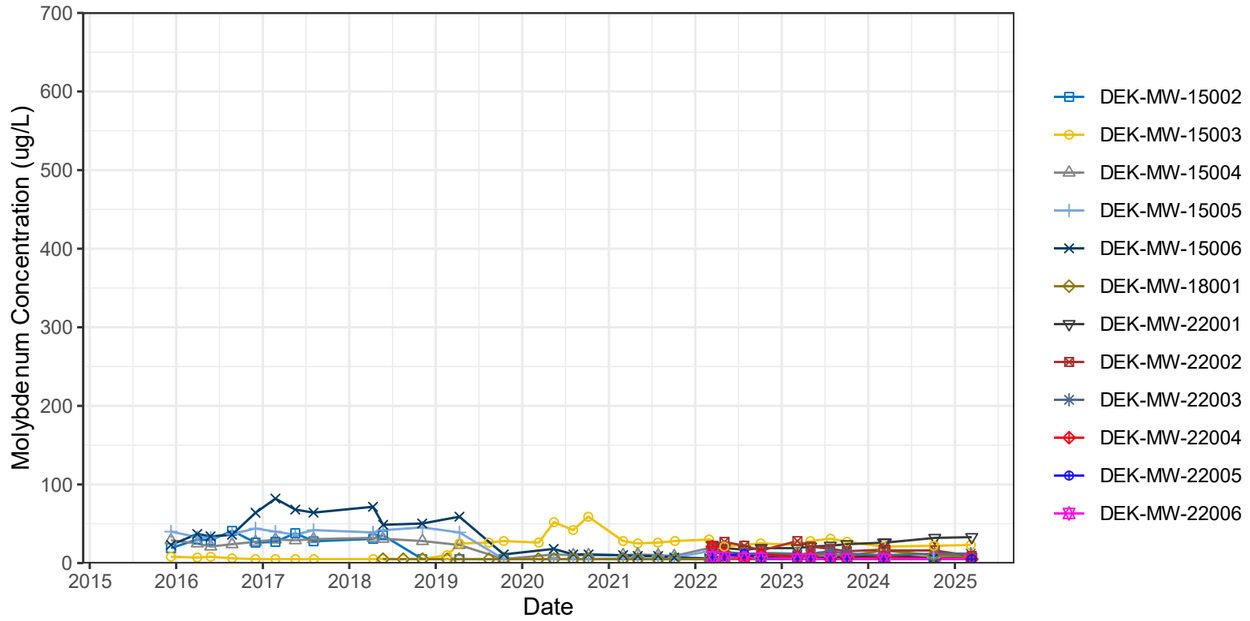
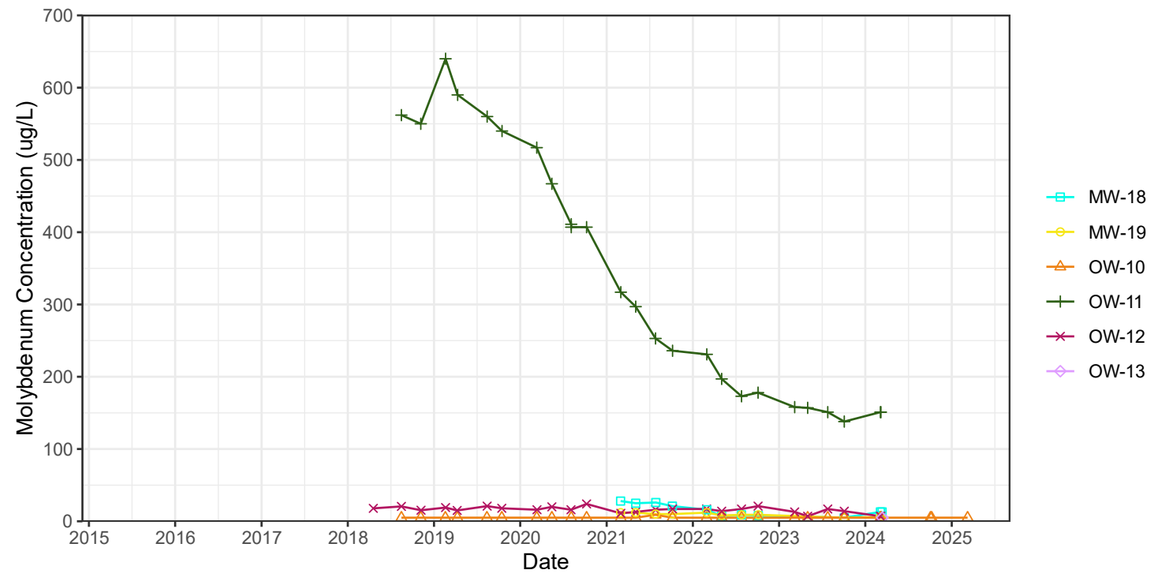
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
TOTAL CHROMIUM CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	7





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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
TOTAL MOLYBDENUM CONCENTRATIONS IN GROUNDWATER AT THE BAP

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PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	8

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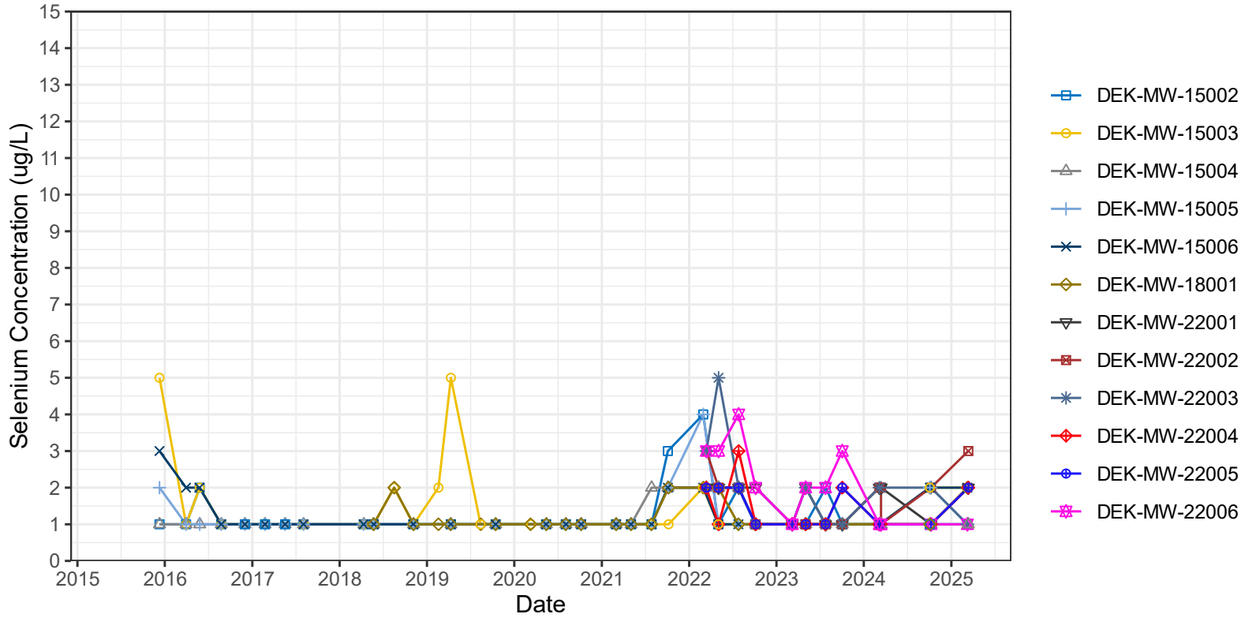

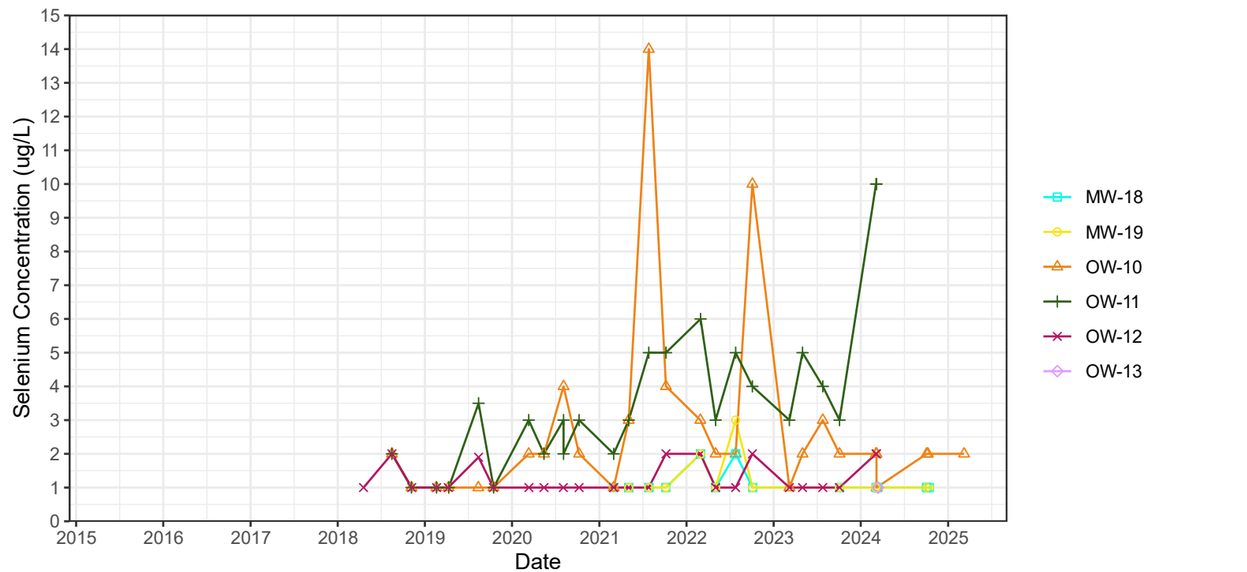

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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
TOTAL SELENIUM CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
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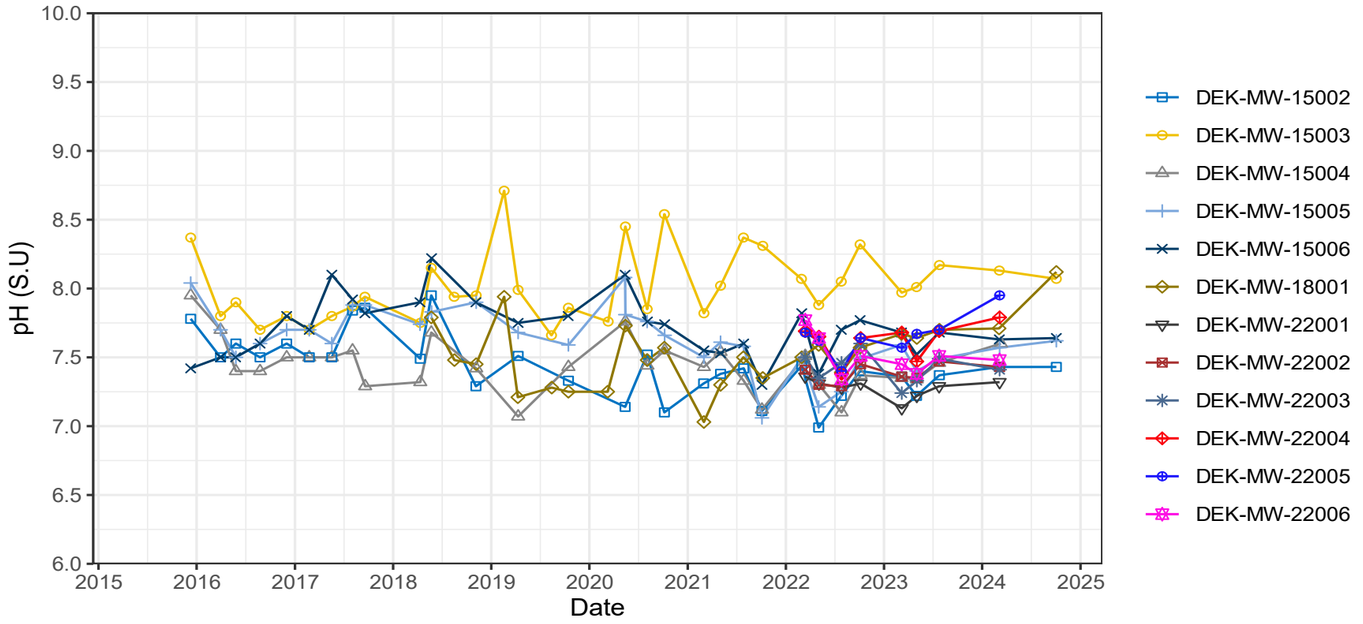

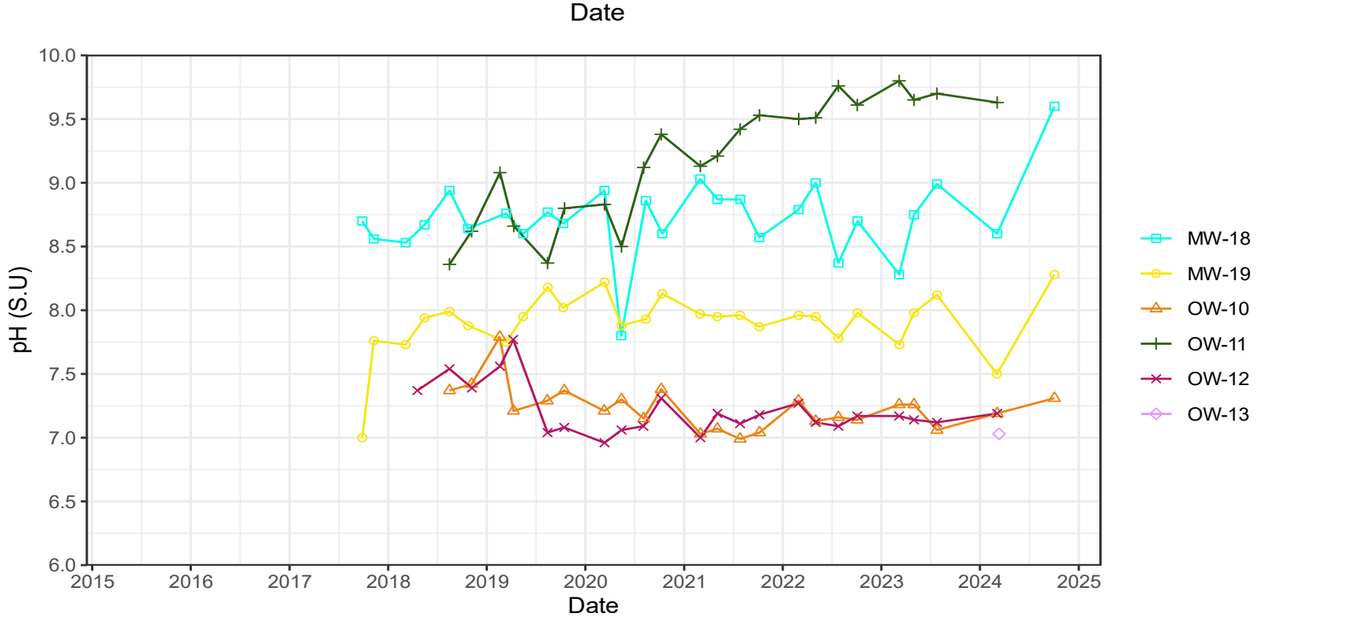

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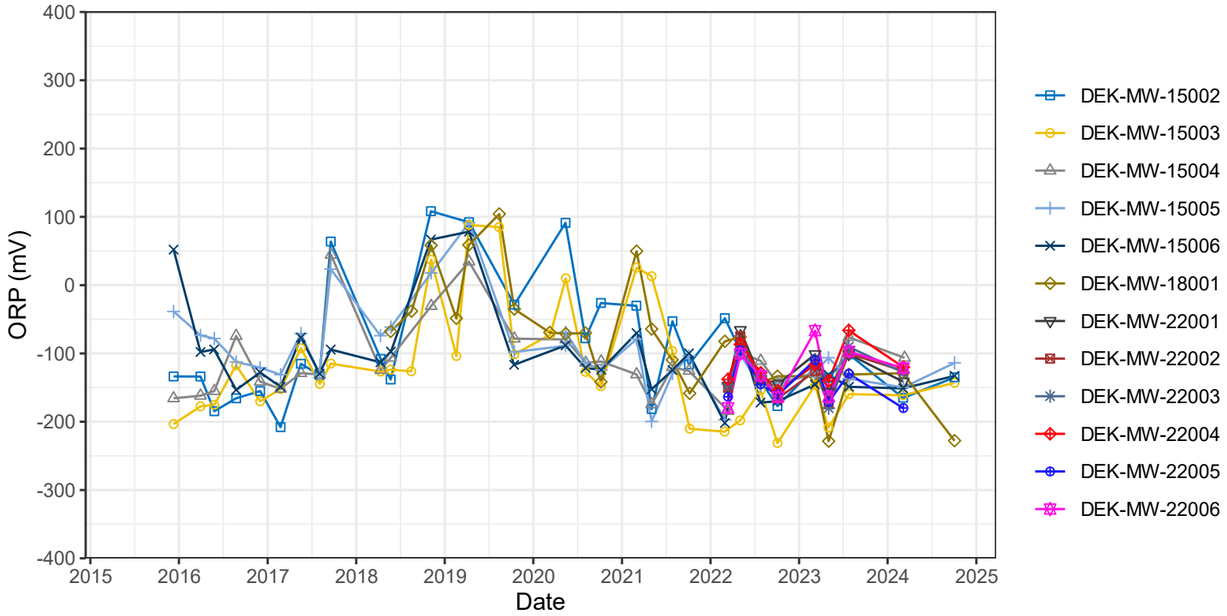
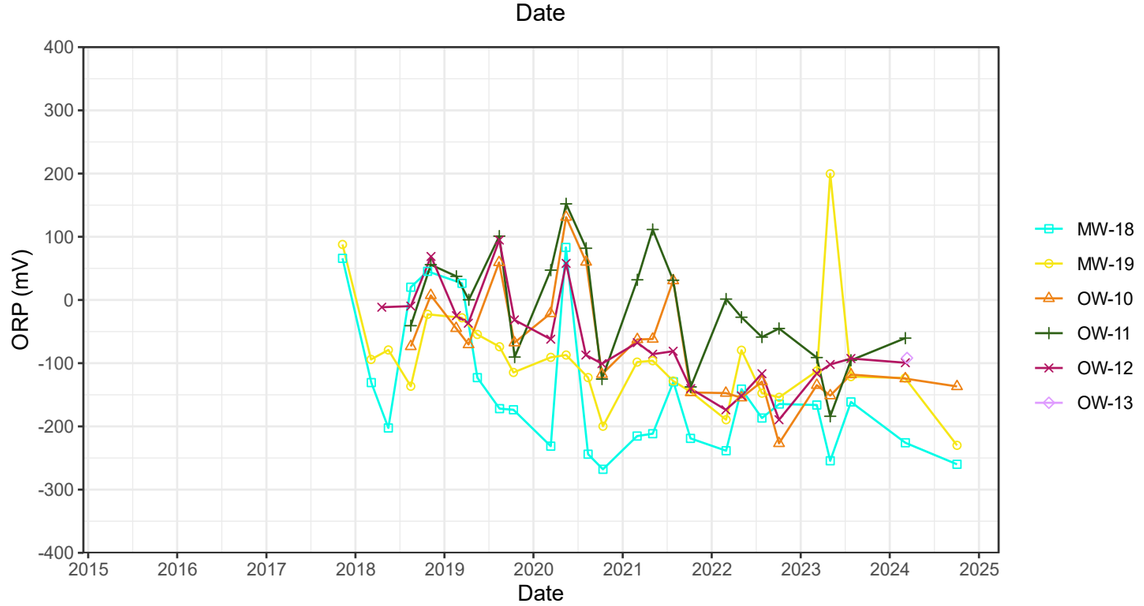
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
GROUNDWATER pH
IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	10





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GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

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YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
GROUNDWATER ORP
IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	11

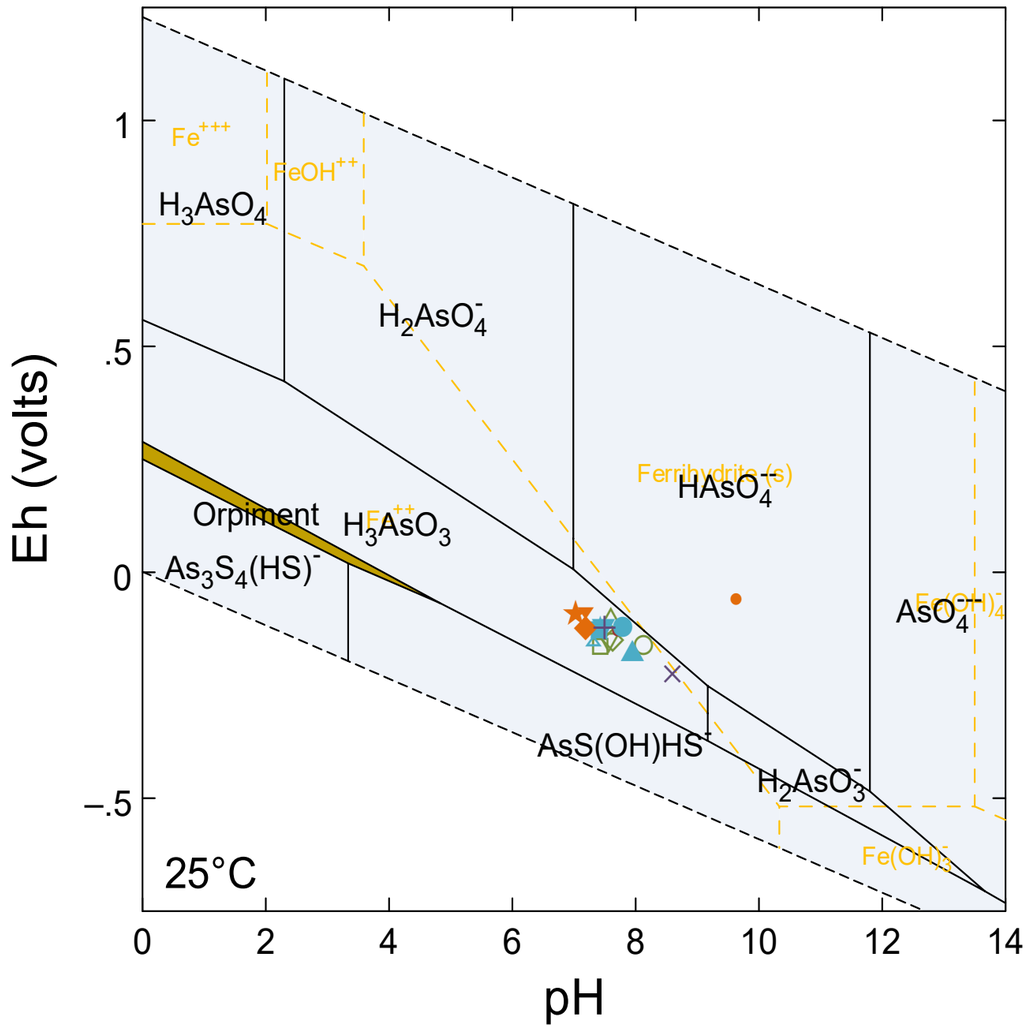

Diagram AsO_4^{---}, T = 25 °C, P = 1.013 bars, a [main] = 10^{-6}, a [H_2O] = 1, a [Fe^{+++}] = 10^{-6} (speciates, a [SO_4^{--}] = 10^{-6}, a [CO_3^{--}] = 10^{-6}, Suppressed: $Fe(OH)_2$ (am), $Fe(OH)_2$ (aq), $Fe_3(OH)_8$, $FeOH^+$, Ferrihydrite (aged), Goethite, Hematite, Lepidocrocite, Maghemite, Magnetite

- DEK-MW–15002 03–2024
- DEK-MW–15003 03–2024
- DEK-MW–15004 03–2024
- DEK-MW–15005 03–2024
- DEK-MW–15006 03–2024
- DEK-MW–18001 03–2024
- DEK-MW–22001 03–2024
- DEK-MW–22002 03–2024
- DEK-MW–22003 03–2024
- DEK-MW–22004 03–2024
- DEK-MW–22005 03–2024
- DEK-MW–22006 03–2024
- OW–10 03–2024
- OW–11 03–2024
- OW–12 03–2024
- OW–13 03–2024
- MW–18 03–2024
- MW–19 03–2024

Note: Samples collected on 03/2024 represent the most recent event during which all BAP wells were sampled

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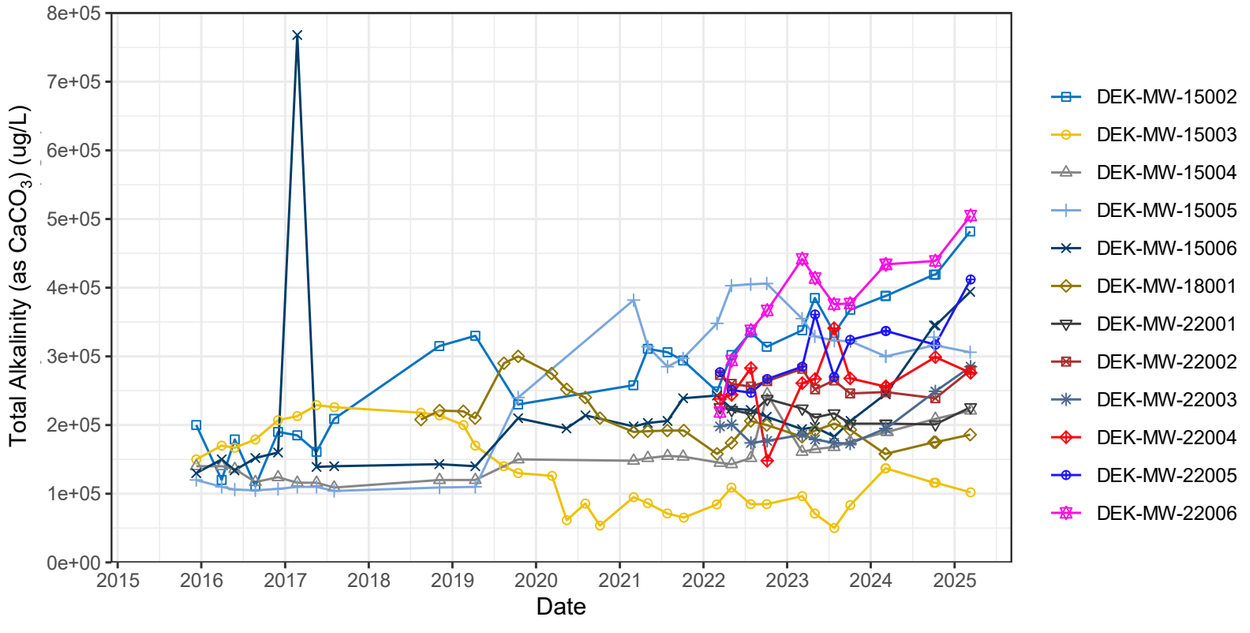
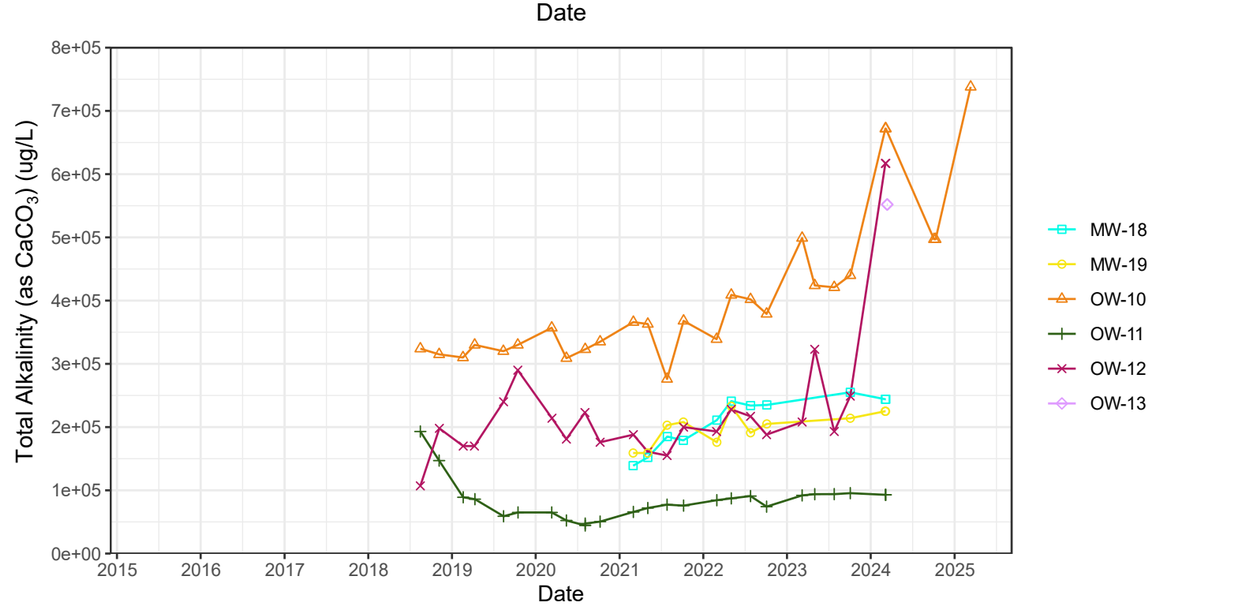
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
ARSENIC PREDOMINANCE DIAGRAM (WITH IRON STABILITY OVERLAID)

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	12





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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

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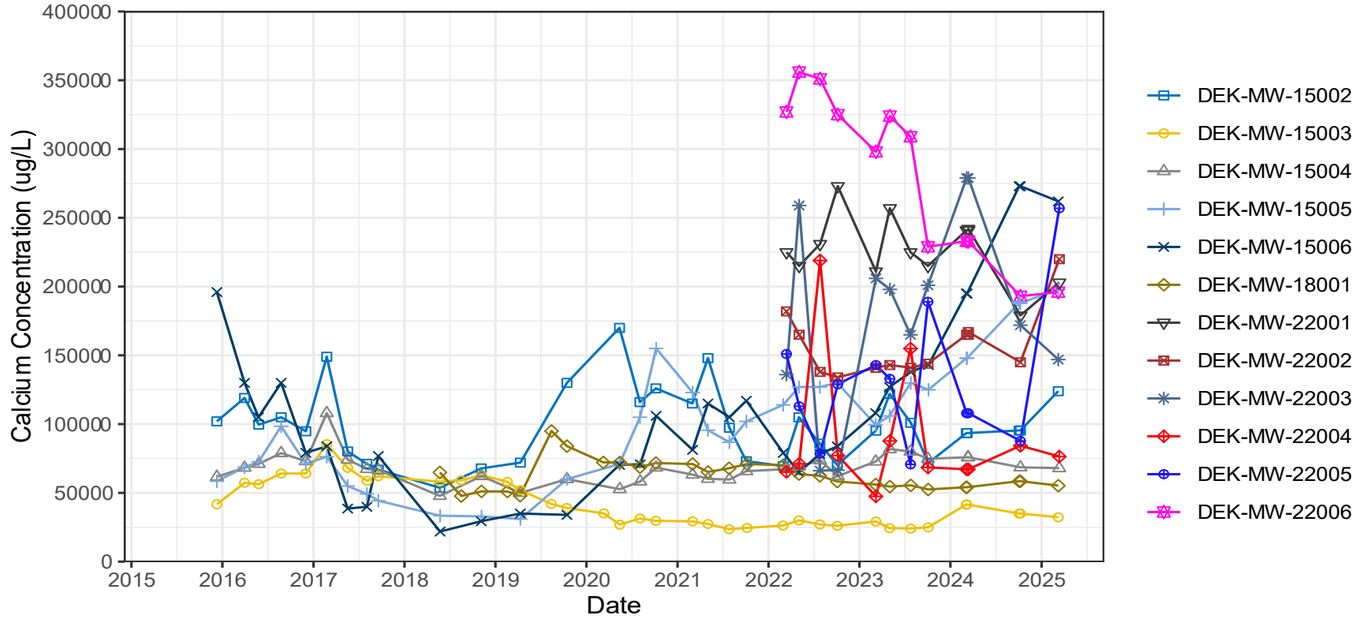
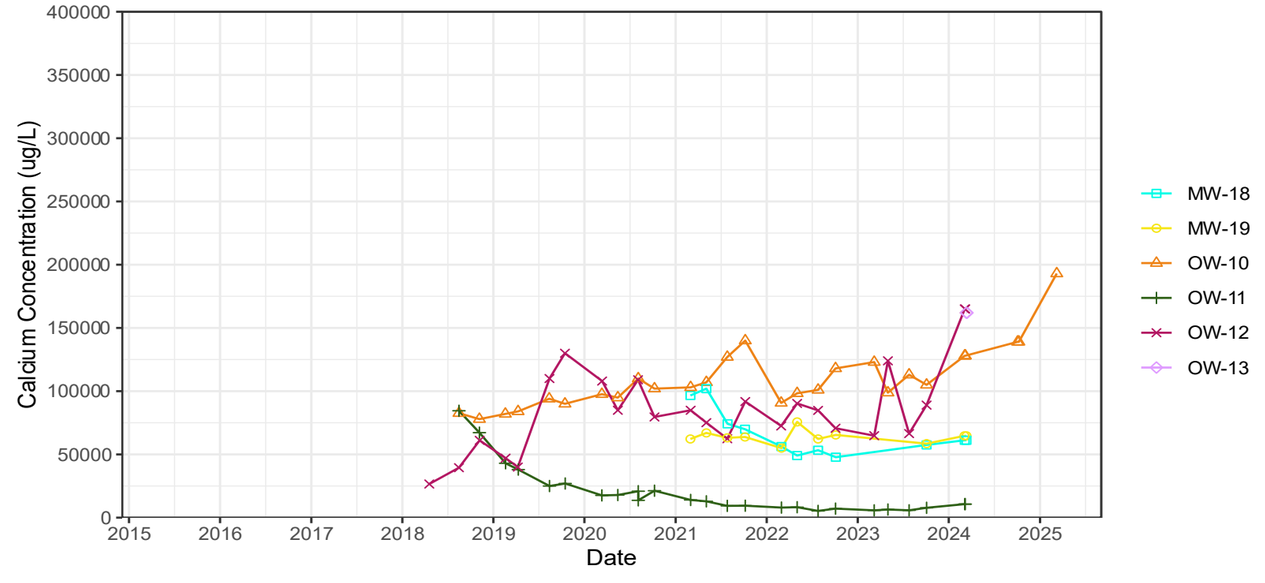
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
TOTAL ALKALINITY CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	13





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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

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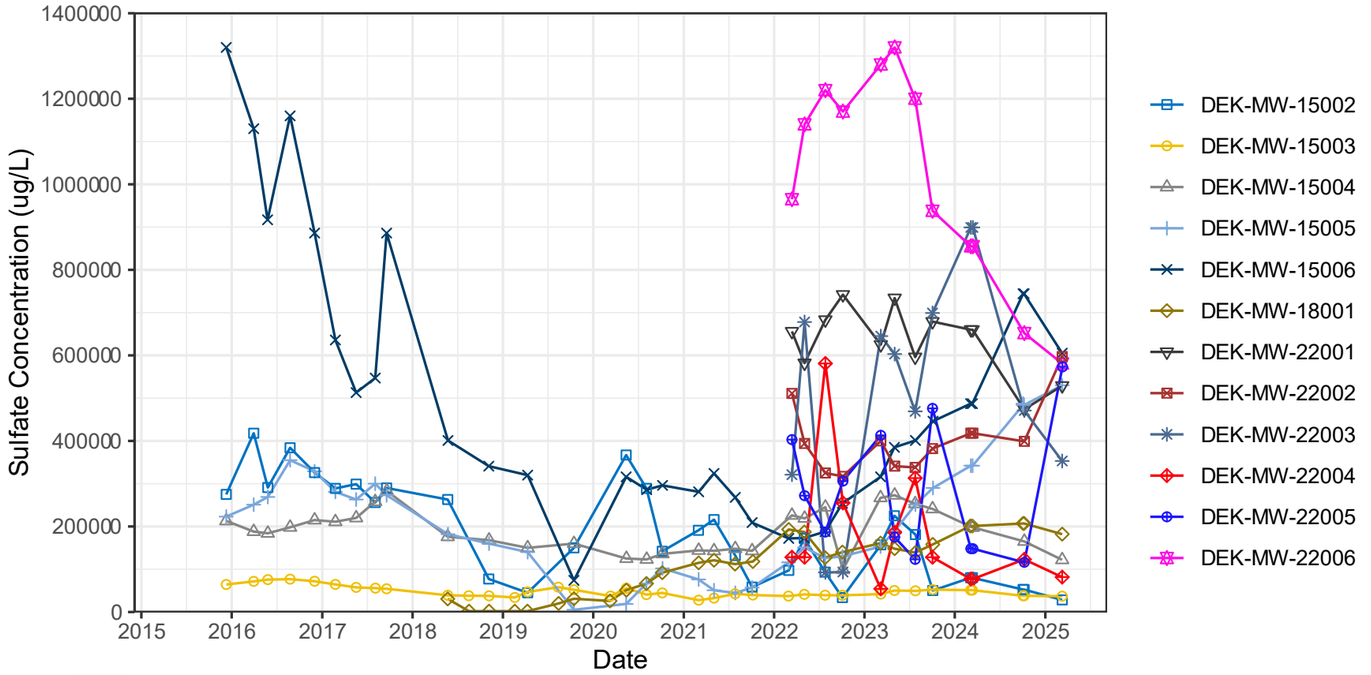
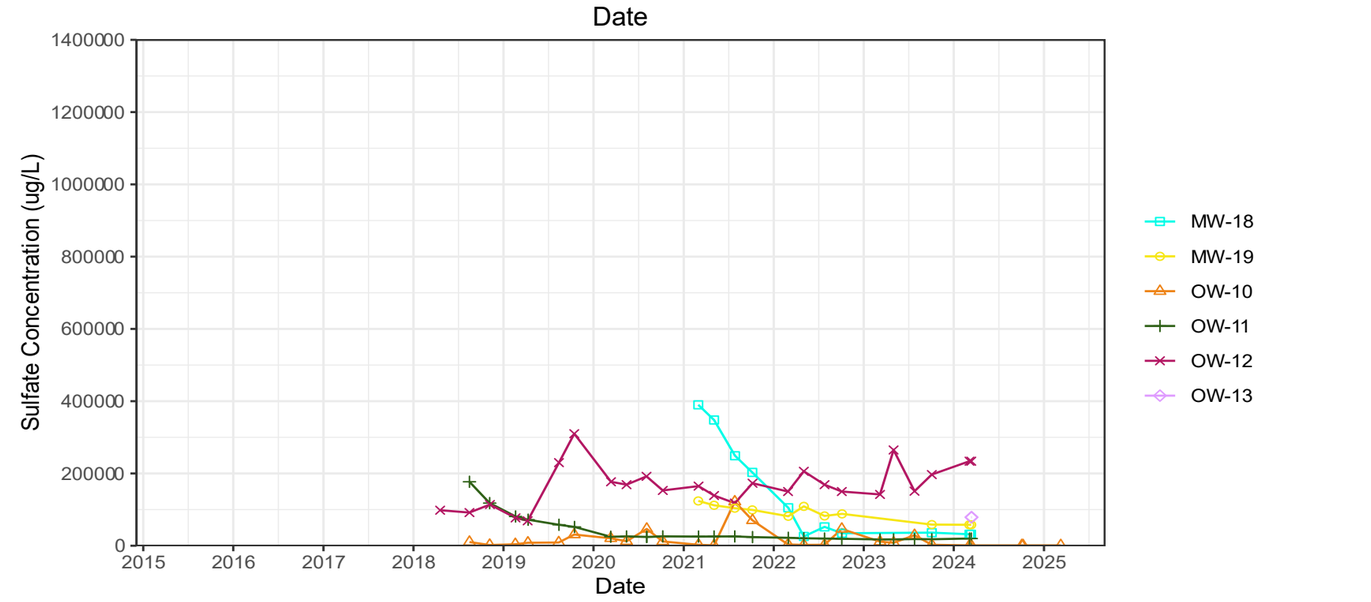
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
TOTAL CALCIUM CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	14





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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

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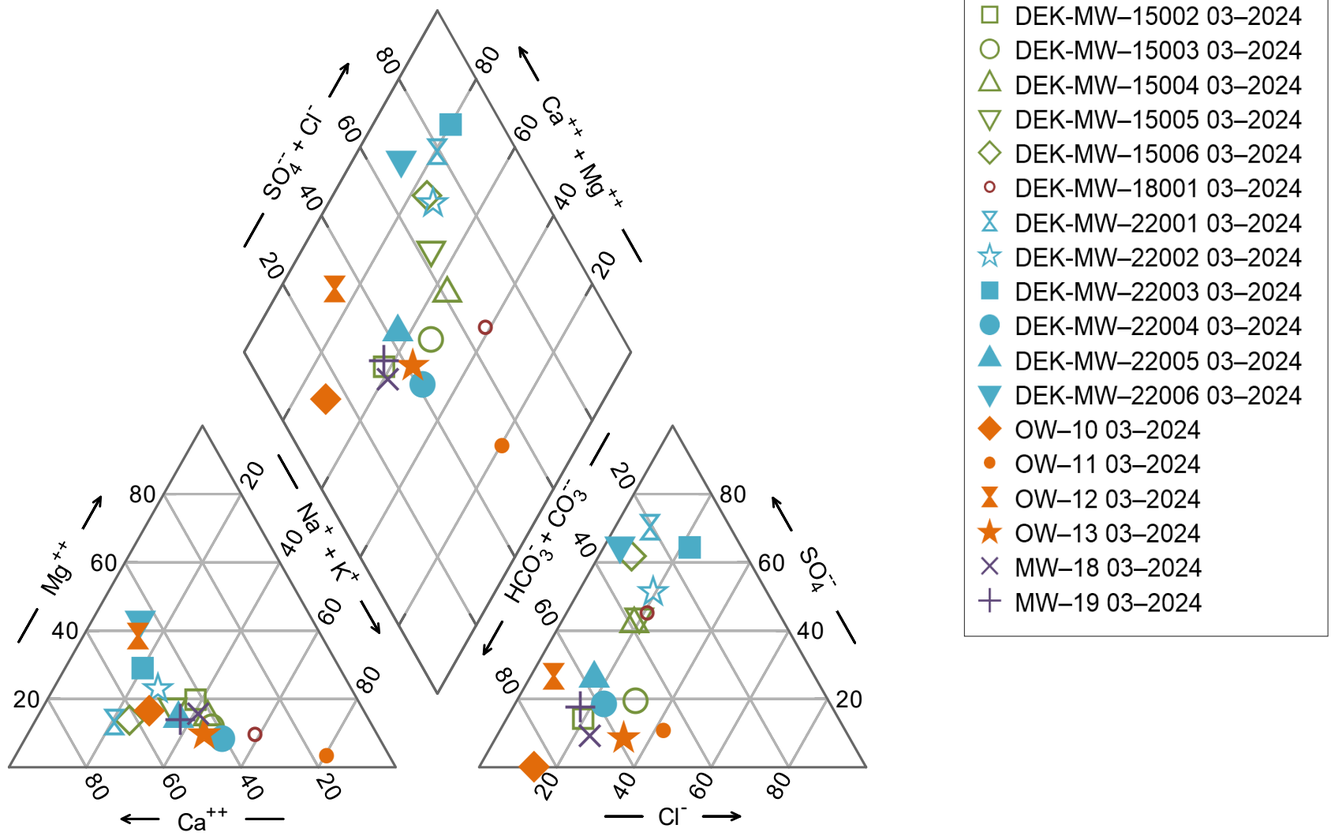
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
TOTAL SULFATE CONCENTRATIONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



DEK-MW–15002 03–2024
DEK-MW–15003 03–2024
DEK-MW–15004 03–2024
DEK-MW–15005 03–2024
DEK-MW–15006 03–2024
DEK-MW–18001 03–2024
DEK-MW–22001 03–2024
DEK-MW–22002 03–2024
DEK-MW–22003 03–2024
DEK-MW–22004 03–2024
DEK-MW–22005 03–2024
DEK-MW–22006 03–2024
OW–10 03–2024
OW–11 03–2024
OW–12 03–2024
OW–13 03–2024
MW–18 03–2024
MW–19 03–2024

% meq/kg

Note: Samples collected on 03/2024 represent the most recent event during which all BAP wells were sampled

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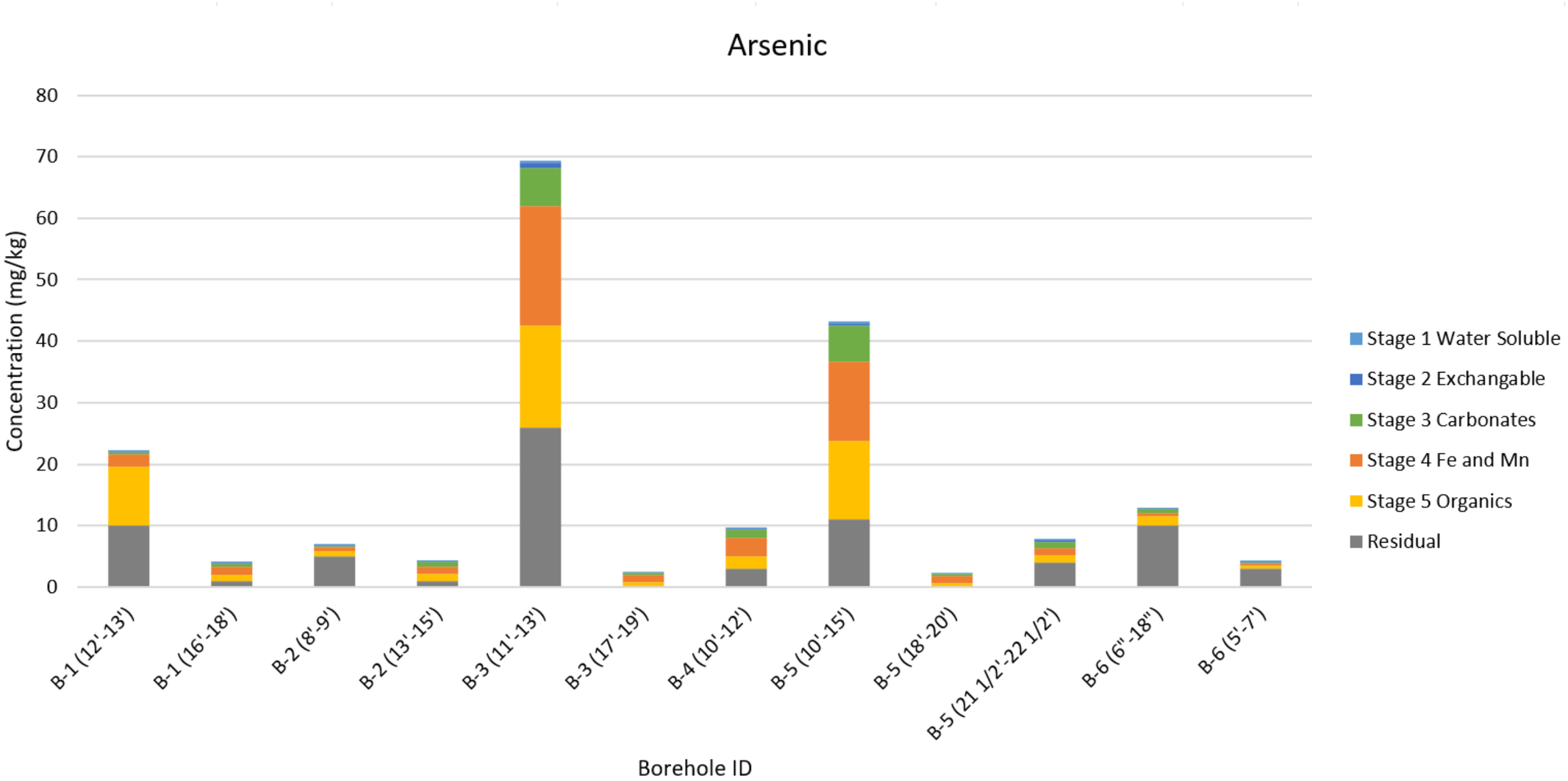
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
RELATIVE ABUNDANCE OF MAJOR IONS IN GROUNDWATER AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	16



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YYYY-MM-DD	7/10/2025
DESIGNED	CM
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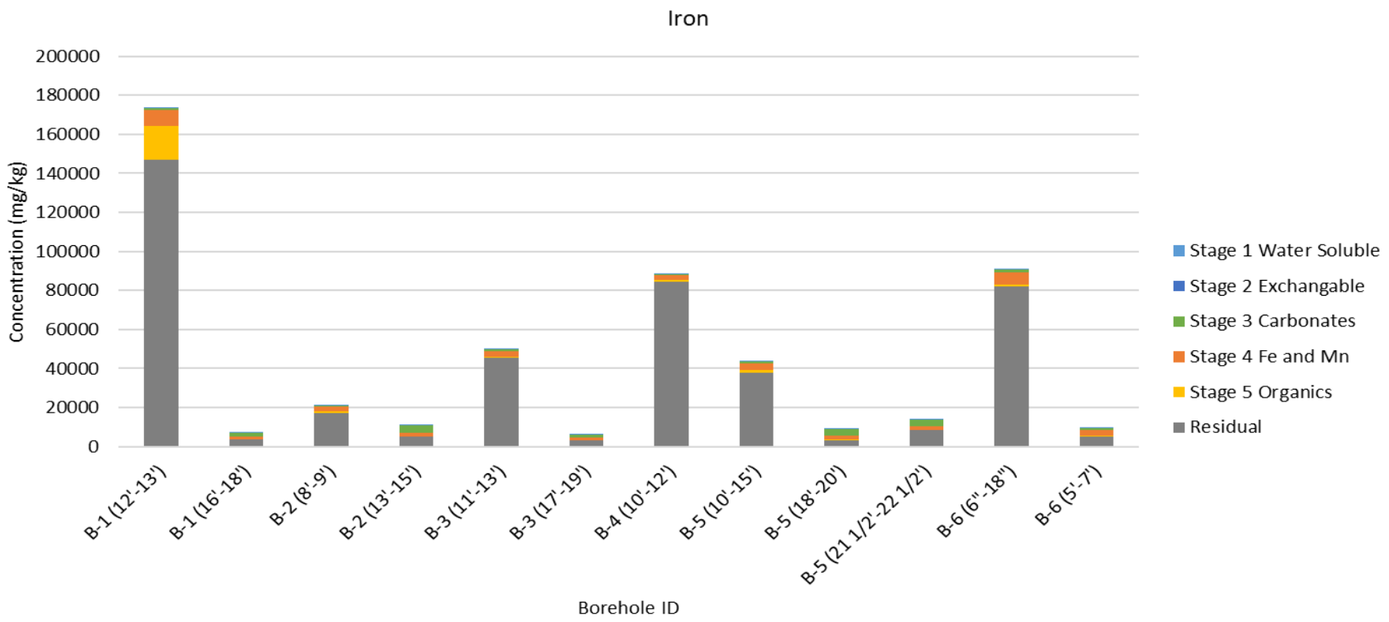
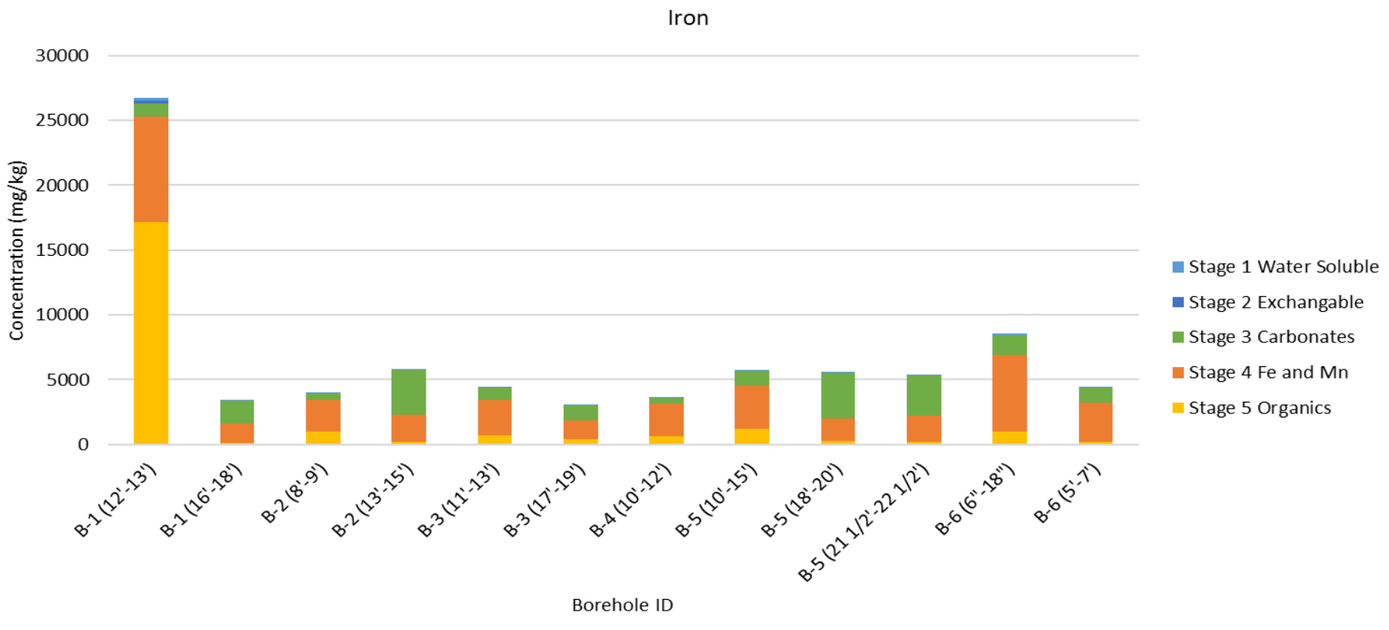
APPROVED	TR

PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SEQUENTIAL EXTRACTION OF ARSENIC FROM SOIL IN BORINGS AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	17





Note: Residual fraction not shown on bottom figure

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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

CONSULTANT

YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
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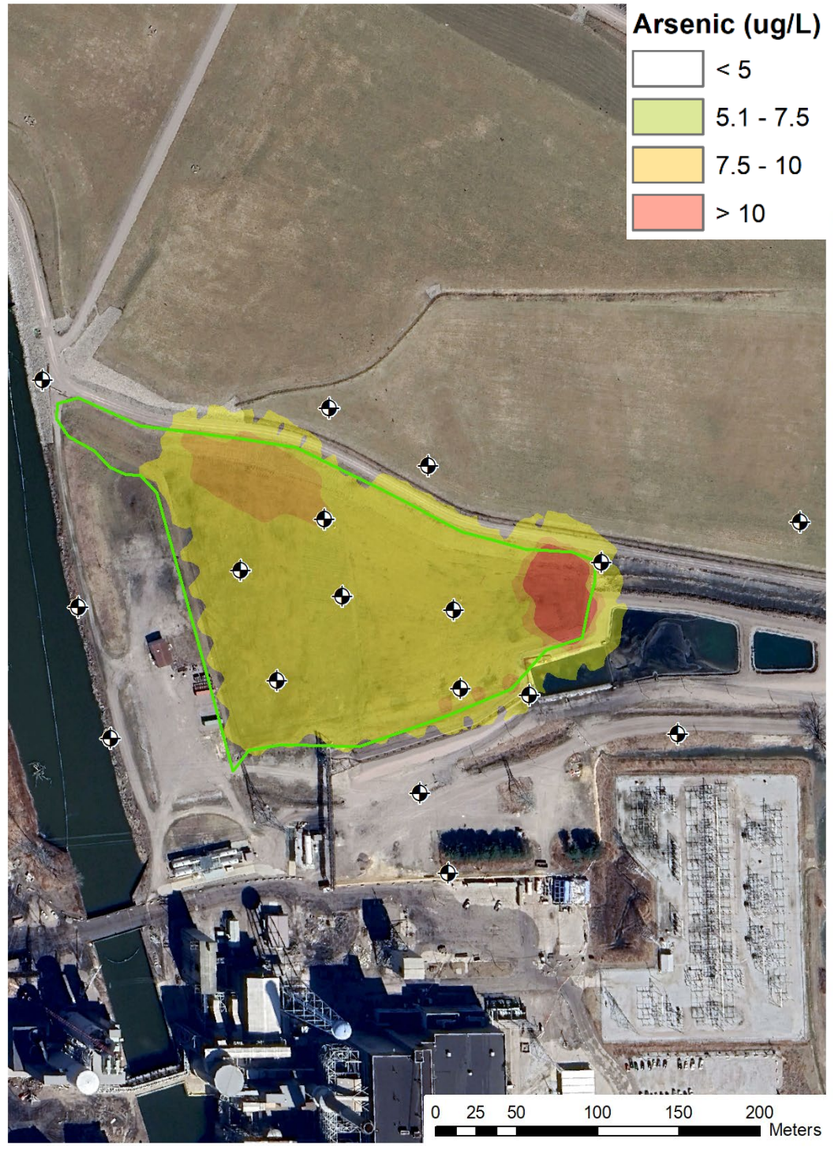
APPROVED	TR

TITLE
SEQUENTIAL EXTRACTION OF IRON FROM SOIL IN BORINGS AT THE BAP

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	18

Interpolated arsenic concentrations



Initial modeled arsenic concentrations

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PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

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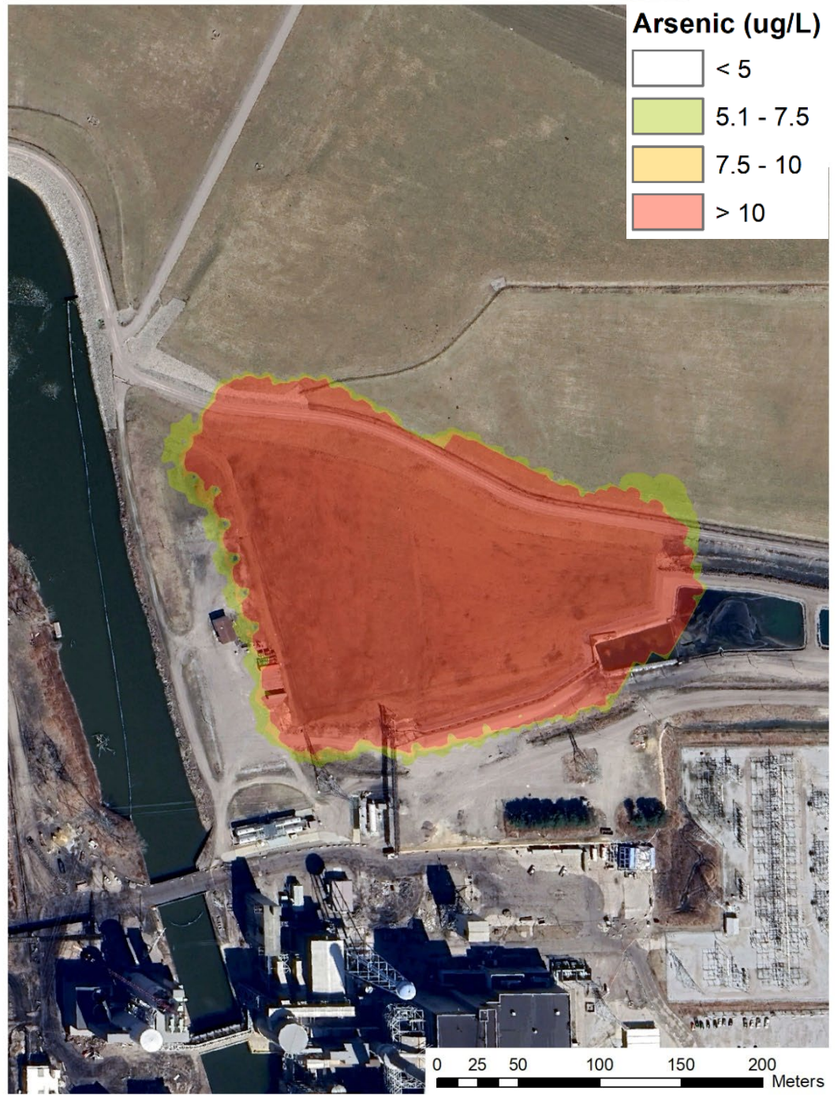
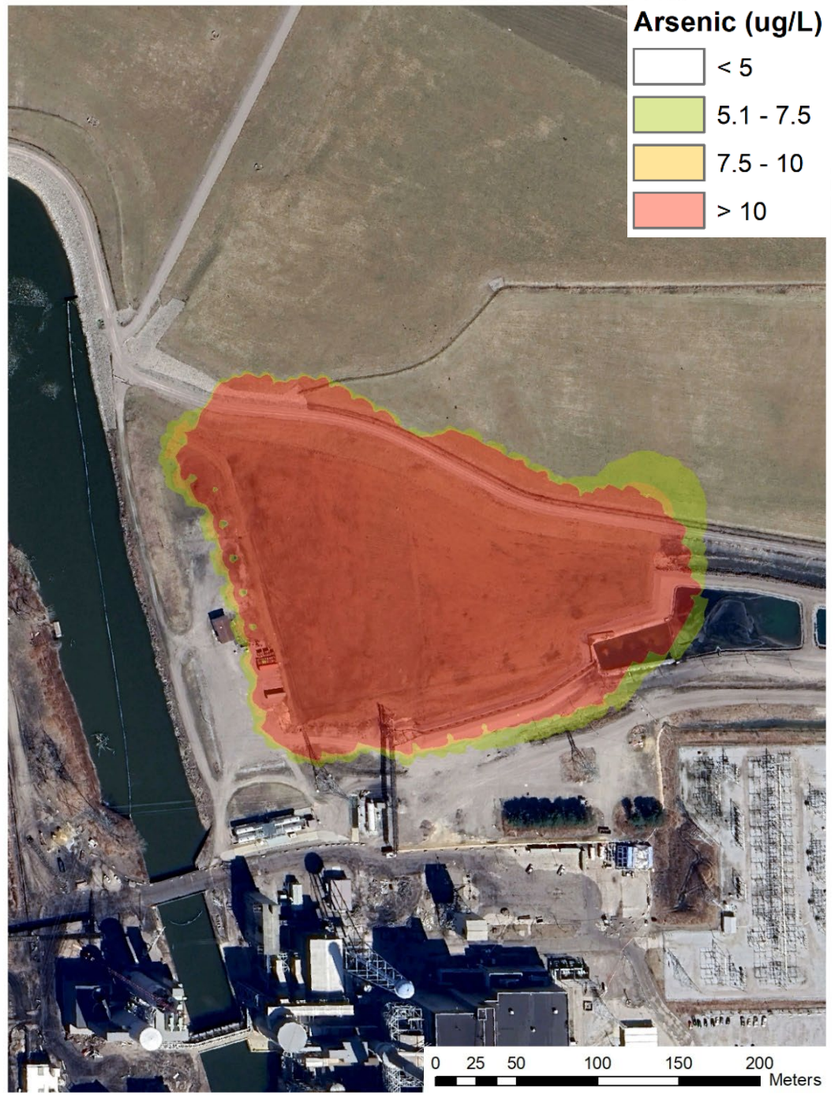
APPROVED	TR

TITLE
INITIAL PHAST MODEL ARSENIC CALIBRATION

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	19



25 years of MNA



50 years of MNA

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DESIGNED	CM
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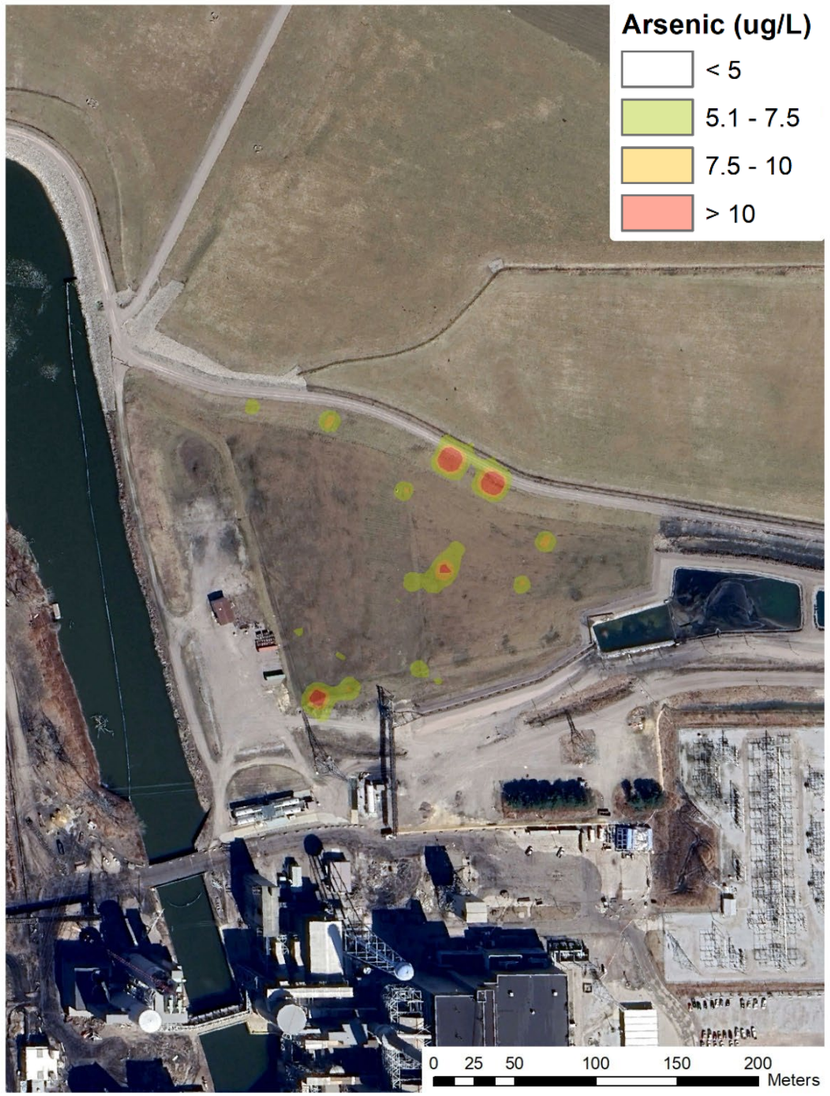
APPROVED	TR

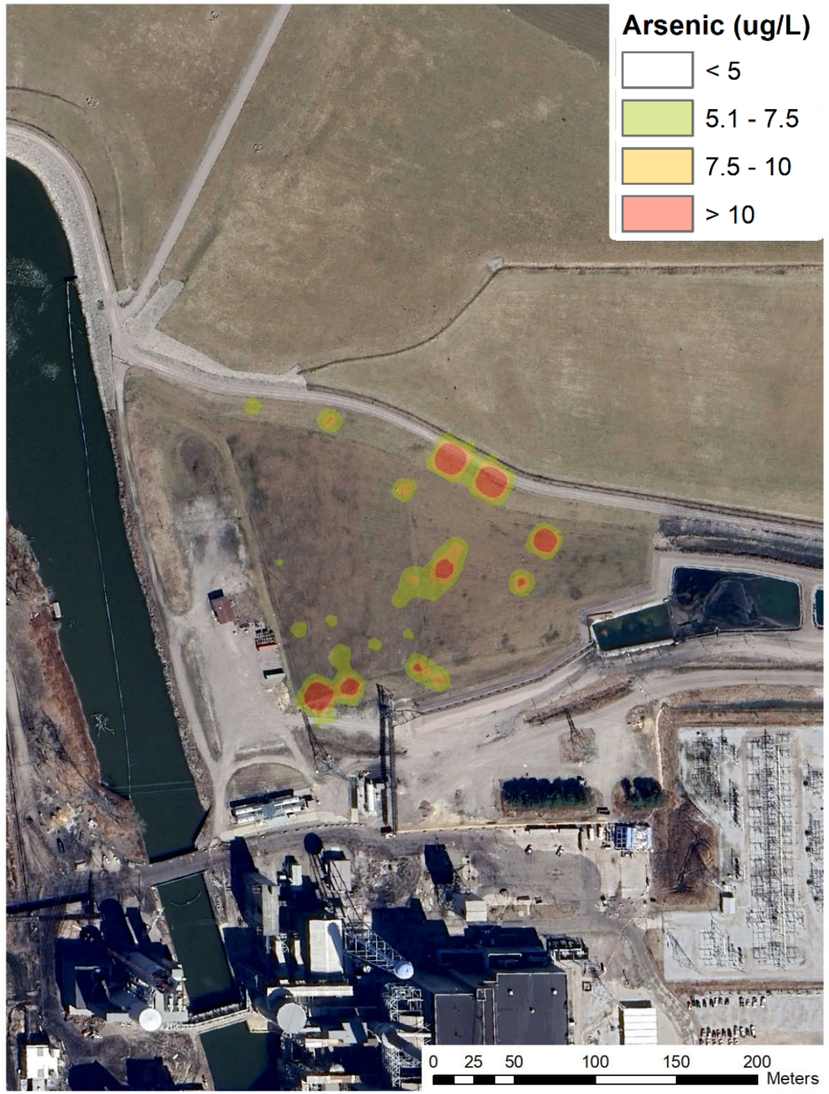
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SCENARIO 1: MNA MODEL RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	20



Approximately 3 months after injection



5 years after injection

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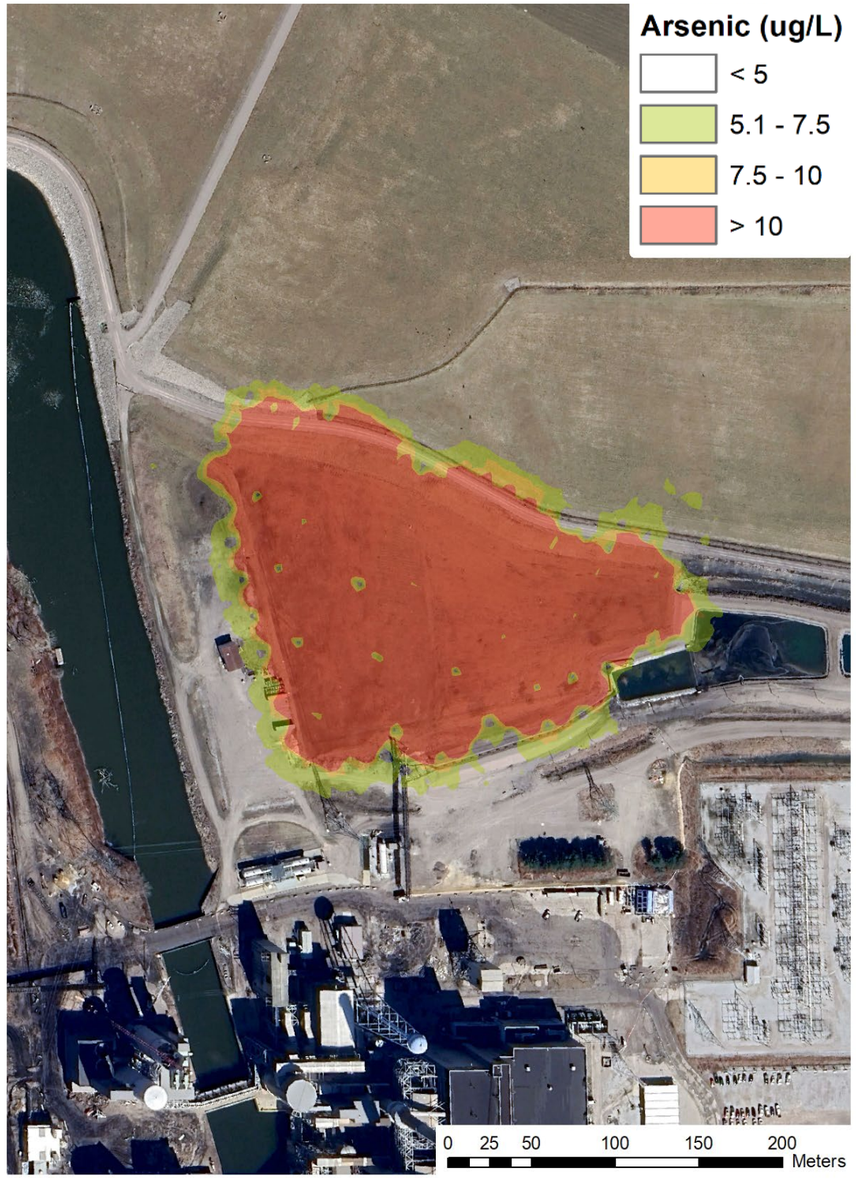
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

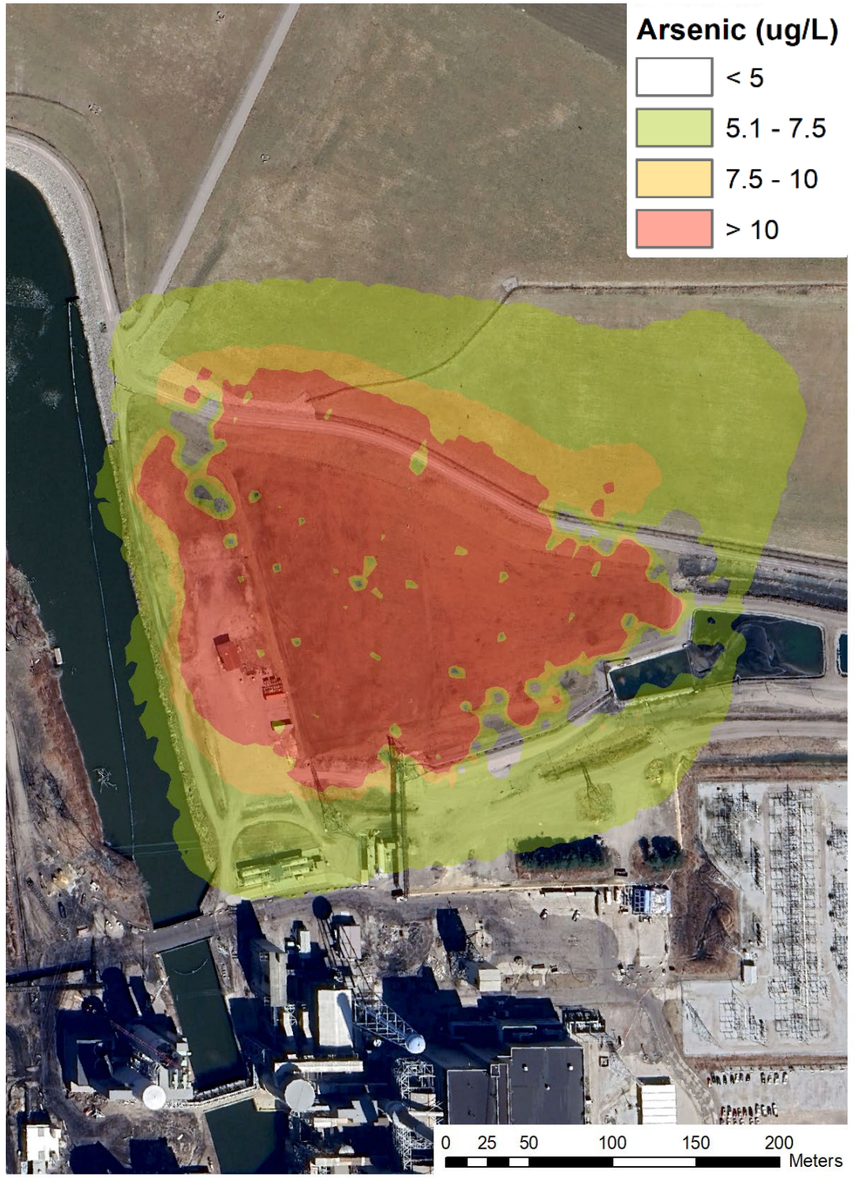
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SCENARIO 2: ISI OF ZVI MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	21



Approximately 3 months after injection



5 years after injection

CLIENT
CONSUMERS ENERGY COMPANY

CONSULTANT
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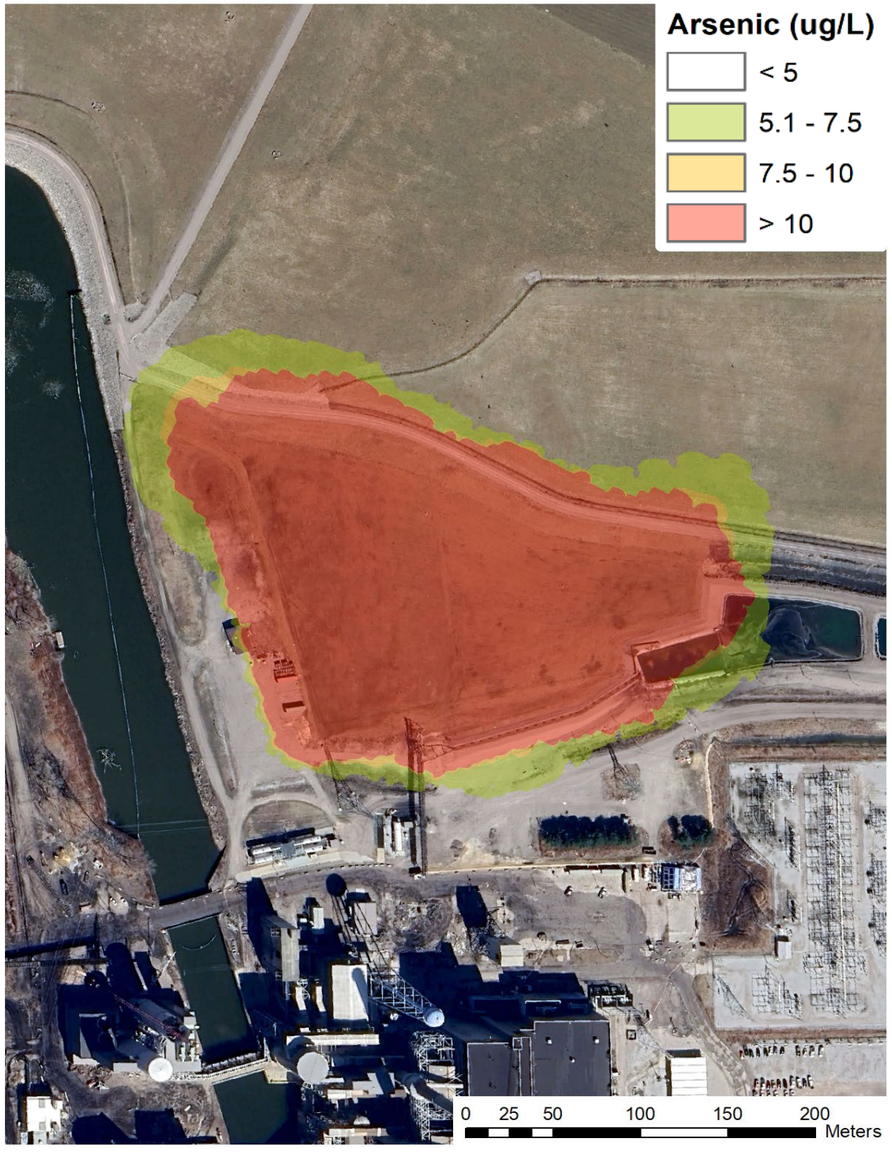
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

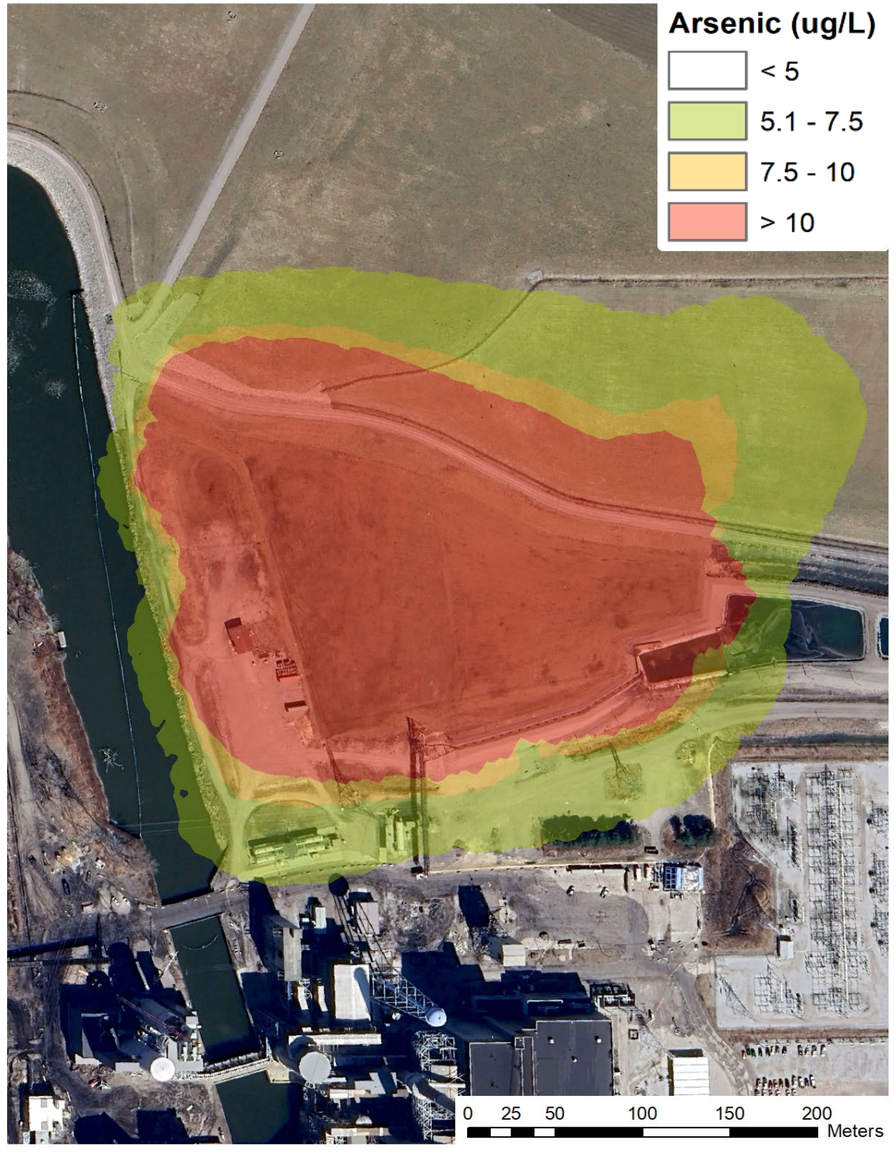
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SCENARIO 3: ISI OF FERRIC SULFATE MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	22



Approximately 3 months after injection



5 years after injection

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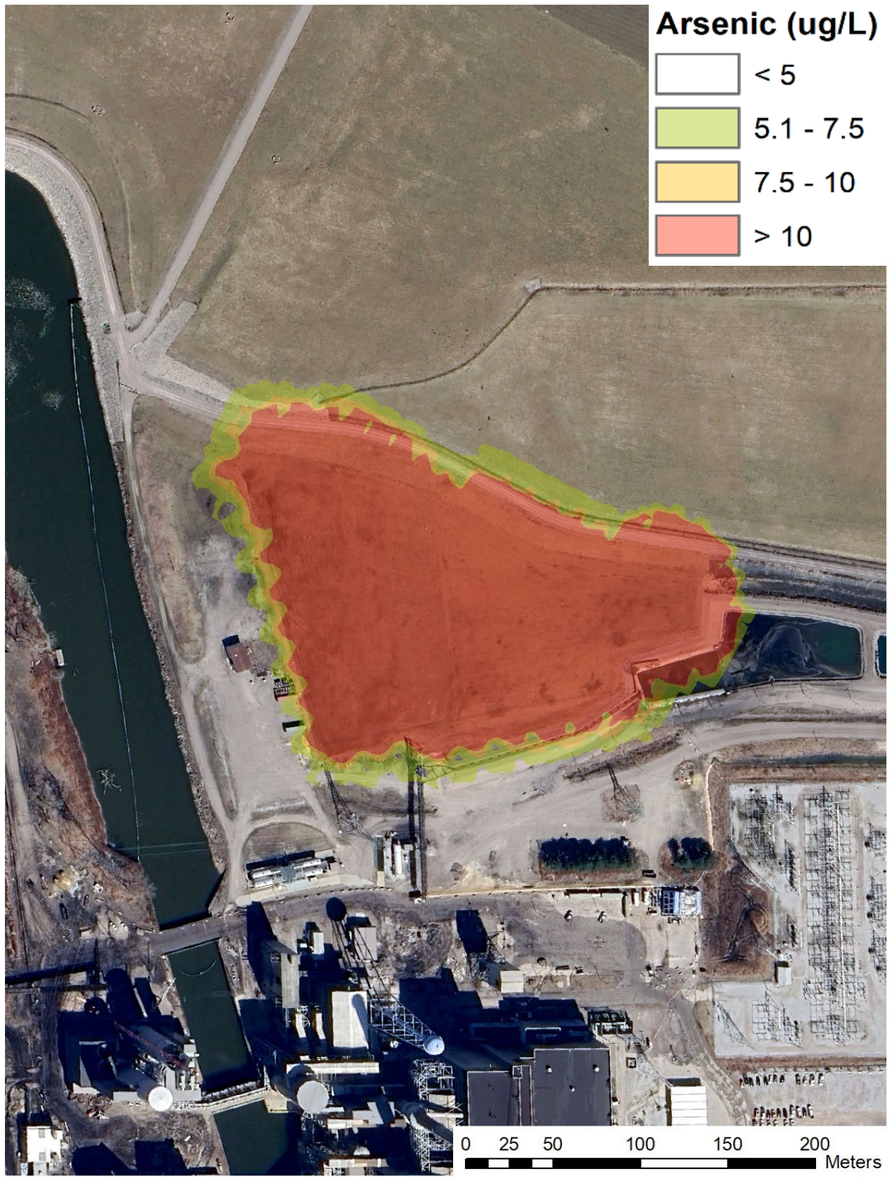
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

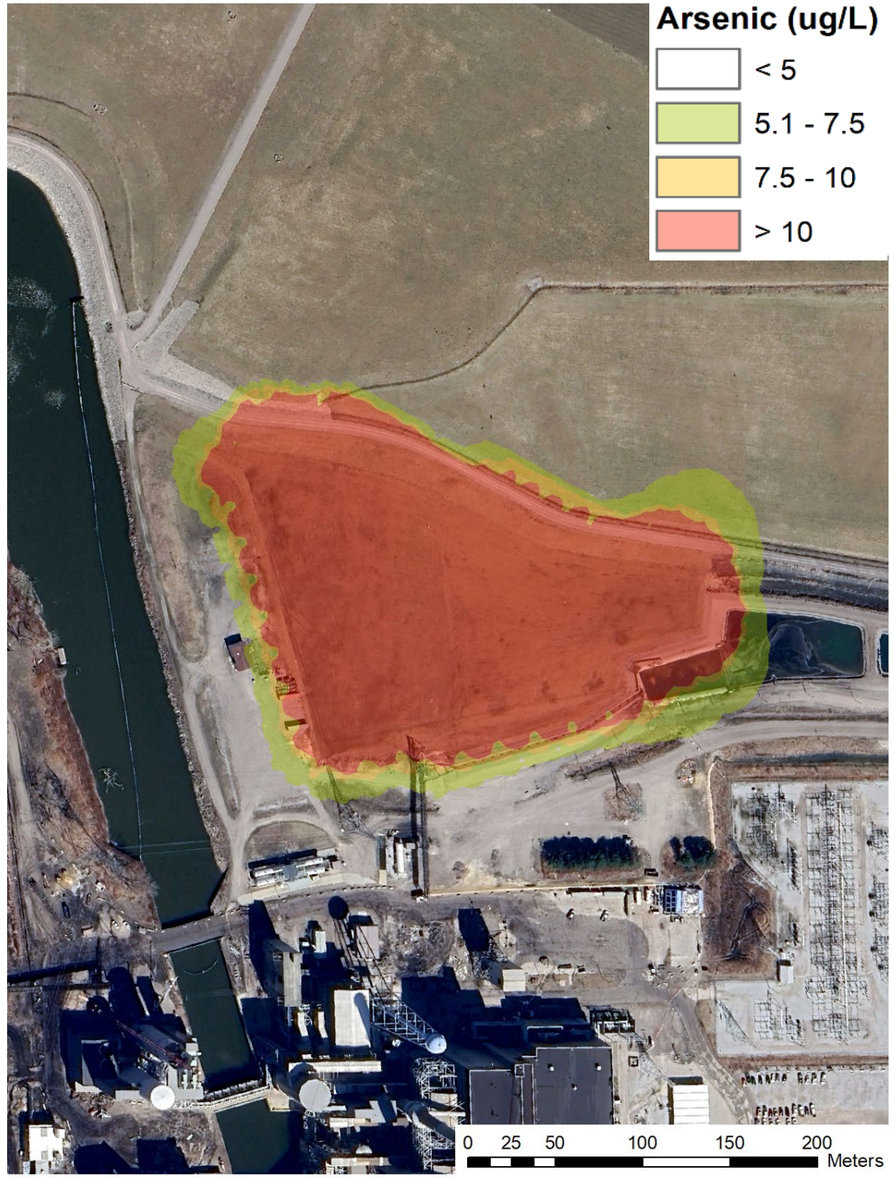
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SCENARIO 4: ISI OF FERROUS SULFATE HEPTAHYDRATE MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	23



2 years of pump and treat with reinjection



15 years of pump and treat with reinjection

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DESIGNED	CM
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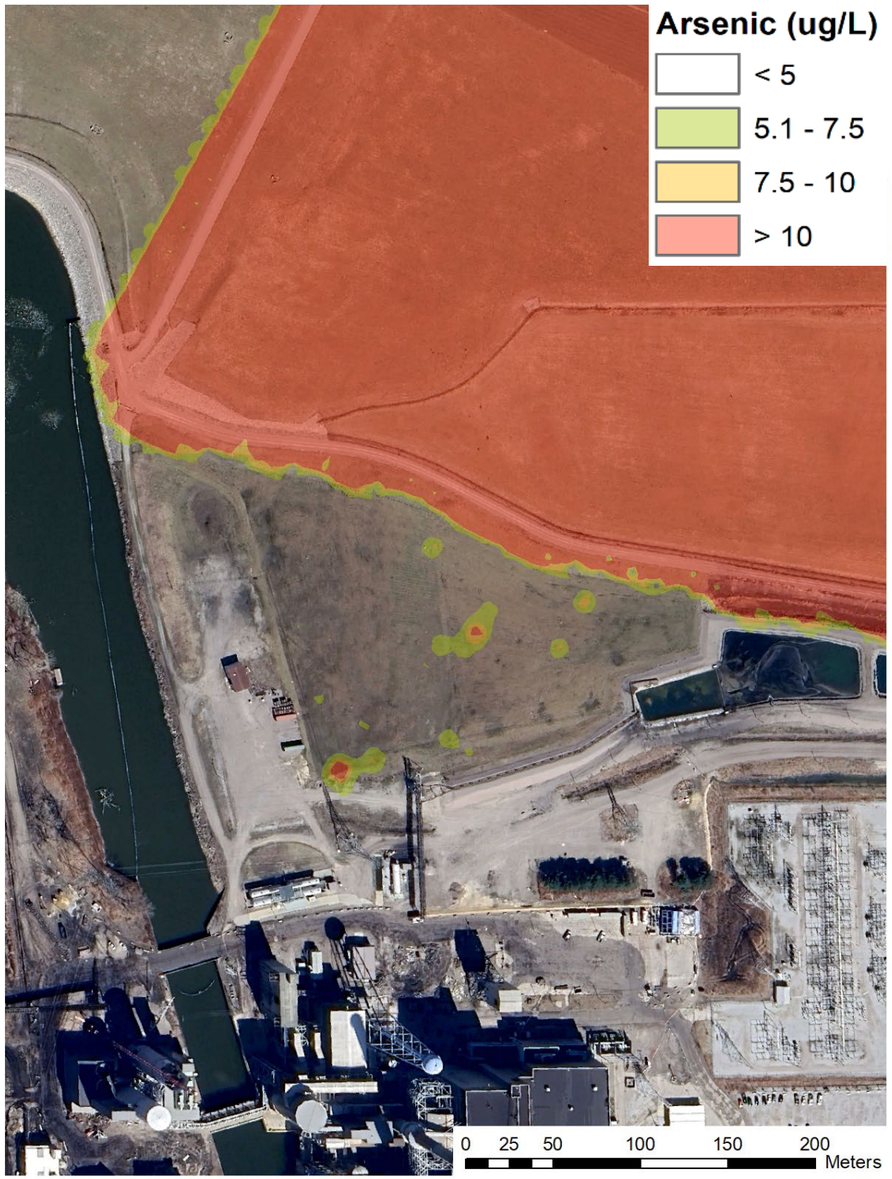
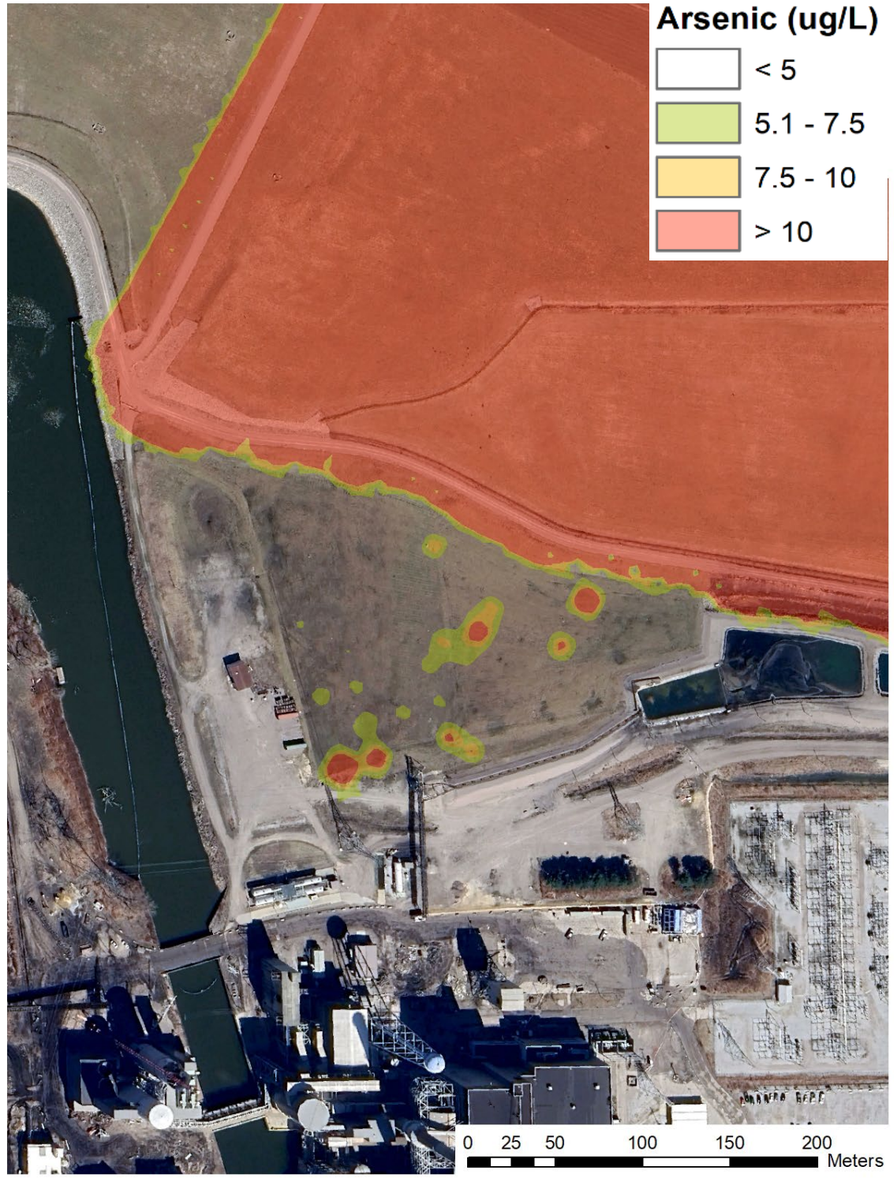
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SCENARIO 5: PUMP AND TREAT WITH REINJECTION MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	24



Approximately 3 months after injection



5 years after injection

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CONSULTANT
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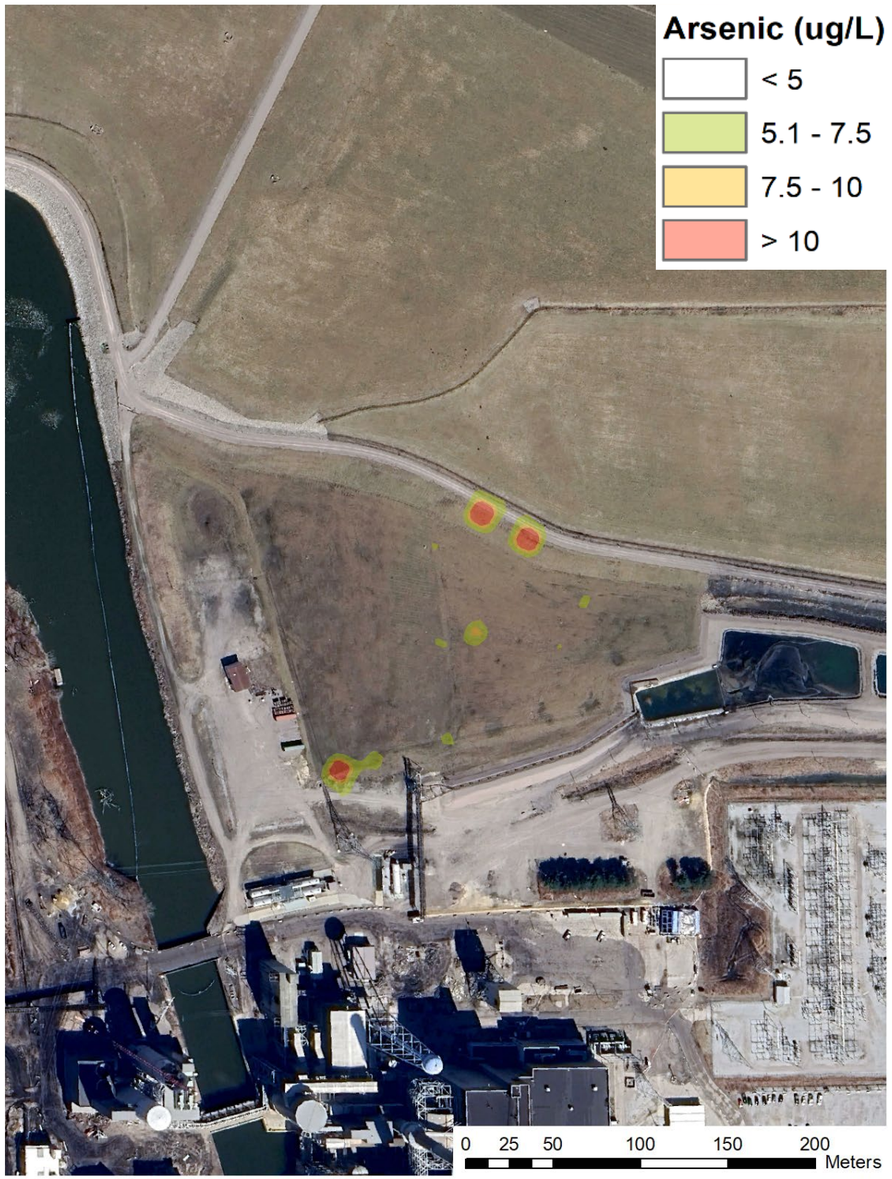
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

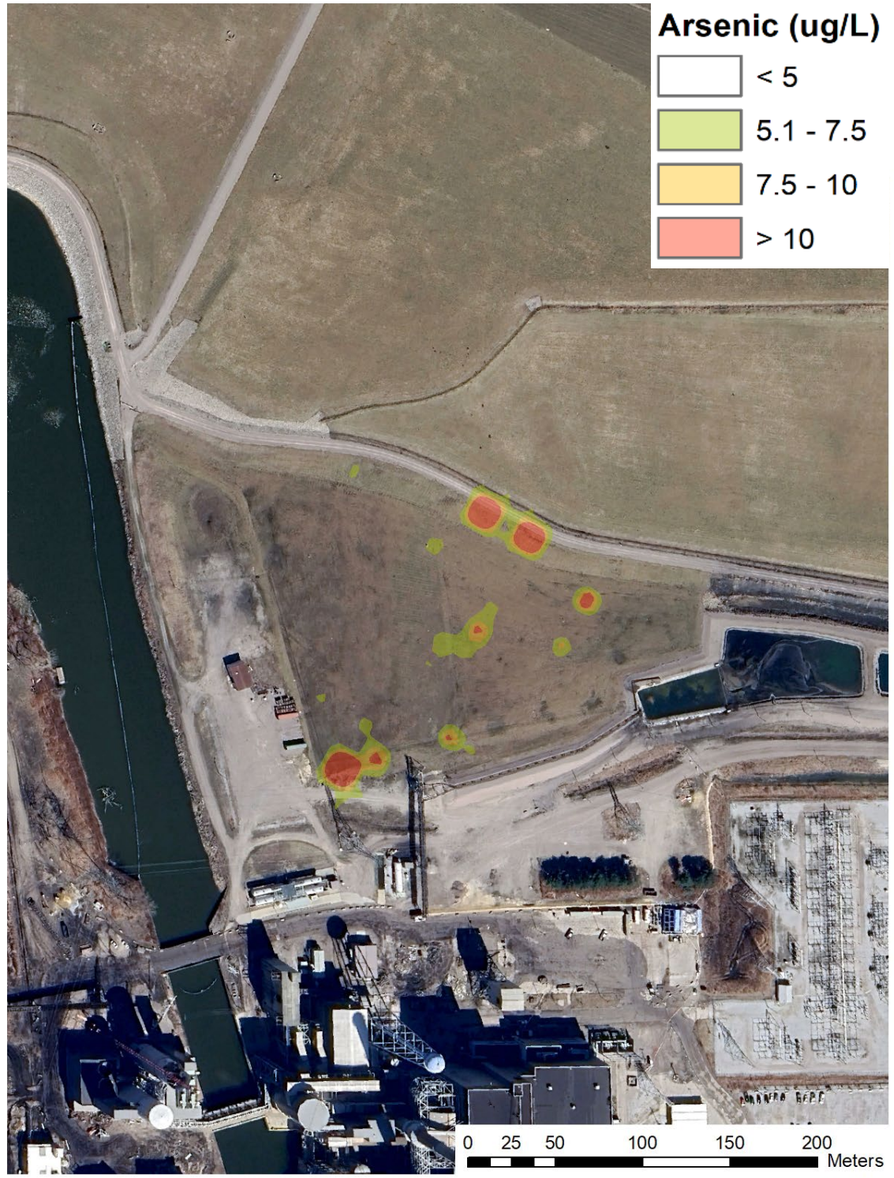
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
SENSITIVITY ANALYSIS 1 MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	25



Approximately 3 months after injection



5 years after injection

CLIENT
CONSUMERS ENERGY COMPANY

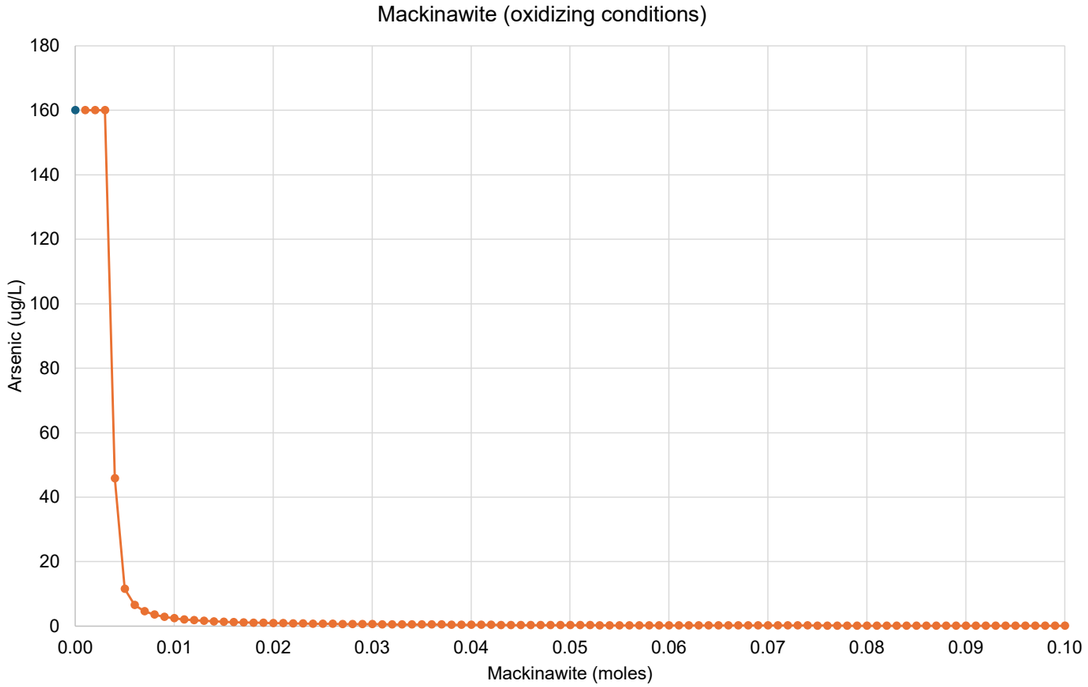
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

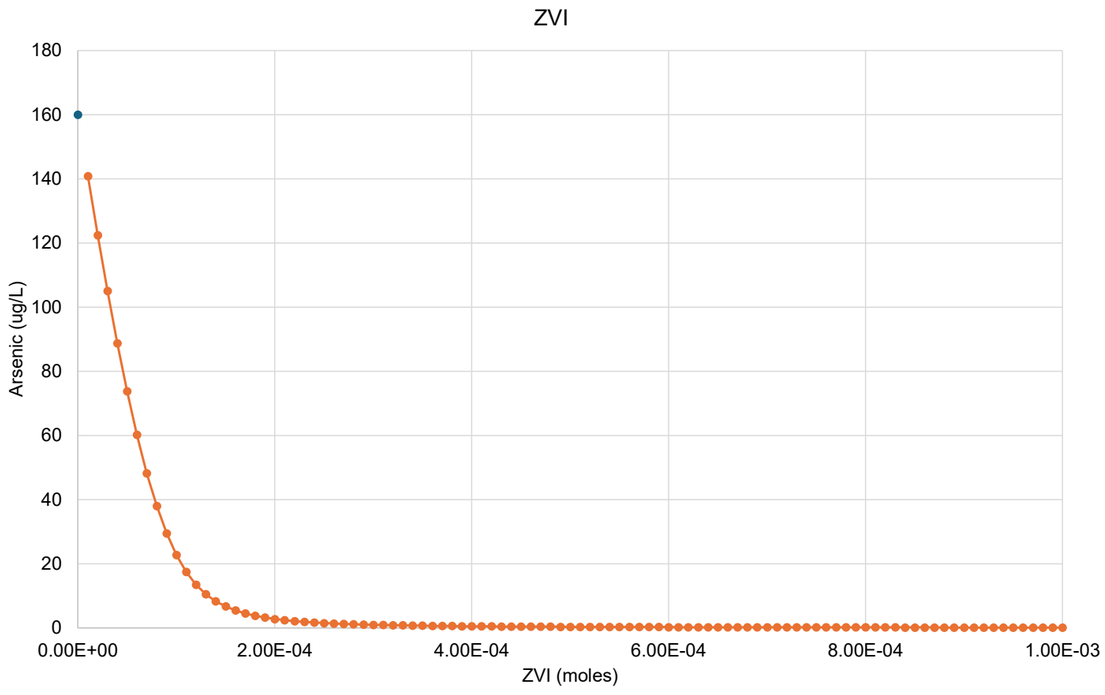
CONSULTANT

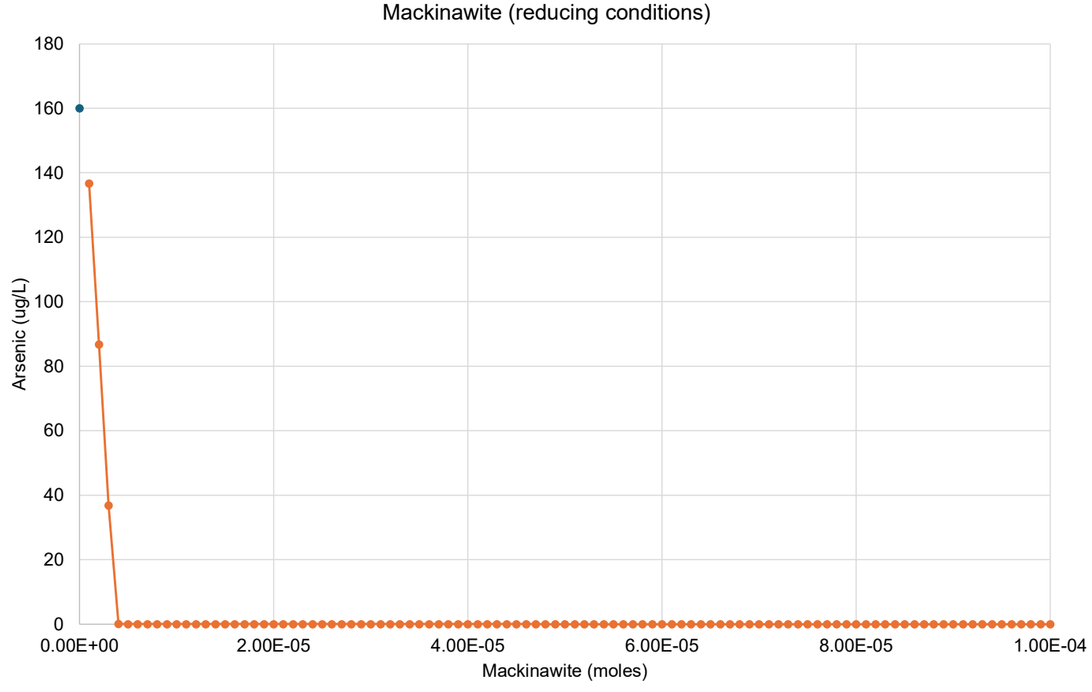
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
SENSITIVITY ANALYSIS 2 MODELING RESULTS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	26







Initial Arsenic Concentration

Injection Material Titration

CLIENT
CONSUMERS ENERGY COMPANY

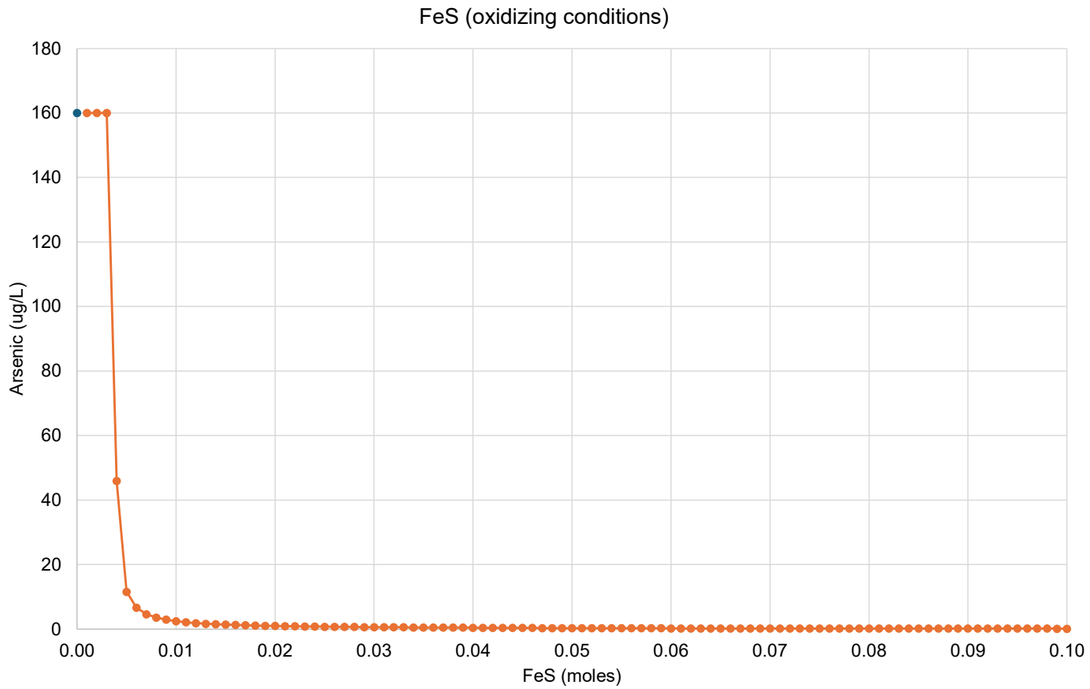
PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

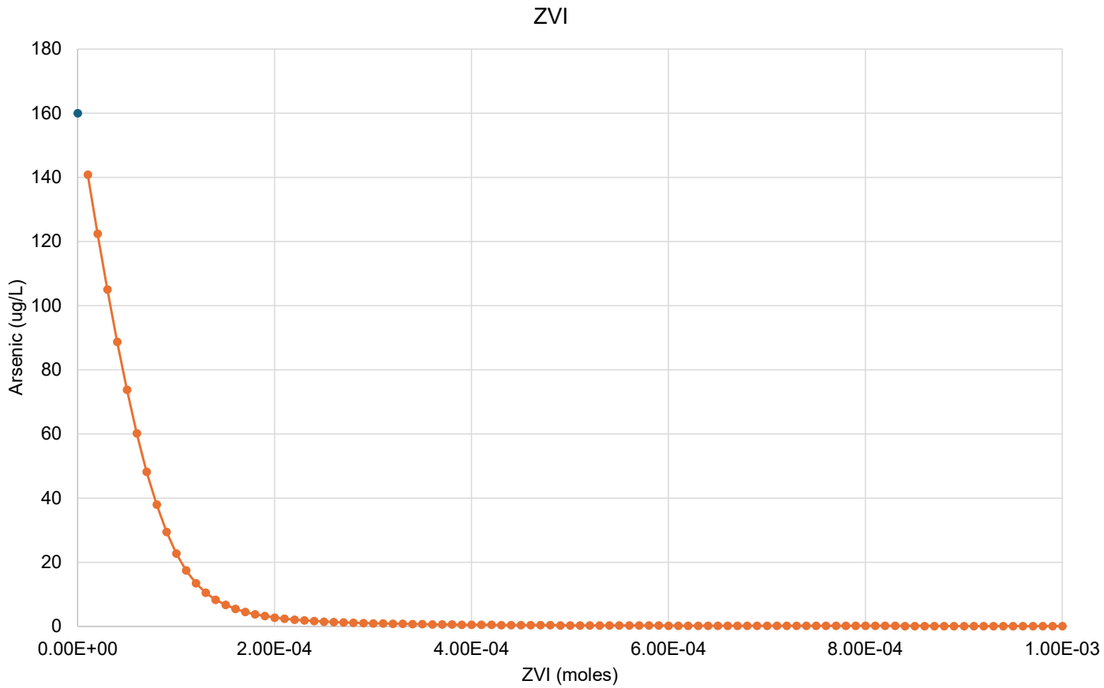
CONSULTANT
wsp

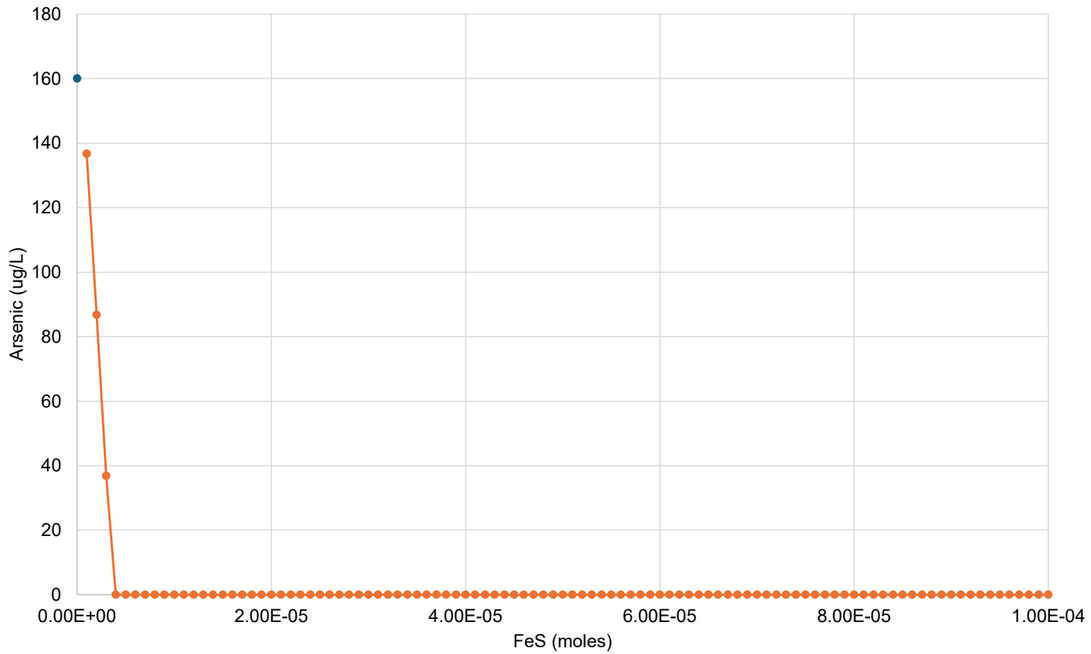
YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

TITLE
IN-SITU INJECTION COMPOUND EQUIVALENCY EVALUATION FOR MACKINAWITE

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	27







Initial Arsenic Concentration

Injection Material Titration

CLIENT
CONSUMERS ENERGY COMPANY

CONSULTANT
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YYYY-MM-DD	7/10/2025
DESIGNED	CM
PREPARED	CM
REVIEWED	PJN
APPROVED	TR

PROJECT
BOTTOM ASH POND REMEDY SELECTION FOR GROUNDWATER CORRECTIVE ACTION, KARN COMPLEX

TITLE
IN-SITU INJECTION COMPOUND EQUIVALENCY EVALUATION FOR FeS

PROJECT NO.	CONTROL	REV.	FIGURE
31404348US.2729	-	A	28

APPENDIX A

Karn BAP Boring Logs

6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-1**

TOTAL DEPTH: **20'**

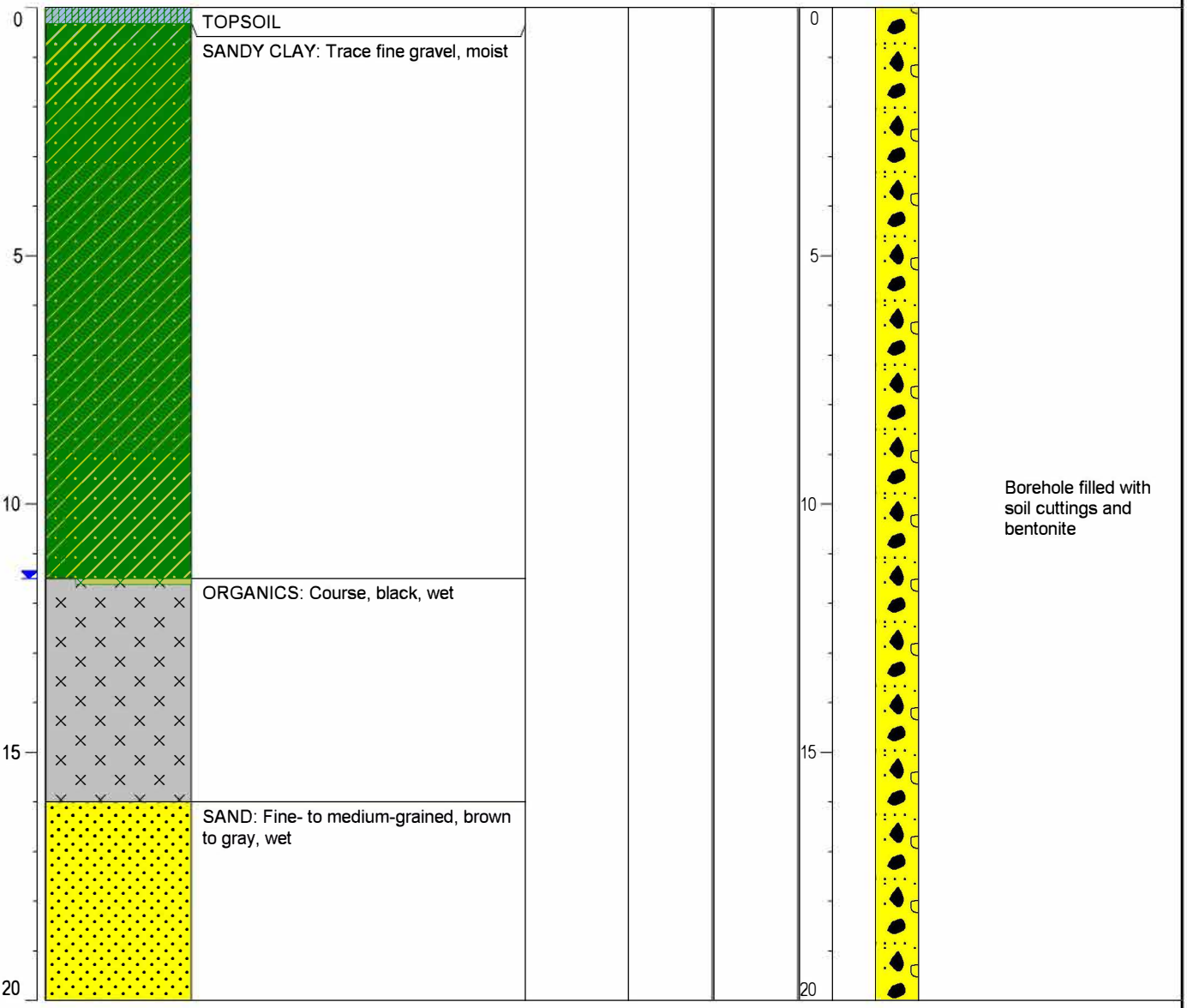
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Consumers Energy - Karn	DRILLING CO.:	Pearson Drilling
SITE LOCATION:	Karn - Essexville, MI	DRILLER:	Pearson Drilling
JOB NO.:	31404348US.2729	RIG TYPE:	Geoprobe 7722 DT
LOGGED BY:	Steve Thumma	METHOD OF DRILLING:	Direct Push
PROJECT MANAGER:	Gary Daniels	SAMPLING METHODS:	Macro Core
DATES DRILLED:	11/11/2024	HAMMER WT./DROP	NA

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION
0		TOPSOIL					
		SANDY CLAY: Trace fine gravel, moist					
10		ORGANICS: Course, black, wet					
15		SAND: Fine- to medium-grained, brown to gray, wet					
20							



6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-2**

TOTAL DEPTH: **20'**

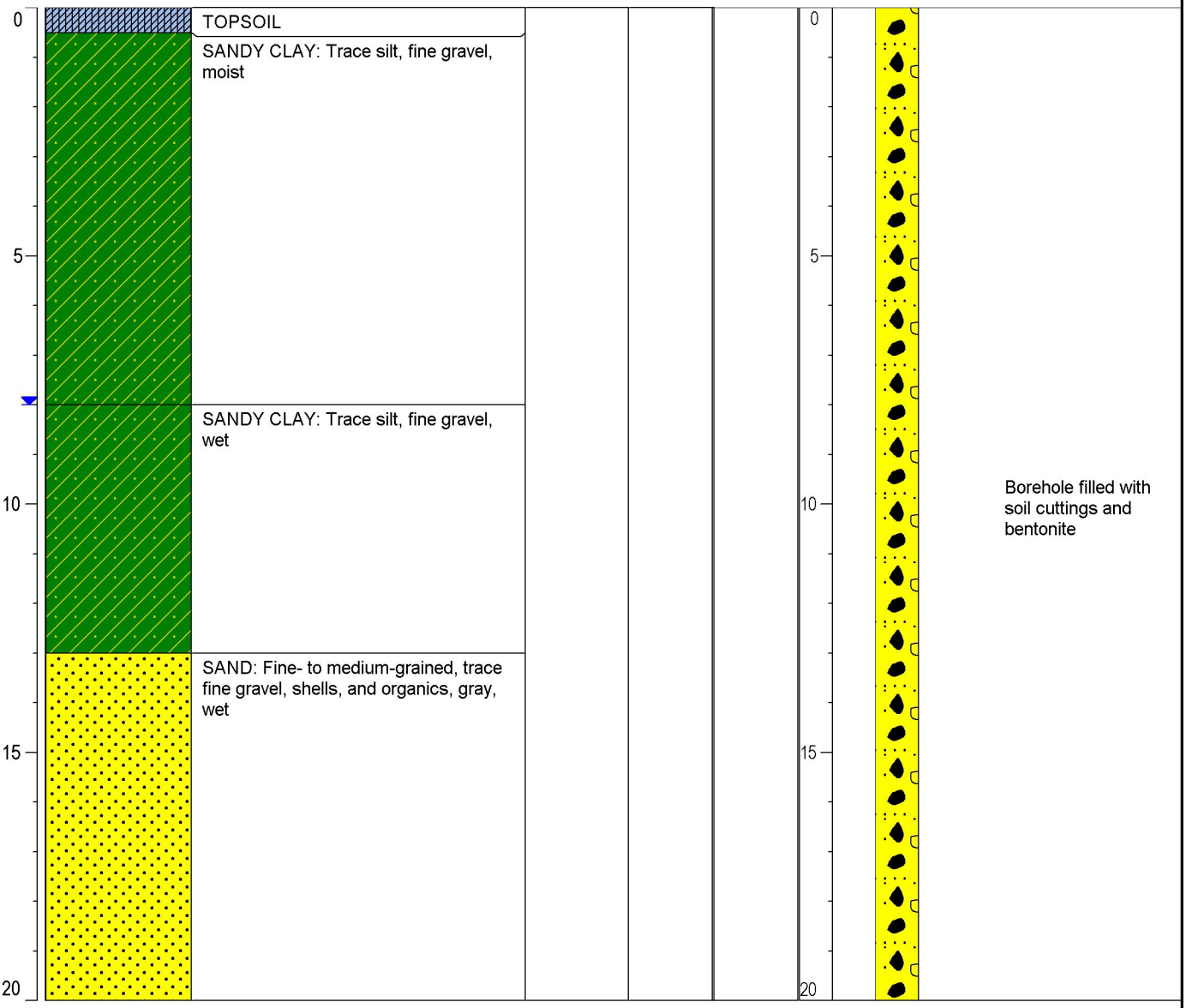
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Consumers Energy - Karn**	DRILLING CO.:	**Pearson Drilling**
SITE LOCATION:	**Karn - Essexville, MI**	DRILLER:	**Pearson Drilling**
JOB NO.:	**31404348US.2729**	RIG TYPE:	**Geoprobe 7722 DT**
LOGGED BY:	**Steve Thumma**	METHOD OF DRILLING:	**Direct Push**
PROJECT MANAGER:	**Gary Daniels**	SAMPLING METHODS:	**Macro Core**
DATES DRILLED:	**11/11/2024**	HAMMER WT./DROP	**NA**

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION
0		TOPSOIL					
		SANDY CLAY: Trace silt, fine gravel, moist					
5							
		SANDY CLAY: Trace silt, fine gravel, wet					
10							
		SAND: Fine- to medium-grained, trace fine gravel, shells, and organics, gray, wet					
15							
20							



6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-3**

TOTAL DEPTH: **20'**

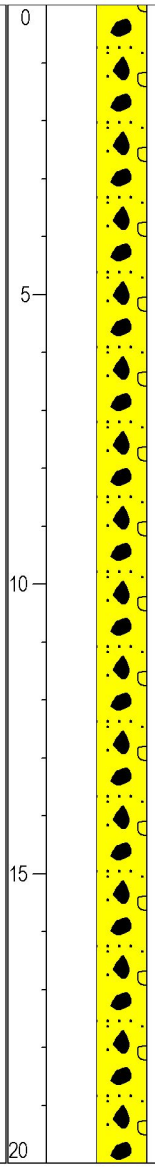
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Consumers Energy - Karn	DRILLING CO.:	Pearson Drilling
SITE LOCATION:	Karn - Essexville, MI	DRILLER:	Pearson Drilling
JOB NO.:	31404348US.2729	RIG TYPE:	Geoprobe 7722 DT
LOGGED BY:	Steve Thumma	METHOD OF DRILLING:	Direct Push
PROJECT MANAGER:	Gary Daniels	SAMPLING METHODS:	Macro Core
DATES DRILLED:	11/11/2024	HAMMER WT./DROP	NA

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION
0		TOPSOIL					
		SANDY CLAY: Trace fine gravel, brown, moist					
5							
		ASH: Fine grained, black, moist					
10		ASH: Clayey, black, wet					
15							
		SAND: Fine- to medium-grained, trace fine gravel, shells, and organics, gray, wet					
20							



Borehole filled with soil cuttings and bentonite

6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-4**

TOTAL DEPTH: **20'**

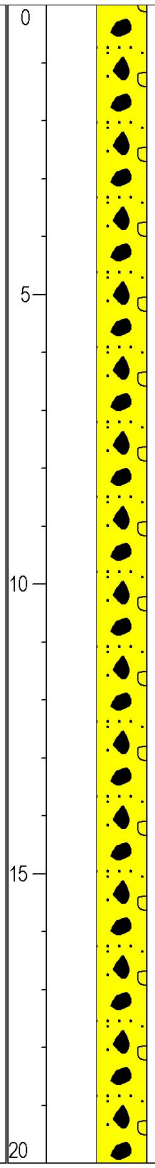
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Consumers Energy - Karn**	DRILLING CO.:	**Pearson Drilling**
SITE LOCATION:	**Karn - Essexville, MI**	DRILLER:	**Pearson Drilling**
JOB NO.:	**31404348US.2729**	RIG TYPE:	**Geoprobe 7722 DT**
LOGGED BY:	**Steve Thumma**	METHOD OF DRILLING:	**Direct Push**
PROJECT MANAGER:	**Gary Daniels**	SAMPLING METHODS:	**Macro Core**
DATES DRILLED:	**11/11/2024**	HAMMER WT./DROP	**NA**

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION
0		TOPSOIL					
		SAND: Fine- to medium-grained, light brown, moist					
		ASH: Black, moist					
5							
		ASH: Black, wet					
10		SAND: Fine- to medium-grained, trace organics, wet					
15		CLAY: Gray, wet					
		SAND: Fine- to medium-grained, trace shells, and organics, wet					
20							



Borehole filled with soil cuttings and bentonite

6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-5**

TOTAL DEPTH: **25'**

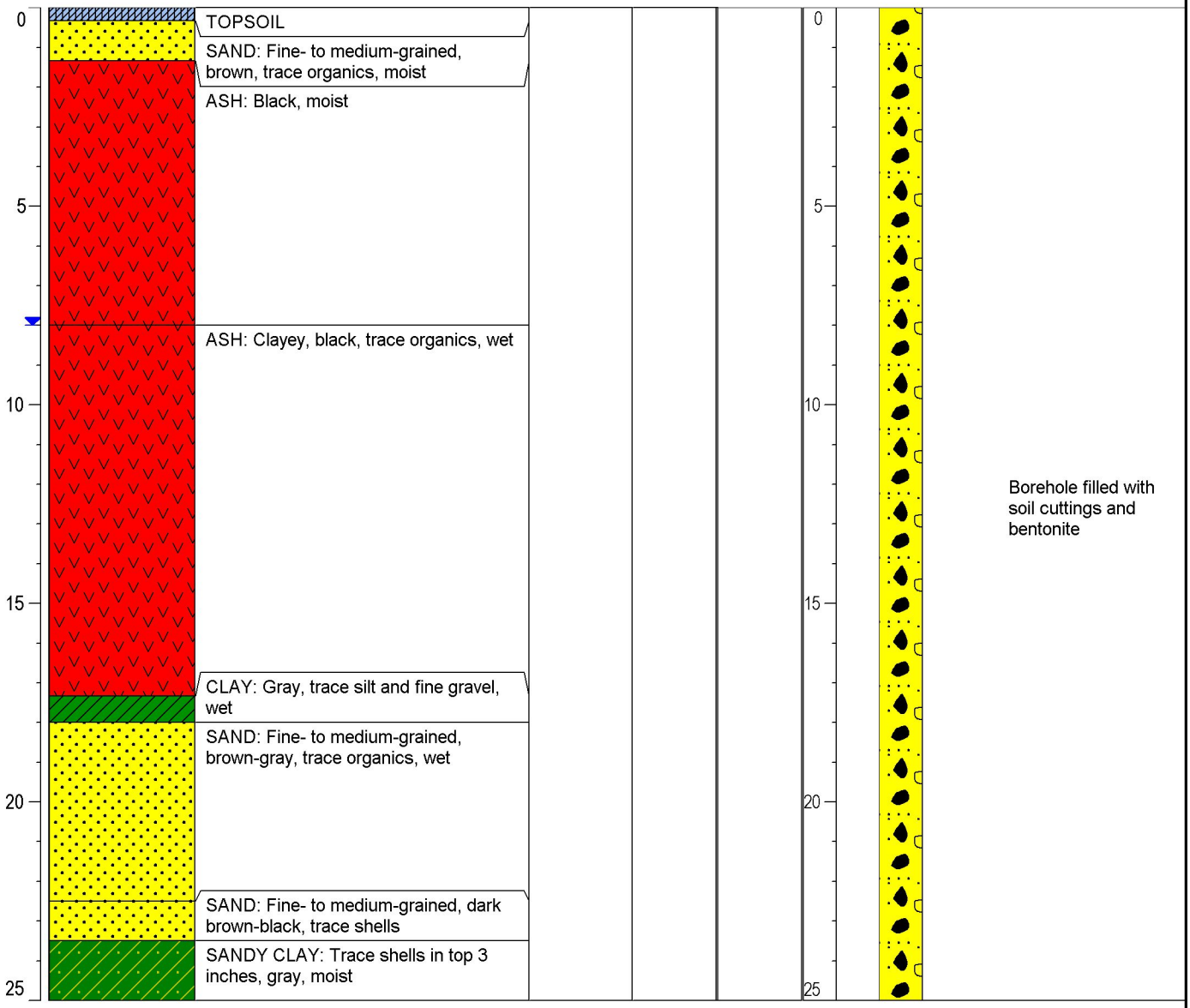
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Consumers Energy - Karn	DRILLING CO.:	Pearson Drilling
SITE LOCATION:	Karn - Essexville, MI	DRILLER:	Pearson Drilling
JOB NO.:	31404348US.2729	RIG TYPE:	Geoprobe 7722 DT
LOGGED BY:	Steve Thumma	METHOD OF DRILLING:	Direct Push
PROJECT MANAGER:	Gary Daniels	SAMPLING METHODS:	Macro Core
DATES DRILLED:	11/11/2024	HAMMER WT./DROP	NA

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION



6011 W. St. Joseph Highway
Suite 400
Lansing, MI 48917

FIELD BOREHOLE LOG

BOREHOLE NO.: **B-6**

TOTAL DEPTH: **15'**

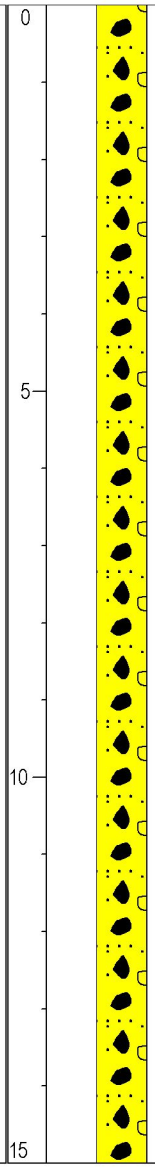
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Consumers Energy - Karn	DRILLING CO.:	Pearson Drilling
SITE LOCATION:	Karn - Essexville, MI	DRILLER:	Pearson Drilling
JOB NO.:	31404348US.2729	RIG TYPE:	Geoprobe 7722 DT
LOGGED BY:	Steve Thumma	METHOD OF DRILLING:	Direct Push
PROJECT MANAGER:	Gary Daniels	SAMPLING METHODS:	Macro Core
DATES DRILLED:	11/11/2024	HAMMER WT./DROP	NA

NOTES: Mostly cloudy and windy, mid 50's

Water level during drilling

Water level in completed well

DEPTH	LITHOLOGY SYMBOLS	LITHOLOGIC DESCRIPTION	SAMP. #	Blows / ft.	PID ppm	BORING COMPLETION	WELL DESCRIPTION
0		GRAVEL: Road aggregate					
		ASH: Black					
5		SAND: Fine- to medium-grained, tan, moist					
		SAND: Fine- to medium-grained, gray, trace shells, moist					
10		SAND: Fine- to medium-grained, black, trace shells, wet					
		CLAY: Gray, trace sand, wet					
15		SAND: Fine- to medium-grained, gray, trace shells and organics, wet					



Borehole filled with soil cuttings and bentonite

APPENDIX B

BAP Aquifer Solids Laboratory Testing Reports

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*ARD-XRD* *3260 Production Way, Burnaby, Canada*
Project Number/ LIMS No.	*Custom XRD/MI7004-DEC24*
Sample Receipt:	*December 12, 2024*
Sample Analysis:	*December 16, 2024*
Reporting Date:	*January 21, 2025*

Instrument:	Panalytical X'pert Pro Diffractometer
Test Conditions:	Co radiation, 40 kV, 45 mA; Detector: X'Celerator Regular Scanning: Step: 0.033°, Step time:0.15s, 2θ range: 5-80°
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:

Melody Hao, M.Sc.
Mineralogist

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

Method Summary

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.

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Diffrac Topas 7 (Bruker), 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.

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

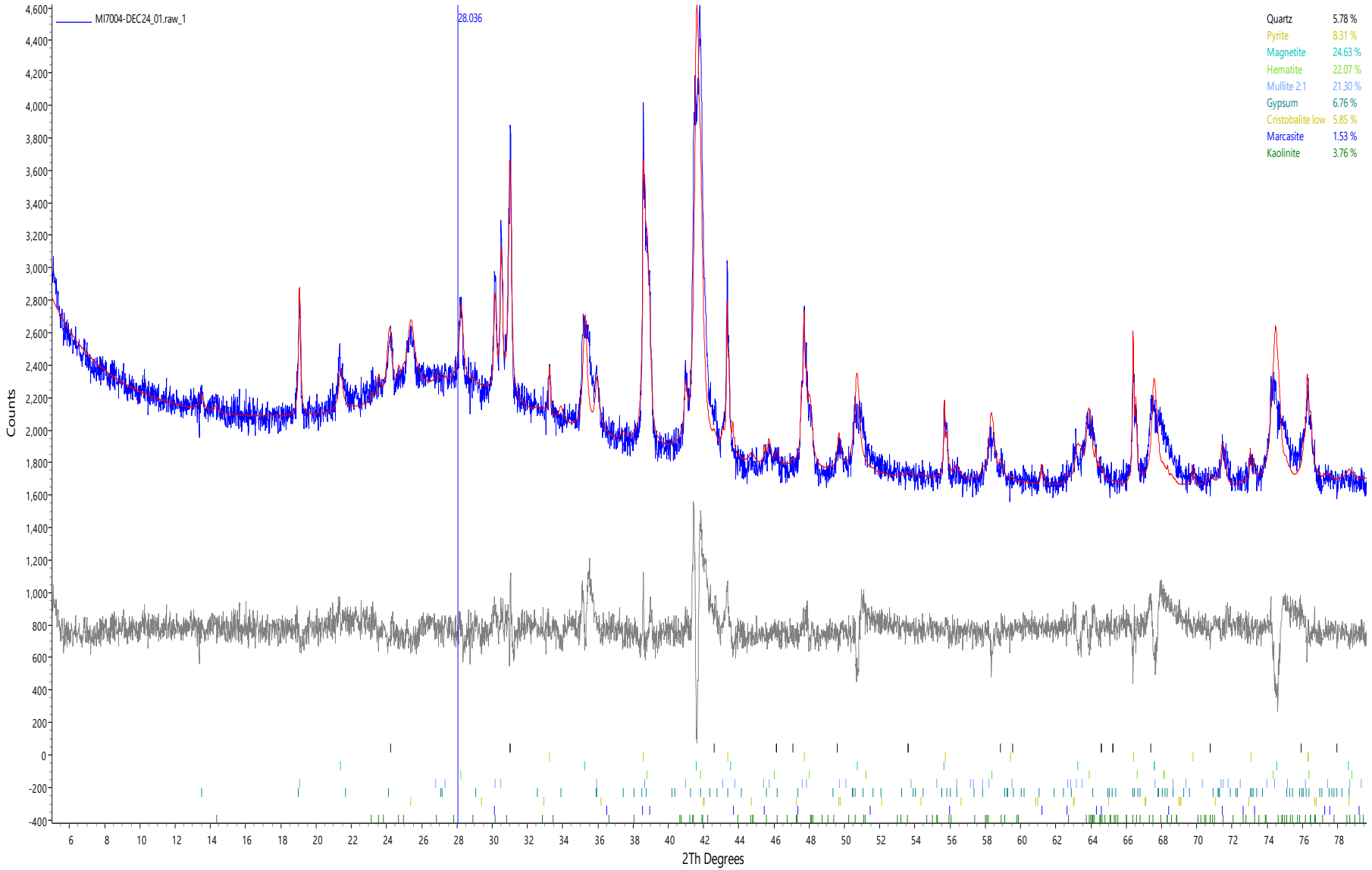
Mineral/Compound	B-1 12'-13' DEC7004-01 (wt %)	B-1 16'-18' DEC7004-02 (wt %)	B-2 8'-9' DEC7004-03 (wt %)	B-2 13'-15' DEC7004-04 (wt %)	B-3 11'-13' DEC7004-05 (wt %)	B-3 17'-19' DEC7004-06 (wt %)	B-4 10'-12' DEC7004-07 (wt %)	B-5 10'-15' DEC7004-08 (wt %)	B-5 18'-20' DEC7004-09 (wt %)	B-5 21 1/2'-22 1/2' DEC7004-10 (wt %)	B-6 6"-18" DEC7004-11 (wt %)	B-6 5'-7' DEC7004-12 (wt %)
Quartz	5.8	69.6	32.5	69.0	23.3	76.4	36.0	54.6	77.2	68.9	28.4	59.4
Pyrite	8.3	-	-	-	0.2	-	-	-	-	-	-	-
Magnetite	24.6	-	-	-	3.4	-	3.9	1.6	-	-	4.6	-
Hematite	22.1	-	-	-	4.6	0.5	6.1	3.7	-	-	5.7	-
Mullite	21.3	-	-	-	67.2	-	32.3	17.2	-	-	33.6	-
Gypsum	6.8	-	-	-	-	-	-	-	-	-	-	-
Cristobalite	5.8	-	-	-	-	-	-	-	-	-	-	-
Marcasite	1.5	-	-	-	-	-	-	-	-	-	-	-
Kaolinite	3.8	-	-	-	-	-	-	-	-	-	-	-
Albite	-	8.4	9.3	11.1	-	9.4	10.4	10.3	8.1	7.3	3.9	7.6
Dolomite	-	1.6	23.8	3.1	-	1.3	1.1	2.0	1.3	7.1	5.9	4.5
Ankerite	-	1.0	-	-	-	-	1.6	-	-	-	2.1	-
Chlorite	-	0.1	4.4	0.7	-	0.7	-	-	1.3	3.1	-	1.6
Biotite	-	1.4	2.4	-	-	0.3	-	-	1.3	-	-	0.8
Calcite	-	0.7	11.7	-	1.1	-	0.7	2.4	-	5.7	13.7	19.7
Hornblende	-	1.3	0.7	1.4	-	1.2	-	-	1.5	2.7	-	1.0
Microcline	-	15.9	5.5	12.2	0.3	7.8	6.6	6.3	5.6	3.2	2.1	5.5
Muscovite	-	-	9.8	2.3	-	-	-	-	-	-	-	-
Diopside	-	-	-	-	-	2.4	-	1.8	3.7	-	-	-
Rutile	-	-	-	-	-	-	1.4	-	-	-	-	-
Phlogopite	-	-	-	-	-	-	-	-	-	1.9	-	-
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100

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

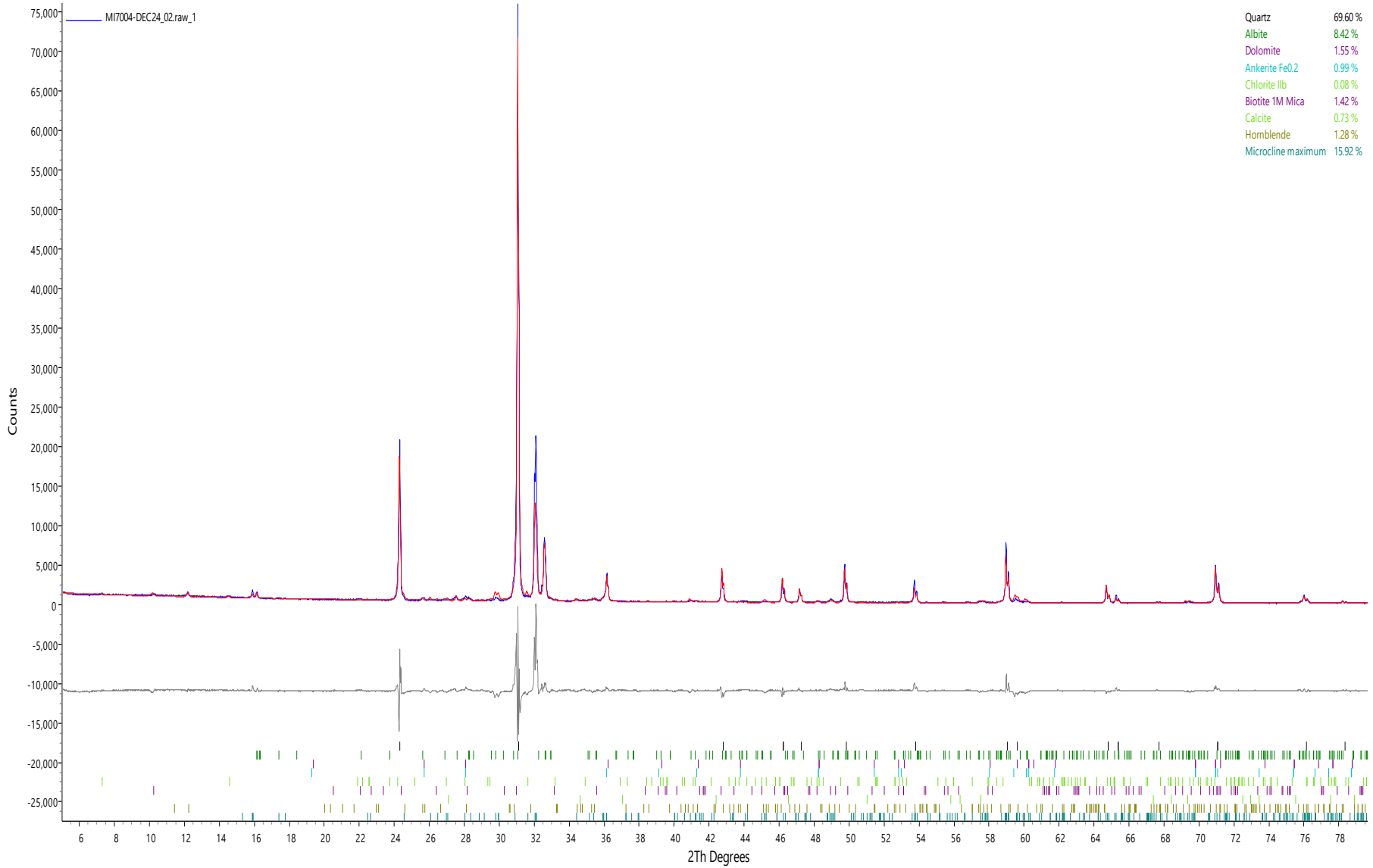
The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO_2
Pyrite	FeS_2
Magnetite	Fe_3O_4
Hematite	Fe_2O_3
Mullite	$\sim Al_6Si_3O_{15}$
Gypsum	$CaSO_4 \cdot 2H_2O$
Cristobalite	SiO_2
Marcasite	FeS_2
Kaolinite	$Al_2Si_2O_5(OH)_4$
Albite	$NaAlSi_3O_8$
Dolomite	$CaMg(CO_3)_2$
Ankerite	$CaFe(CO_3)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Calcite	$CaCO_3$
Hornblende	$(Ca,Na)_{2\text{-}3}(Mg,Fe,Al)_5Si_6(Si,Al)_2O_{22}(OH)_2$
Microcline	$KAlSi_3O_8$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Diopside	$CaMgSi_2O_6$
Rutile	TiO_2
Phlogopite	$KMg_3(AlSi_3O_{10})(OH)_2$

B-1 12'-13'


MI7004-DEC24_01.raw_1
28.036
Quartz 5.78 %
Pyrite 8.31 %
Magnetite 24.63 %
Hematite 22.07 %
Mullite 2:1 21.30 %
Gypsum 6.76 %
Cristobalite low 5.85 %
Marcasite 1.53 %
Kaolinite 3.76 %
Counts
2Th Degrees

B-1 16'-18'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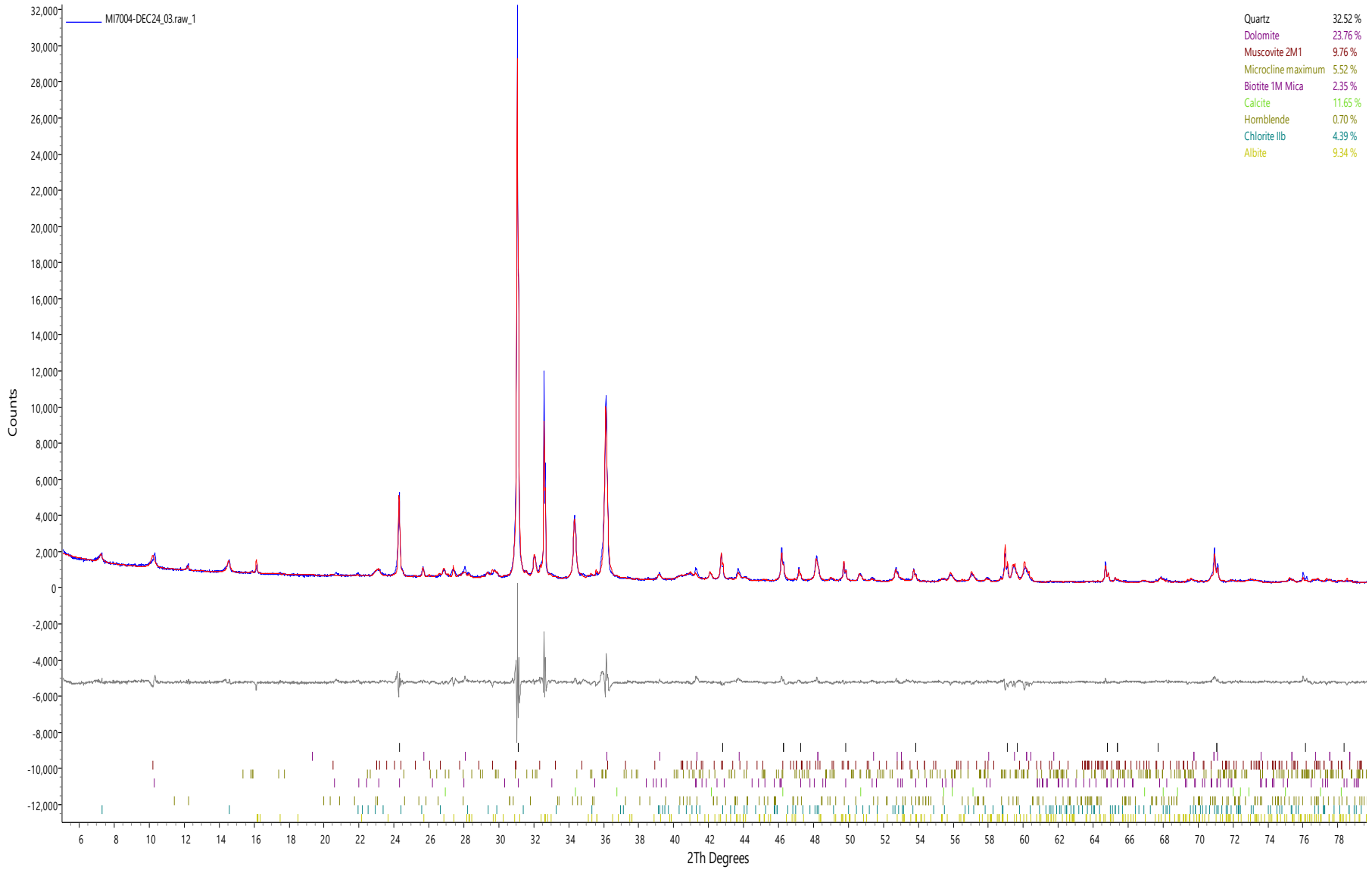
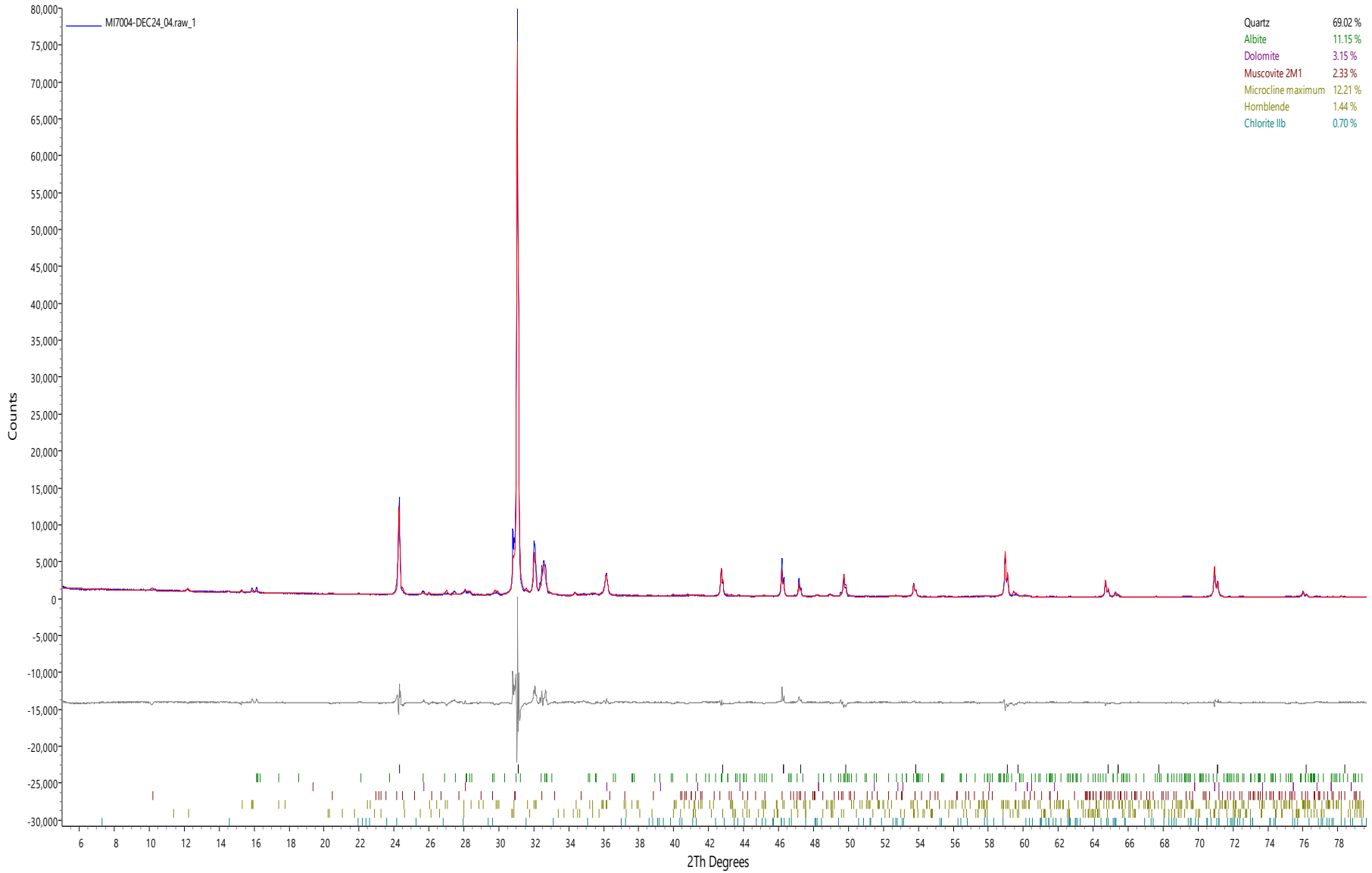
Quartz 69.60 %
Albite 8.42 %
Dolomite 1.55 %
Ankerite Fe0.2 0.99 %
Chlorite IIb 0.08 %
Biotite 1M Mica 1.42 %
Calcite 0.73 %
Hornblende 1.28 %
Microcline maximum 15.92 %
Counts
2Th Degrees

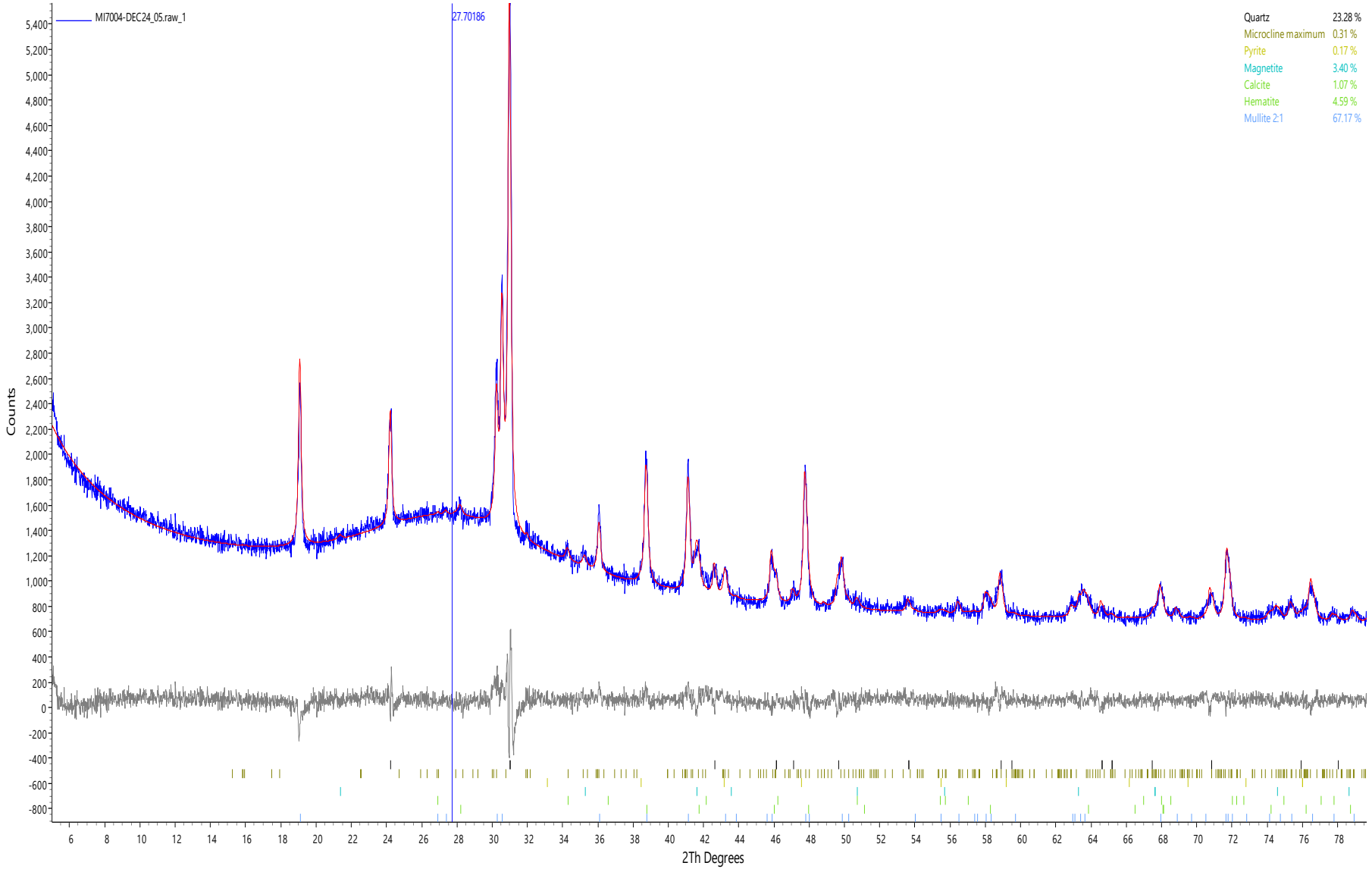
B-2 8'-9'


MI7004-DEC24_03.raw_1
Quartz 32.52 %
Dolomite 23.76 %
Muscovite 2M1 9.76 %
Microcline maximum 5.52 %
Biotite 1M Mica 2.35 %
Calcite 11.65 %
Hornblende 0.70 %
Chlorite IIb 4.39 %
Albite 9.34 %
Counts
2Th Degrees

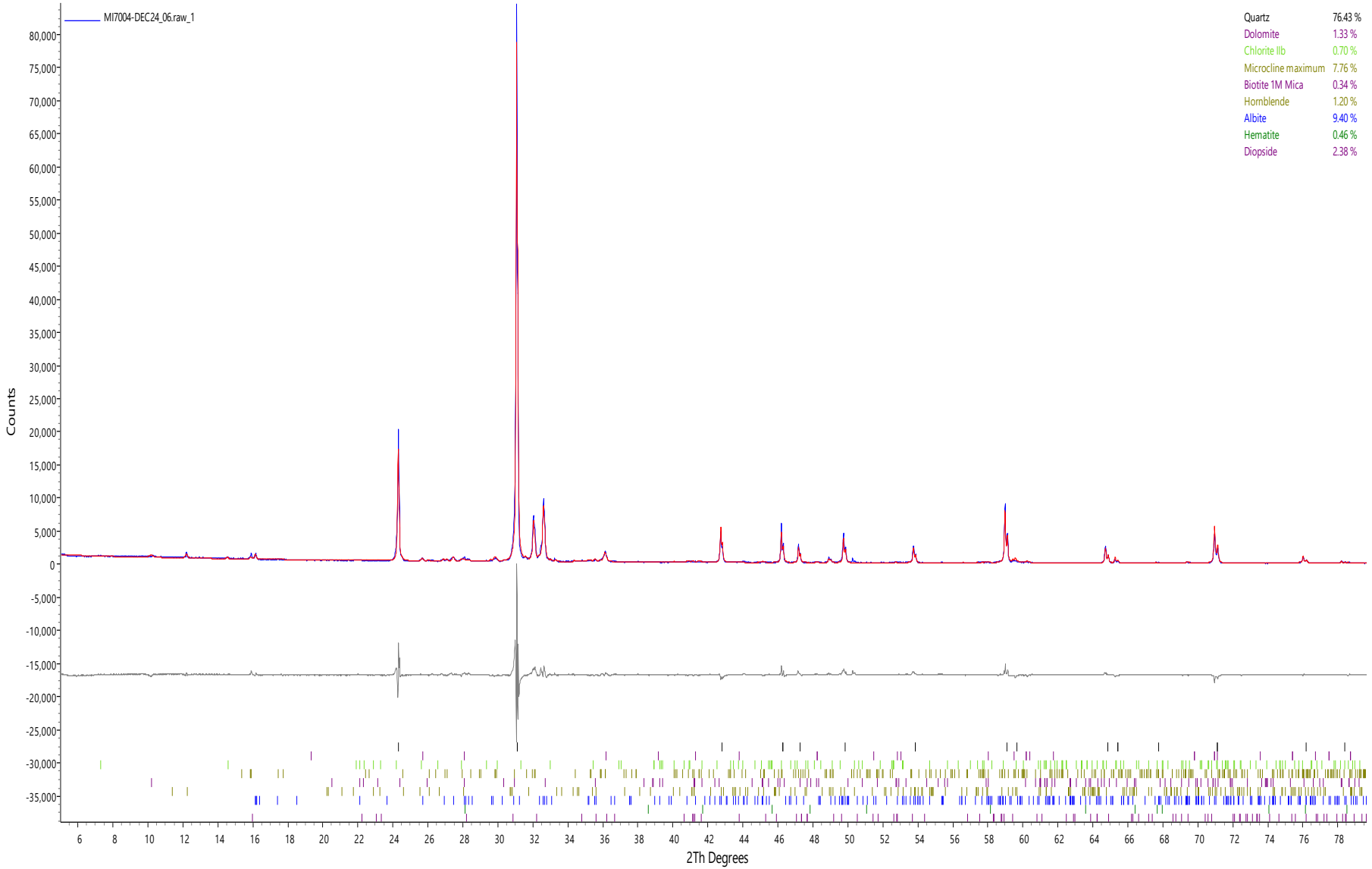
B-2 13'-15'


MI7004-DEC24_04.raw_1
Quartz 69.02 %
Albite 11.15 %
Dolomite 3.15 %
Muscovite 2M1 2.33 %
Microcline maximum 12.21 %
Hornblende 1.44 %
Chlorite IIb 0.70 %
Counts
2Th Degrees

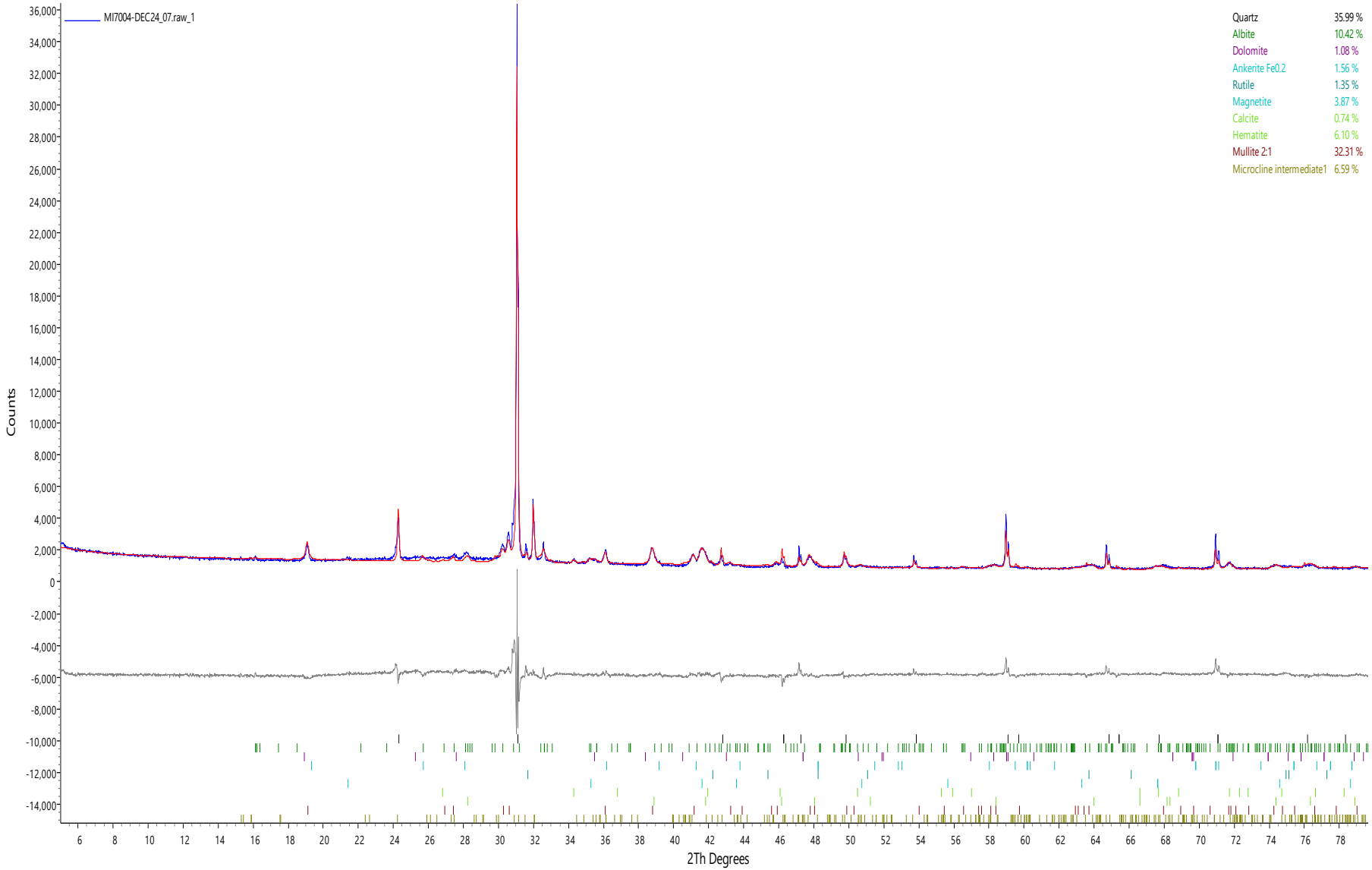
B-3 11'-13'


MI7004-DEC24_05.raw_1
27.70186
Quartz 23.28 %
Microcline maximum 0.31 %
Pyrite 0.17 %
Magnetite 3.40 %
Calcite 1.07 %
Hematite 4.59 %
Mullite 2:1 67.17 %
Counts
2Th Degrees

B-3 17'-19'


MI7004-DEC24_06.raw_1
Counts
2Th Degrees
Quartz 76.43 %
Dolomite 1.33 %
Chlorite IIb 0.70 %
Microcline maximum 7.76 %
Biotite 1M Mica 0.34 %
Hornblende 1.20 %
Albite 9.40 %
Hematite 0.46 %
Diopside 2.38 %

B-4 10'-12'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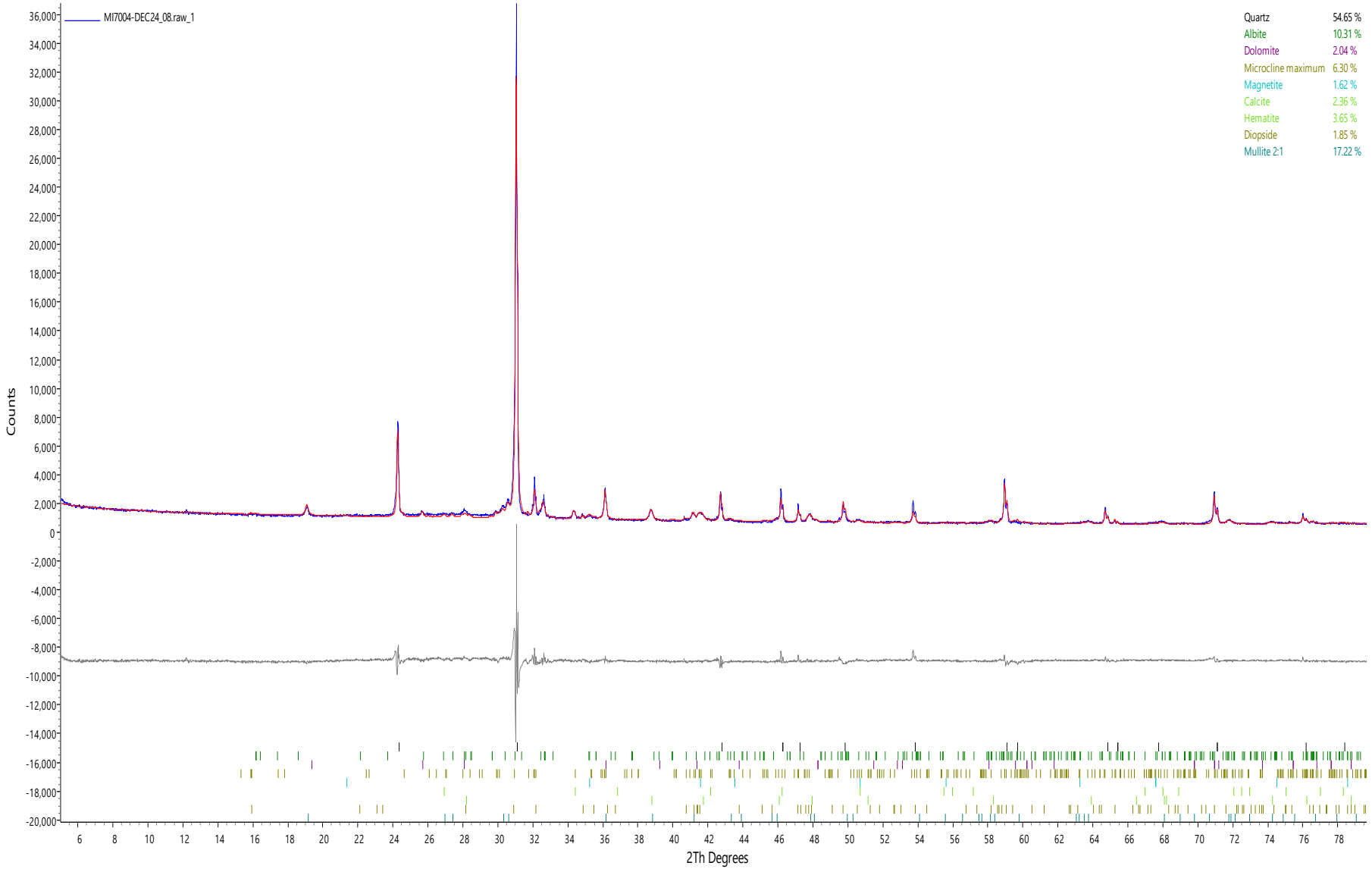
Quartz 35.99 %
Albite 10.42 %
Dolomite 1.08 %
Ankerite Fe0.2 1.56 %
Rutile 1.35 %
Magnetite 3.87 %
Calcite 0.74 %
Hematite 6.10 %
Mullite 2:1 32.31 %
Microcline intermediate1 6.59 %
Counts
2Th Degrees

B-5 10'-15'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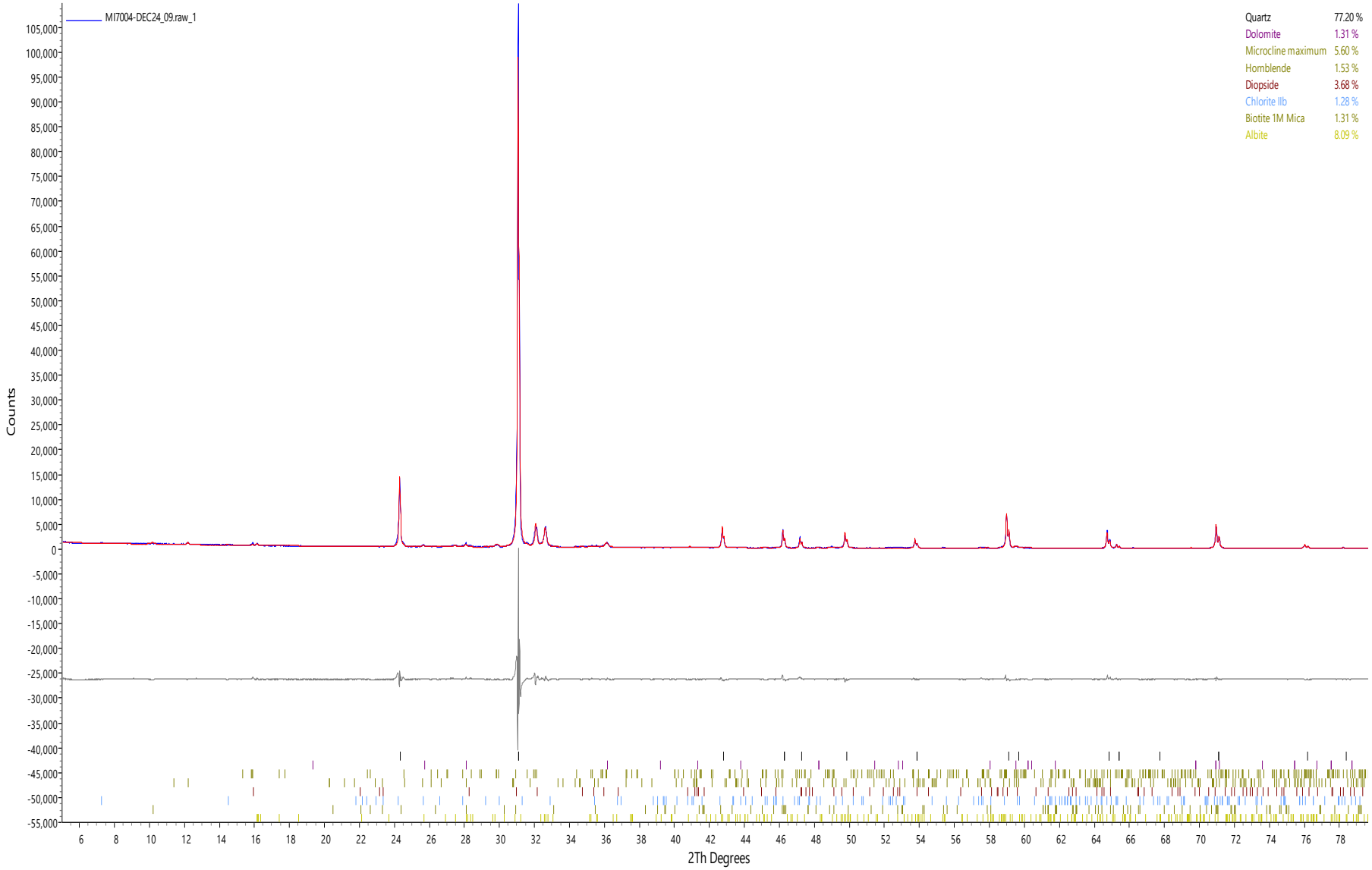
Quartz 54.65 %
Albite 10.31 %
Dolomite 2.04 %
Microcline maximum 6.30 %
Magnetite 1.62 %
Calcite 2.36 %
Hematite 3.65 %
Diopside 1.85 %
Mullite 2:1 17.22 %
Counts
2Th Degrees

B-5 18'-20'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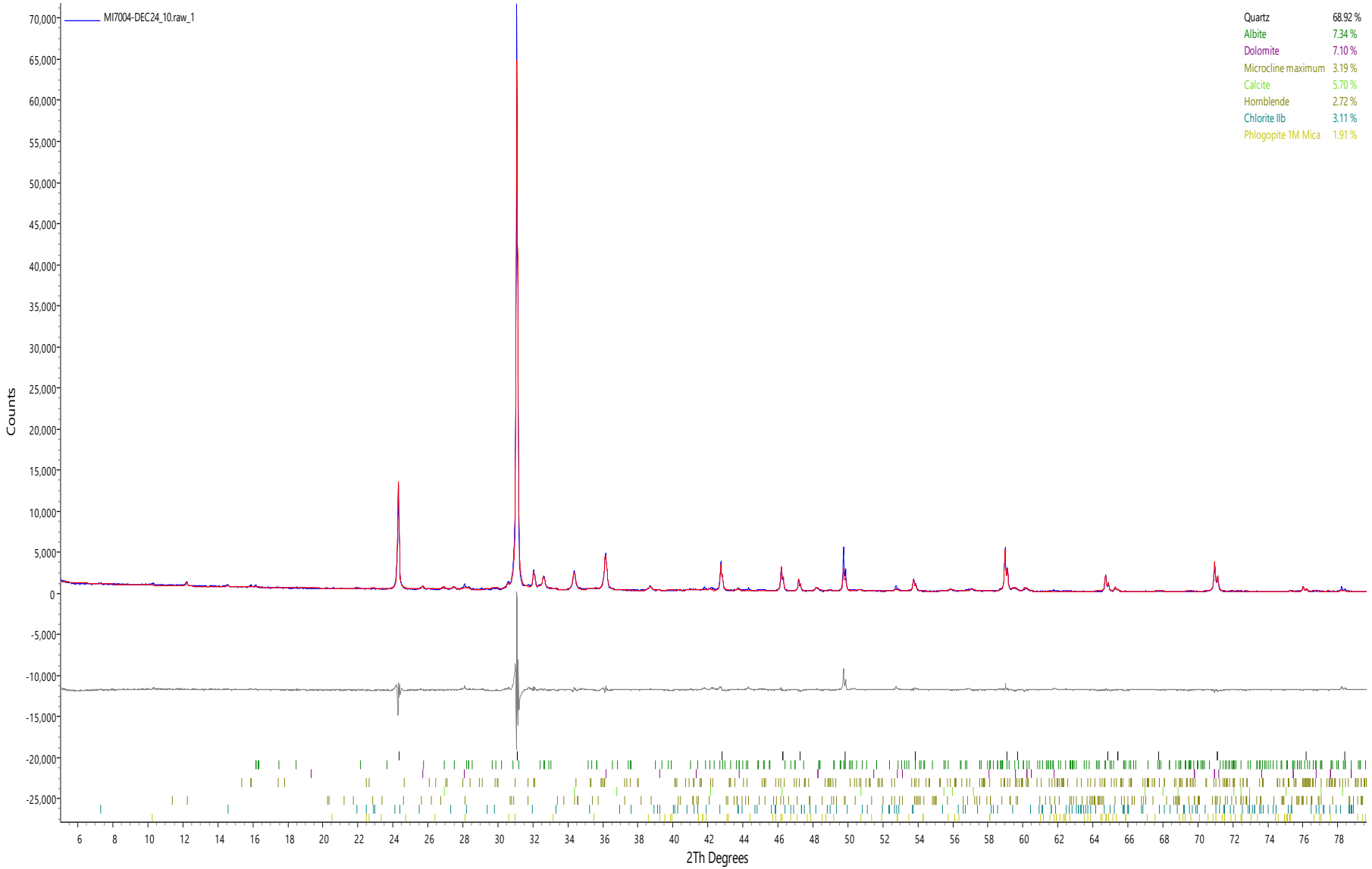
Quartz 77.20 %
Dolomite 1.31 %
Microcline maximum 5.60 %
Hornblende 1.53 %
Diopside 3.68 %
Chlorite IIb 1.28 %
Biotite 1M Mica 1.31 %
Albite 8.09 %
Counts
2Th Degrees

B-5 21 1/2'-22 1/2'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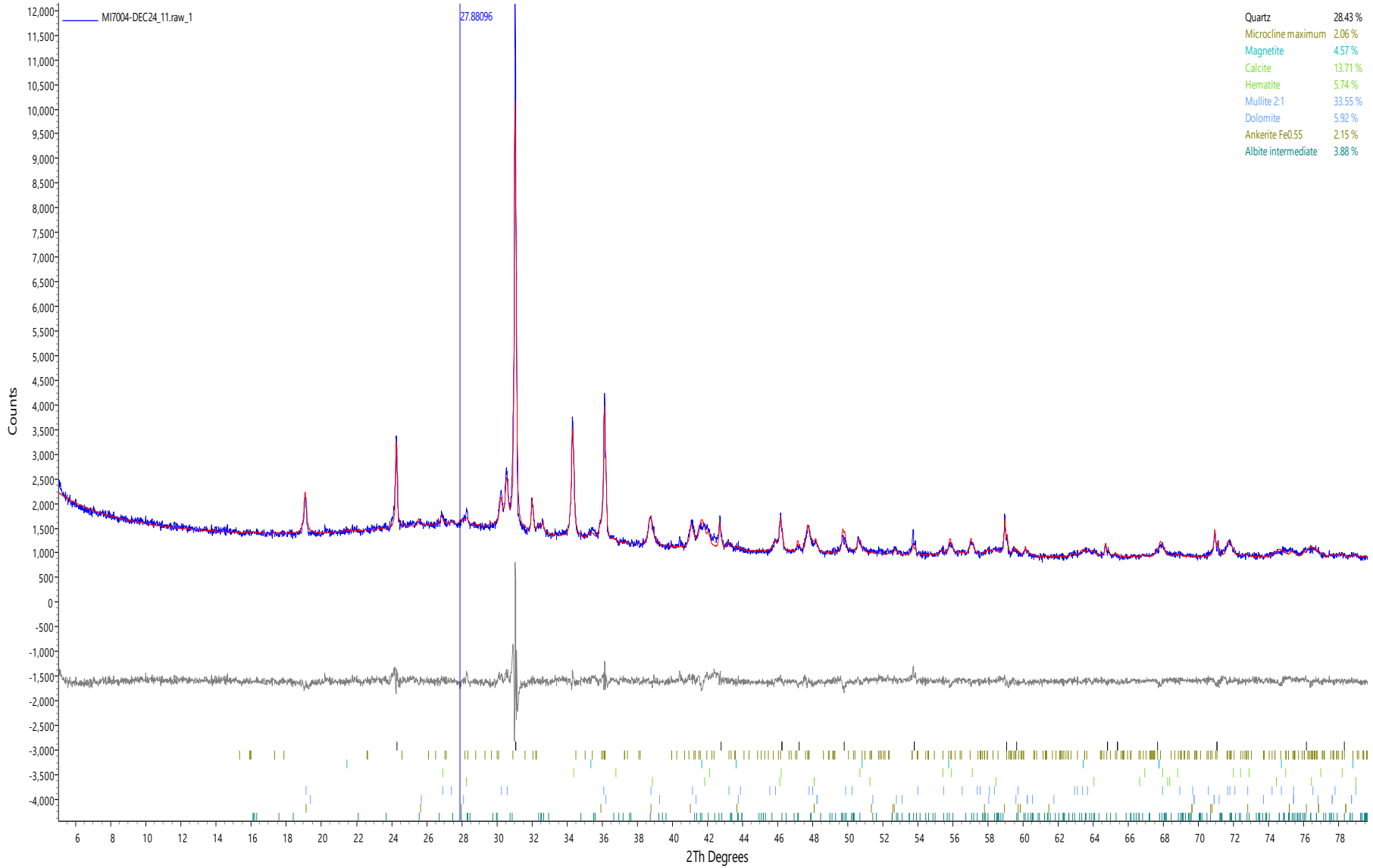
Quartz 68.92 %
Albite 7.34 %
Dolomite 7.10 %
Microcline maximum 3.19 %
Calcite 5.70 %
Hornblende 2.72 %
Chlorite IIb 3.11 %
Phlogopite 1M Mica 1.91 %
Counts
2Th Degrees

B-6 6"-18"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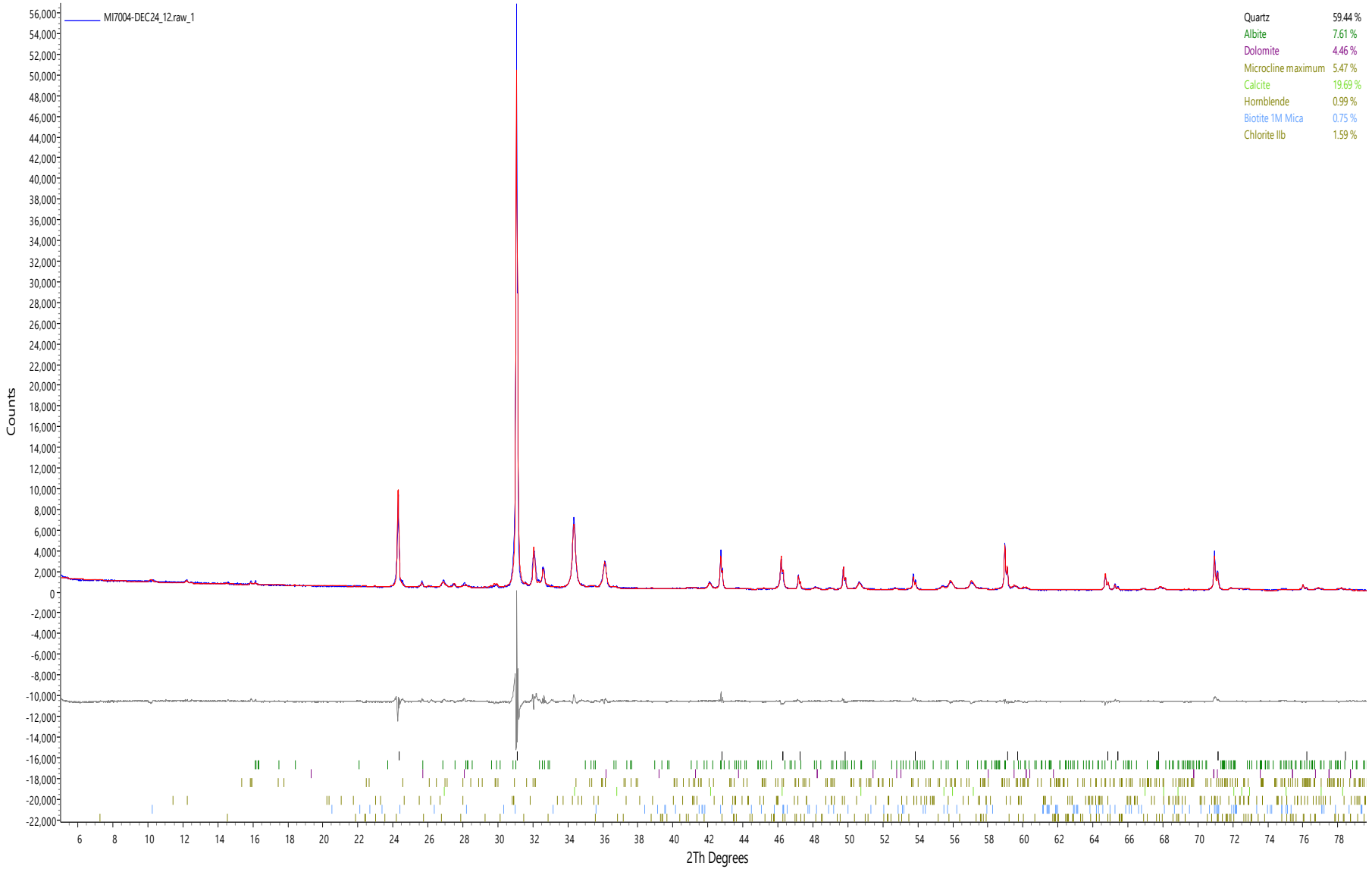
Quartz 28.43 %
Microcline maximum 2.06 %
Magnetite 4.57 %
Calcite 13.71 %
Hematite 5.74 %
Mullite 2:1 33.55 %
Dolomite 5.92 %
Ankerite Fe0.55 2.15 %
Albite intermediate 3.88 %
Counts
2Th Degrees

B-6 5'-7'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Quartz 59.44 %
Albite 7.61 %
Dolomite 4.46 %
Microcline maximum 5.47 %
Calcite 19.69 %
Hornblende 0.99 %
Biotite 1M Mica 0.75 %
Chlorite IIb 1.59 %
Counts
2Th Degrees

SGS proposal: 2452
SGS project #: 20676-PR1-R1

Work order date: 2-Dec-24
Report date: 20-Jan-25
Sample receipt date: 13-Nov-24
Version: Final

Customer details

Name:	Gary Daniels
Address:	WSP USA

Project reference: CEC Karn

P.O. number:

COC:

ANALYSIS REPORT

SGS WO: 1

Report Distribution

Name	Email
Gary Daniels	gary.Daniels@wsp.com

Special notes:

3260 Production Way
Burnaby - British Columbia - V5A 4W4
Phone: 604-638-2349 FAX: 604-444-5486

SGS proposal: 2452
SGS project #: 20676-PR1-R1

Work order date: 2-Dec-24
Report date: 20-Jan-25

Version: Final

ANALYSIS REPORT

Method Summaries *Test method information available upon request.*

S(T) and C(T): Total sulfur and total carbon by LECO, Method CSA06V
S(SO4): Sulfate by HCl digestion with ICP finish, Method CSA07V
S(S2-): Sulfide by calculation of S(T) - S(SO4) or by nitric acid digestion with ICP finish (Method CSA08C1)

TIC: Total inorganic carbon by coulometry, Method CSB02V
AP: Acid generating potential based on sulfide sulfur
NP: Modified neutralisation potential by excess acid addition and back titration to pH 8.3
Net NP: Net neutralisation potential = NP - AP

Metals by aqua regia digest with ICP-OES/MS finish, Method ICP21B20/ICM21B20
Metals by multi-acid digest with ICP-OES/MS finish, Method ICP40Q12/IMS40Q12

Preliminary Data

Anahita Etemadifar - Laboratory Supervisor

Final Data Approval

Noelene Ahern - Manager: ARD

3260 Production Way
Burnaby - British Columbia - V5A 4W4
Phone: 604-638-2349 FAX: 604-444-5486

ABA Report

Test	S(T)	S(SO4)	S(S-2)	Insoluble S	AP
Units	%	%	%	%	kg CaCO3/t
Method Code	CSA06V	CSA07C1	CSA08C1	Calc.	Calc.
LOD	0.005	0.01	0.01	#N/A	#N/A
Sample ID					
B-1 12'-13'	2.475	0.22	2.06	0.195	64.4
B-1 16'-18'	0.034	0.01	0.01	0.014	0.3
B-2 8'-9'	0.075	0.02	0.05	0.005	1.6
B-2 13'-15'	0.044	0.02	0.02	0.004	0.6
B-3 11'-13'	0.137	0.04	0.03	0.067	0.9
B-3 17'-19'	0.067	0.01	0.04	0.017	1.3
B-4 10'-12'	0.105	0.02	0.03	0.055	0.9
B-5 10'-15'	0.199	0.03	0.11	0.059	3.4
B-5 18'-20'	0.055	0.02	0.03	0.005	0.9
B-5 21 1/2'-22 1/2'	0.028	<0.01	0.01	0.018	0.3
B-6 6"-18"	0.106	0.07	0.02	0.016	0.6
B-6 5'-7'	0.023	0.01	<0.01	0.013	<0.3
Duplicates					
B-5 18'-20'		0.02			
B-1 12'-13'	2.431				

QA/QC					
Blank	0.005	<0.01	<0.01		
Certified standards					
OREAS 278			0.62		
RTS-3a		1.02			
GS-314-2	2.583				
GS915-8	0.130				

SGS proposal: 2452
SGS project #: 20676-PR1-R1

Work order date: 2-Dec-24
Report date: 20-Jan-25

ABA Report

Test	C(T)	TIC	CaCO3 NP	C (Org)
Units	%	%	kg CaCO3/t	
Method Code	CSA06V	CSB02V	Calc.	Calc.
LOD	0.005	0.01		
Sample ID				
B-1 12'-13'	3.996	<0.01	<0.8	4.00
B-1 16'-18'	0.377	0.24	20.0	0.14
B-2 8'-9'	4.166	4.16	346.7	0.01
B-2 13'-15'	0.609	0.39	32.5	0.22
B-3 11'-13'	7.421	0.09	7.5	7.33
B-3 17'-19'	0.523	0.22	18.3	0.30
B-4 10'-12'	4.946	0.18	15.0	4.77
B-5 10'-15'	6.587	0.51	42.5	6.08
B-5 18'-20'	0.466	0.19	15.8	0.28
B-5 21 1/2'-22 1/2'	2.135	1.84	153.3	0.30
B-6 6"-18"	4.374	0.91	75.8	3.46
B-6 5'-7'	2.575	2.28	190.0	0.30
Duplicates				
B-1 12'-13'	4.080			

QA/QC				
Blank	0.005	<0.01		
Certified standards				
TIC-L1		0.13		
SX35-13		11.84		
GS-314-2	5.197			
GS915-8	0.067			

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SGS

ANALYSIS REPORT

ABA Report - CRM Expected Values and Tolerances

CRM	Test	S(T)	S(SO4)	S(SO4)	S(S-2)	C(T)	TIC	CO2	Modified NP	Modified with Siderite Correction NP
	Units	%	%	%	%	%	%	%	kg CaCO3/t	kg CaCO3/t
	Method Code	CSA06V	CSA07V	CSA07D	Calc.	CSA06V	CSB02V	CSB02V	Modified	
	LOD	0.005	0.01	1.01	0.01	0.005	0.01	0.005	0.5	
GGC-07	Expected value	0.51				0.56				
	Tolerance (+/-)	0.09				0.09				
HCC-1	Expected value	33.92								
	Tolerance (+/-)	5.04								
RTS-3a	Expected value		0.98	1.34						
	Tolerance (+/-)		0.12	0.35						
OREAS 278	Expected value				0.699					
	Tolerance (+/-)				0.06					
NBM-1	Expected value								42.44	50.27
	Tolerance (+/-)								3.04	2.31
TIC-L1	Expected value						0.13	0.477		
	Tolerance (+/-)						0.02	0.78		
GS314-2	Expected value	2.56				5.15				
	Tolerance (+/-)	0.14				0.27				
GS915-8	Expected value	0.13				0.07				
	Tolerance (+/-)	0.02				0.02				
OREAS 550	Expected value	0.220				4.110				
	Tolerance (+/-)	0.004				0.22				
SX35-13	Expected value						11.954			
	Tolerance (+/-)									
SY4	Expected value						0.95			
	Tolerance (+/-)						0.06			

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Sobek With Siderite NP kg CaCO3/t	Fizz Test	Paste pH
	Sobek	Sobek 0.2
57.6	Slight	
1.3		

3260 Production Way
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Phone: 604-638-2349 FAX: 604-444-5486

SGS proposal: 20676-PR1-R1
SGS project #: 2452

Sample receipt date: 2-Dec-24
Report date: 17-Jan-25

Version: Final

Customer details

Name:	Gary Daniels
Address:	wsP USA

Project reference: CEC Karn

P.O. number:

COC:

ANALYSIS REPORT

SGS WO: 1

Report Distribution

Name	Email
Gary Daniels	
PJ Nolan	

Special notes:

Tessier Sequential extraction

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ANALYSIS REPORT

Method Summaries *Test method information available upon request.*

S(T) and C(T): Total sulfur and total carbon by LECO, Method CSA06V
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S(S2-): Sulfide by calculation of S(T) - S(SO4)

TIC: Total inorganic carbon by coulometry, Method CSB02V
AP: Acid generating potential based on sulfide sulfur
NP: Modified neutralisation potential by excess acid addition and back titration to pH 8.3
Net NP: Net neutralisation potential = NP - AP
NPR: Neutralisation potential ratio = NP/AP

Metals by Aqua regia digest with ICP-OES/MS finish, Method ICP21B20/ICM21B20
Metals by multi-acid digest with ICP-OES/MS finish, Method ICP40Q12/IMS40Q12
Tessier Sequential Extraction - method available on request

Preliminary Data

Noelene Ahern - Manager: ARD

Final Data Approval

Noelene Ahern - Manager: ARD

Tessier Extraction

Water Soluble Metals
Reagent: 15 mL of Nanopure Distilled Water

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Sample weight (g)			1.0842	1.0847	1.0730	1.0794	1.0792
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	42.2	15.1	20.9	21.2	25.6
Aluminum Al	mg/L	0.001	0.28	0.248	0.313	0.287	1.21
Antimony Sb	mg/L	0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	0.0029
Arsenic As	mg/L	0.0002	0.0021	0.0013	0.0004	0.0012	0.0075
Barium Ba	mg/L	0.00008	0.0353	0.00427	0.00552	0.00621	0.0386
Beryllium Be	mg/L	0.000007	0.000066	0.00001	0.000019	0.000012	0.000194
Bismuth Bi	mg/L	0.00001	0.00001	< 0.00001	< 0.00001	0.00001	0.00006
Boron B	mg/L	0.002	0.025	0.016	0.009	0.014	0.036
Cadmium Cd	mg/L	0.000003	0.000126	0.000007	0.000004	0.00001	0.00003
Calcium Ca	mg/L	0.01	13.3	4.76	4.86	6.41	8.55
Chromium Cr	mg/L	0.00008	0.00098	0.00097	0.00108	0.00102	0.00272
Cobalt Co	mg/L	0.000004	0.00251	0.000184	0.000162	0.000138	0.00033
Copper Cu	mg/L	0.001	0.001	< 0.001	< 0.001	0.018	0.003
Iron Fe	mg/L	0.007	4.15	0.813	0.346	0.575	0.551
Lead Pb	mg/L	0.00009	0.00063	0.00037	0.00048	0.00038	0.00168
Lithium Li	mg/L	0.0001	0.0116	0.0007	0.0034	0.0011	0.0051
Magnesium Mg	mg/L	0.001	2.19	0.783	2.14	1.27	1.03
Manganese Mn	mg/L	0.00001	0.288	0.0303	0.00383	0.0228	0.00318
Mercury Hg	ug/L	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	< 0.0004	0.0023	0.0032	0.0011	0.0319
Nickel Ni	mg/L	0.0001	0.0105	0.0003	0.0006	0.0003	0.001
Phosphorus P	mg/L	0.003	0.024	0.028	0.018	0.026	0.071
Potassium K	mg/L	0.009	0.731	0.842	1.3	1.48	0.487
Selenium Se	mg/L	0.00004	0.00424	0.00012	0.00021	0.00013	0.0337
Silicon Si	mg/L	0.02	0.71	1.1	1.33	1.57	1.26
Silver Ag	mg/L	0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Sodium Na	mg/L	0.01	0.77	0.72	0.88	0.88	1.34
Strontium Sr	mg/L	0.00008	0.14	0.0218	0.0638	0.0253	0.319
Sulphur (S)	mg/L	5	17	< 5	< 5	< 5	< 5
Thallium Tl	mg/L	0.000005	0.000881	0.00001	0.00001	0.000007	0.000163
Tin Sn	mg/L	0.00006	0.0002	0.00018	0.00021	0.00029	0.0004
Titanium Ti	mg/L	0.0001	0.0198	0.0061	0.0075	0.0059	0.0496
Uranium U	mg/L	0.000002	0.000174	0.000047	0.000154	0.000089	0.000443
Vanadium V	mg/L	0.00001	0.00135	0.0012	0.00096	0.00138	0.00953
Zinc Zn	mg/L	0.002	0.004	< 0.002	< 0.002	< 0.002	0.002
Zirconium Zr	mg/L	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Tessier Extraction

Water Soluble Metals
Reagent: 15 mL of Nanopure Distilled Water

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'	B-6 6"-18"
Sample weight (g)			1.0775	1.0918	1.0821	1.0833	1.0774	1.0814
Reagent volume (mL)			15	15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50	50
Parameter	**Units**	**RDL**						
Hardness CaCO3	mg/L	0.05	15.2	21.8	23.2	15.5	19.1	31.9
Aluminum Al	mg/L	0.001	0.367	1.2	0.509	0.434	0.076	1.11
Antimony Sb	mg/L	0.0009	< 0.0009	< 0.0009	0.0013	< 0.0009	< 0.0009	< 0.0009
Arsenic As	mg/L	0.0002	0.0018	0.0048	0.008	0.0019	0.0017	0.0031
Barium Ba	mg/L	0.00008	0.00643	0.0216	0.0141	0.00843	0.00199	0.0325
Beryllium Be	mg/L	0.000007	0.000015	0.000242	0.000067	0.000011	< 0.000007	0.000165
Bismuth Bi	mg/L	0.00001	0.00001	0.00004	0.00001	< 0.00001	< 0.00001	0.00004
Boron B	mg/L	0.002	0.018	0.019	0.019	0.02	0.01	0.048
Cadmium Cd	mg/L	0.000003	0.000016	0.000035	0.000018	0.000012	0.000003	0.000051
Calcium Ca	mg/L	0.01	4.38	6.7	7.16	4.46	4.79	9.96
Chromium Cr	mg/L	0.00008	0.0012	0.00276	0.00138	0.0011	0.00078	0.00263
Cobalt Co	mg/L	0.000004	0.000224	0.000715	0.000148	0.000274	0.000057	0.000466
Copper Cu	mg/L	0.001	< 0.001	0.005	< 0.001	< 0.001	< 0.001	0.003
Iron Fe	mg/L	0.007	0.641	1.09	0.336	0.518	0.147	2.05
Lead Pb	mg/L	0.00009	0.00097	0.00161	0.00061	0.0006	0.00026	0.00285
Lithium Li	mg/L	0.0001	0.001	0.0048	0.0032	0.0012	0.001	0.0078
Magnesium Mg	mg/L	0.001	1.02	1.22	1.3	1.06	1.74	1.69
Manganese Mn	mg/L	0.00001	0.0122	0.0114	0.00868	0.0115	0.0137	0.0188
Mercury Hg	ug/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.0018	0.0042	0.0142	0.0012	0.0025	0.004
Nickel Ni	mg/L	0.0001	0.0005	0.0027	0.0006	0.0005	0.0001	0.0015
Phosphorus P	mg/L	0.003	0.032	0.067	0.032	0.033	0.017	0.051
Potassium K	mg/L	0.009	1.07	0.514	0.715	1.95	1.21	0.995
Selenium Se	mg/L	0.00004	0.00042	0.0015	0.00822	0.00015	0.00007	0.00119
Silicon Si	mg/L	0.02	1.38	1.36	0.72	2.04	1.33	1.69
Silver Ag	mg/L	0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Sodium Na	mg/L	0.01	0.74	0.51	0.76	1.16	1.05	2.78
Strontium Sr	mg/L	0.00008	0.0433	0.0588	0.0495	0.016	0.0109	0.0664
Sulphur (S)	mg/L	5	< 5	< 5	< 5	< 5	< 5	< 5
Thallium Tl	mg/L	0.000005	0.000009	0.000192	0.000072	0.00001	< 0.000005	0.000181
Tin Sn	mg/L	0.00006	0.00022	0.00038	0.00022	0.0003	0.00019	0.00032
Titanium Ti	mg/L	0.0001	0.0077	0.0572	0.0195	0.0086	0.0013	0.0507
Uranium U	mg/L	0.000002	0.000111	0.000421	0.000569	0.00013	0.000032	0.00054
Vanadium V	mg/L	0.00001	0.00245	0.00484	0.00612	0.00319	0.00216	0.00458
Zinc Zn	mg/L	0.002	0.003	0.004	< 0.002	0.002	< 0.002	0.006
Zirconium Zr	mg/L	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Tessier Extraction

Water Soluble Metals Reagent: 15 mL of Nanopure Distilled Water				
Sample			**B-6 5'-7'**	**Blank**
Sample weight (g)			1.0907	0
Reagent volume (mL)			15	15
Final diluted solution volume after wash and preservation (mL)			50	50
Parameter	**Units**	**RDL**		
Hardness CaCO3	mg/L	0.05	21.2	0.87
Aluminum Al	mg/L	0.001	0.07	0.002
Antimony Sb	mg/L	0.0009	< 0.0009	< 0.0009
Arsenic As	mg/L	0.0002	0.0003	0.0005
Barium Ba	mg/L	0.00008	0.00107	0.00024
Beryllium Be	mg/L	0.000007	< 0.000007	< 0.000007
Bismuth Bi	mg/L	0.00001	< 0.00001	< 0.00001
Boron B	mg/L	0.002	0.019	< 0.002
Cadmium Cd	mg/L	0.000003	0.000004	< 0.000003
Calcium Ca	mg/L	0.01	6.49	0.33
Chromium Cr	mg/L	0.00008	0.00061	0.0006
Cobalt Co	mg/L	0.000004	0.000043	< 0.000004
Copper Cu	mg/L	0.001	< 0.001	< 0.001
Iron Fe	mg/L	0.007	0.158	< 0.007
Lead Pb	mg/L	0.00009	0.00033	0.00059
Lithium Li	mg/L	0.0001	0.0017	< 0.0001
Magnesium Mg	mg/L	0.001	1.21	0.011
Manganese Mn	mg/L	0.00001	0.0108	0.00014
Mercury Hg	ug/L	0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.0011	< 0.0004
Nickel Ni	mg/L	0.0001	0.0001	< 0.0001
Phosphorus P	mg/L	0.003	0.016	0.014
Potassium K	mg/L	0.009	0.905	< 0.009
Selenium Se	mg/L	0.00004	0.00037	< 0.00004
Silicon Si	mg/L	0.02	0.82	< 0.02
Silver Ag	mg/L	0.00005	< 0.00005	< 0.00005
Sodium Na	mg/L	0.01	1.62	< 0.01
Strontium Sr	mg/L	0.00008	0.0295	0.00017
Sulphur (S)	mg/L	5	< 5	< 5
Thallium Tl	mg/L	0.000005	< 0.000005	< 0.000005
Tin Sn	mg/L	0.00006	0.00019	0.00017
Titanium Ti	mg/L	0.0001	0.0015	< 0.0001
Uranium U	mg/L	0.000002	0.00009	< 0.000002
Vanadium V	mg/L	0.00001	0.00025	< 0.00001
Zinc Zn	mg/L	0.002	< 0.002	0.003
Zirconium Zr	mg/L	0.002	< 0.002	< 0.002

Tessier Extraction

Water Soluble Metals
Reagent: 15 mL of Nanopure Distilled Water

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Concentration leached relative to initial sample mass (no correction for blank is included)							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		12.9	11.4	14.6	13.3	56.1
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	0.1
Arsenic As	mg/kg		0.1	0.1	0.0	0.1	0.3
Barium Ba	mg/kg		1.6	0.2	0.3	0.3	1.8
Beryllium Be	mg/kg		0.00	0.00	0.00	0.00	0.01
Bismuth Bi	mg/kg		0.00	<DL	<DL	0.00	0.00
Boron B	mg/kg		1.2	0.7	0.4	0.6	1.7
Cadmium Cd	mg/kg		0.01	0.00	0.00	0.00	0.00
Calcium Ca	mg/kg		613.4	219.4	226.5	296.9	396.1
Chromium Cr	mg/kg		0.05	0.04	0.05	0.05	0.13
Cobalt Co	mg/kg		0.12	0.01	0.01	0.01	0.02
Copper Cu	mg/kg		0.05	<DL	<DL	0.83	0.14
Iron Fe	mg/kg		191.4	37.5	16.1	26.6	25.5
Lead Pb	mg/kg		0.03	0.02	0.02	0.02	0.08
Lithium Li	mg/kg		0.53	0.03	0.16	0.05	0.24
Magnesium Mg	mg/kg		101.0	36.1	99.7	58.8	47.7
Manganese Mn	mg/kg		13.3	1.4	0.2	1.1	0.1
Mercury Hg	ug/kg		0.5	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		<DL	0.1	0.1	0.1	1.5
Nickel Ni	mg/kg		0.5	0.0	0.0	0.0	0.0
Phosphorus P	mg/kg		1.1	1.3	0.8	1.2	3.3
Potassium K	mg/kg		33.7	38.8	60.6	68.6	22.6
Selenium Se	mg/kg		0.2	0.0	0.0	0.0	1.6
Silicon Si	mg/kg		32.7	50.7	62.0	72.7	58.4
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		35.5	33.2	41.0	40.8	62.1
Strontium Sr	mg/kg		6.5	1.0	3.0	1.2	14.8
Sulphur (S)	mg/kg		784.0	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.04	0.00	0.00	0.00	0.01
Tin Sn	mg/kg		0.01	0.01	0.01	0.01	0.02
Titanium Ti	mg/kg		0.91	0.28	0.35	0.27	2.30
Uranium U	mg/kg		0.01	0.00	0.01	0.00	0.02
Vanadium V	mg/kg		0.06	0.06	0.04	0.06	0.44
Zinc Zn	mg/kg		0.18	<DL	<DL	<DL	0.09
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Water Soluble Metals
Reagent: 15 mL of Nanopure Distilled Water

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'	B-6 6"-18"
Concentration leached relative to initial sample m								
Parameter	**Units**	**RDL**						
Aluminum Al	mg/kg		17.0	55.0	23.5	20.0	3.5	51.3
Antimony Sb	mg/kg		<DL	<DL	0.1	<DL	<DL	<DL
Arsenic As	mg/kg		0.1	0.2	0.4	0.1	0.1	0.1
Barium Ba	mg/kg		0.3	1.0	0.7	0.4	0.1	1.5
Beryllium Be	mg/kg		0.00	0.01	0.00	0.00	<DL	0.01
Bismuth Bi	mg/kg		0.00	0.00	0.00	<DL	<DL	0.00
Boron B	mg/kg		0.8	0.9	0.9	0.9	0.5	2.2
Cadmium Cd	mg/kg		0.00	0.00	0.00	0.00	0.00	0.00
Calcium Ca	mg/kg		203.2	306.8	330.8	205.9	222.3	460.5
Chromium Cr	mg/kg		0.06	0.13	0.06	0.05	0.04	0.12
Cobalt Co	mg/kg		0.01	0.03	0.01	0.01	0.00	0.02
Copper Cu	mg/kg		<DL	0.23	<DL	<DL	<DL	0.14
Iron Fe	mg/kg		29.7	49.9	15.5	23.9	6.8	94.8
Lead Pb	mg/kg		0.05	0.07	0.03	0.03	0.01	0.13
Lithium Li	mg/kg		0.05	0.22	0.15	0.06	0.05	0.36
Magnesium Mg	mg/kg		47.3	55.9	60.1	48.9	80.7	78.1
Manganese Mn	mg/kg		0.6	0.5	0.4	0.5	0.6	0.9
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		0.1	0.2	0.7	0.1	0.1	0.2
Nickel Ni	mg/kg		0.0	0.1	0.0	0.0	0.0	0.1
Phosphorus P	mg/kg		1.5	3.1	1.5	1.5	0.8	2.4
Potassium K	mg/kg		49.7	23.5	33.0	90.0	56.2	46.0
Selenium Se	mg/kg		0.0	0.1	0.4	0.0	0.0	0.1
Silicon Si	mg/kg		64.0	62.3	33.3	94.2	61.7	78.1
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		34.3	23.4	35.1	53.5	48.7	128.5
Strontium Sr	mg/kg		2.0	2.7	2.3	0.7	0.5	3.1
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.00	0.01	0.00	0.00	<DL	0.01
Tin Sn	mg/kg		0.01	0.02	0.01	0.01	0.01	0.01
Titanium Ti	mg/kg		0.36	2.62	0.90	0.40	0.06	2.34
Uranium U	mg/kg		0.01	0.02	0.03	0.01	0.00	0.02
Vanadium V	mg/kg		0.11	0.22	0.28	0.15	0.10	0.21
Zinc Zn	mg/kg		0.14	0.18	<DL	0.09	<DL	0.28
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Water Soluble Metals				
Reagent: 15 mL of Nanopure Distilled Water				
Sample			**B-6 5'-7'**	**Blank**
Concentration leached relative to initial sample m				
Parameter	**Units**	**RDL**		
Aluminum Al	mg/kg		3.2	
Antimony Sb	mg/kg		<DL	
Arsenic As	mg/kg		0.0	
Barium Ba	mg/kg		0.0	
Beryllium Be	mg/kg		<DL	
Bismuth Bi	mg/kg		<DL	
Boron B	mg/kg		0.9	
Cadmium Cd	mg/kg		0.00	
Calcium Ca	mg/kg		297.5	
Chromium Cr	mg/kg		0.03	
Cobalt Co	mg/kg		0.00	
Copper Cu	mg/kg		<DL	
Iron Fe	mg/kg		7.2	
Lead Pb	mg/kg		0.02	
Lithium Li	mg/kg		0.08	
Magnesium Mg	mg/kg		55.5	
Manganese Mn	mg/kg		0.5	
Mercury Hg	ug/kg		<DL	
Molybdenum Mo	mg/kg		0.1	
Nickel Ni	mg/kg		0.0	
Phosphorus P	mg/kg		0.7	
Potassium K	mg/kg		41.5	
Selenium Se	mg/kg		0.0	
Silicon Si	mg/kg		37.6	
Silver Ag	mg/kg		<DL	
Sodium Na	mg/kg		74.3	
Strontium Sr	mg/kg		1.4	
Sulphur (S)	mg/kg		<DL	
Thallium Tl	mg/kg		<DL	
Tin Sn	mg/kg		0.01	
Titanium Ti	mg/kg		0.07	
Uranium U	mg/kg		0.00	
Vanadium V	mg/kg		0.01	
Zinc Zn	mg/kg		<DL	
Zirconium Zr	mg/kg		<DL	

Tessier Extraction

Exchangeable Metals
Reagent: 15 mL of 1 M MgCl2 (pH 7)

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Initial sample weight (g)			1.0842	1.0847	1.0730	1.0794	1.0792
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	30700	30200	30500	30500	30300
Aluminum Al	mg/L	0.001	0.38	0.07	0.17	0.09	0.66
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.004	0.003	0.003	0.003	0.017
Barium Ba	mg/L	0.00008	0.647	0.0345	0.328	0.0632	0.461
Beryllium Be	mg/L	0.000007	0.00017	< 0.00007	< 0.00007	< 0.00007	0.00011
Bismuth Bi	mg/L	0.00001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Boron B	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	0.02
Cadmium Cd	mg/L	0.000003	0.00027	0.00007	0.00017	0.00009	0.0004
Calcium Ca	mg/L	0.01	1.9	10.7	45.2	46.4	36.4
Chromium Cr	mg/L	0.00008	0.0037	0.0031	0.0036	0.0032	0.0042
Cobalt Co	mg/L	0.000004	0.00339	0.00079	0.00053	0.00031	0.00124
Copper Cu	mg/L	0.001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron Fe	mg/L	0.007	4.39	0.14	0.15	0.17	0.21
Lead Pb	mg/L	0.00009	0.0017	0.0011	< 0.0009	< 0.0009	< 0.0009
Lithium Li	mg/L	0.0001	0.006	0.004	0.006	0.004	0.017
Magnesium Mg	mg/L	0.001	7460	7340	7380	7390	7330
Manganese Mn	mg/L	0.00001	0.213	0.177	0.187	0.126	0.043
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	< 0.004	< 0.004	0.008
Nickel Ni	mg/L	0.0001	0.015	0.002	0.004	0.002	0.007
Phosphorus P	mg/L	0.003	< 0.03	< 0.03	< 0.03	0.03	0.34
Potassium K	mg/L	0.009	0.69	0.55	2.04	0.92	0.67
Selenium Se	mg/L	0.00004	0.0047	< 0.0004	0.0004	< 0.0004	0.0769
Silicon Si	mg/L	0.02	1.2	0.4	1	0.9	1.2
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	1.2	0.9	0.8	0.9	1
Strontium Sr	mg/L	0.00008	0.0561	0.041	0.365	0.0949	1.59
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00349	< 0.00005	0.00007	< 0.00005	0.00065
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.022	0.0018	0.0046	0.0018	0.0209
Uranium U	mg/L	0.000002	0.00017	0.00006	0.00167	0.00017	0.00193
Vanadium V	mg/L	0.00001	0.0019	0.0013	0.0021	0.002	0.0165
Zinc Zn	mg/L	0.002	< 0.02	0.02	< 0.02	< 0.02	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Tessier Extraction

Exchangeable Metals
Reagent: 15 mL of 1 M MgCl2 (pH 7)

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Initial sample weight (g)			1.0775	1.0918	1.0821	1.0833	1.0774
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	30300	31000	30400	30500	31000
Aluminum Al	mg/L	0.001	0.08	0.66	0.34	0.09	0.11
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	< 0.002	0.004	0.004	< 0.002	0.004
Barium Ba	mg/L	0.00008	0.0402	0.158	0.189	0.0494	0.052
Beryllium Be	mg/L	0.000007	< 0.00007	0.00015	< 0.00007	< 0.00007	< 0.00007
Bismuth Bi	mg/L	0.00001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Boron B	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cadmium Cd	mg/L	0.000003	0.00014	0.00036	0.00034	0.00007	< 0.00003
Calcium Ca	mg/L	0.01	10	15.6	34.4	15.2	71
Chromium Cr	mg/L	0.00008	0.0043	0.0047	0.0037	0.0036	0.0036
Cobalt Co	mg/L	0.000004	0.00095	0.00154	0.00096	0.00118	0.00039
Copper Cu	mg/L	0.001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron Fe	mg/L	0.007	0.11	0.6	0.12	0.12	0.22
Lead Pb	mg/L	0.00009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Lithium Li	mg/L	0.0001	0.003	0.007	0.008	0.003	0.003
Magnesium Mg	mg/L	0.001	7360	7530	7370	7400	7480
Manganese Mn	mg/L	0.00001	0.153	0.0839	0.198	0.244	0.18
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	0.005	< 0.004	< 0.004
Nickel Ni	mg/L	0.0001	0.004	0.01	0.004	0.004	0.001
Phosphorus P	mg/L	0.003	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Potassium K	mg/L	0.009	0.63	0.48	0.68	1.24	0.9
Selenium Se	mg/L	0.00004	< 0.0004	0.0014	0.0052	< 0.0004	< 0.0004
Silicon Si	mg/L	0.02	0.4	1.1	0.6	0.5	1.3
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	0.7	0.6	0.7	0.8	1.9
Strontium Sr	mg/L	0.00008	0.0815	0.088	0.184	0.0483	0.123
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	< 0.00005	0.00044	0.00028	< 0.00005	< 0.00005
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	< 0.001	0.0324	0.0074	0.0014	0.0034
Uranium U	mg/L	0.000002	0.00012	0.00056	0.00119	0.00015	0.0003
Vanadium V	mg/L	0.00001	0.0014	0.0034	0.0028	0.0014	0.0028
Zinc Zn	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Tessier Extraction

Exchangeable Metals Reagent: 15 mL of 1 M MgCl2 (pH 7)					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Initial sample weight (g)			1.0814	1.0907	0.0000
Reagent volume (mL)			15	15	15.00
Final diluted solution volume after wash and preservation (mL)			50	50	50
Parameter	**Units**	**RDL**			
Hardness CaCO3	mg/L	0.05	30200	30300	31200
Aluminum Al	mg/L	0.001	0.52	0.06	< 0.01
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.002	0.002	0.002
Barium Ba	mg/L	0.00008	0.185	0.011	0.0012
Beryllium Be	mg/L	0.000007	0.00007	< 0.00007	< 0.00007
Bismuth Bi	mg/L	0.00001	< 0.0001	< 0.0001	< 0.0001
Boron B	mg/L	0.002	< 0.02	< 0.02	< 0.02
Cadmium Cd	mg/L	0.000003	0.0003	0.00004	< 0.00003
Calcium Ca	mg/L	0.01	49.9	54.7	0.5
Chromium Cr	mg/L	0.00008	0.0036	0.0035	0.0031
Cobalt Co	mg/L	0.000004	0.0005	0.00023	0.00008
Copper Cu	mg/L	0.001	< 0.01	< 0.01	< 0.01
Iron Fe	mg/L	0.007	0.7	0.17	< 0.07
Lead Pb	mg/L	0.00009	< 0.0009	< 0.0009	0.0012
Lithium Li	mg/L	0.0001	0.012	0.003	0.004
Magnesium Mg	mg/L	0.001	7300	7330	7560
Manganese Mn	mg/L	0.00001	0.0915	0.168	0.0024
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	< 0.004
Nickel Ni	mg/L	0.0001	0.002	0.002	0.004
Phosphorus P	mg/L	0.003	< 0.03	< 0.03	< 0.03
Potassium K	mg/L	0.009	0.95	0.69	0.17
Selenium Se	mg/L	0.00004	0.001	0.0006	< 0.0004
Silicon Si	mg/L	0.02	1.4	0.8	< 0.2
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	1	0.7	0.5
Strontium Sr	mg/L	0.00008	0.27	0.105	< 0.0008
Sulphur (S)	mg/L	5	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00013	< 0.00005	< 0.00005
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.0273	0.0022	< 0.001
Uranium U	mg/L	0.000002	0.00107	0.00102	< 0.00002
Vanadium V	mg/L	0.00001	0.0026	0.0015	0.0011
Zinc Zn	mg/L	0.002	< 0.02	< 0.02	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02

Tessier Extraction

Exchangeable Metals
Reagent: 15 mL of 1 M MgCl2 (pH 7)

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Concentration leached relative to initial sample mass (no correction for blank is included)							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		17.5	3.2	7.9	4.2	30.6
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		0.2	0.1	0.1	0.1	0.8
Barium Ba	mg/kg		29.8	1.6	15.3	2.9	21.4
Beryllium Be	mg/kg		0.01	<DL	<DL	<DL	0.01
Bismuth Bi	mg/kg		<DL	<DL	<DL	<DL	<DL
Boron B	mg/kg		<DL	<DL	<DL	<DL	0.9
Cadmium Cd	mg/kg		0.01	0.00	0.01	0.00	0.02
Calcium Ca	mg/kg		87.6	493.2	2106.2	2149.3	1686.4
Chromium Cr	mg/kg		0.2	0.1	0.2	0.1	0.2
Cobalt Co	mg/kg		0.2	0.0	0.0	0.0	0.1
Copper Cu	mg/kg		<DL	<DL	<DL	<DL	<DL
Iron Fe	mg/kg		202.5	6.5	7.0	7.9	9.7
Lead Pb	mg/kg		0.1	0.1	<DL	<DL	<DL
Lithium Li	mg/kg		0.3	0.2	0.3	0.2	0.8
Magnesium Mg	mg/kg		NA	NA	NA	NA	NA
Manganese Mn	mg/kg		9.8	8.2	8.7	5.8	2.0
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		<DL	<DL	<DL	<DL	0.4
Nickel Ni	mg/kg		0.7	0.1	0.2	0.1	0.3
Phosphorus P	mg/kg		<DL	<DL	<DL	1.4	15.8
Potassium K	mg/kg		31.8	25.4	95.1	42.6	31.0
Selenium Se	mg/kg		0.2	<DL	0.0	<DL	3.6
Silicon Si	mg/kg		55.3	18.4	46.6	41.7	55.6
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		55.3	41.5	37.3	41.7	46.3
Strontium Sr	mg/kg		2.6	1.9	17.0	4.4	73.7
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.2	<DL	0.0	<DL	0.0
Tin Sn	mg/kg		<DL	<DL	<DL	<DL	<DL
Titanium Ti	mg/kg		1.0	0.1	0.2	0.1	1.0
Uranium U	mg/kg		0.01	0.00	0.08	0.01	0.09
Vanadium V	mg/kg		0.1	0.1	0.1	0.1	0.8
Zinc Zn	mg/kg		<DL	0.9	<DL	<DL	<DL
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Exchangeable Metals
Reagent: 15 mL of 1 M MgCl2 (pH 7)

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Concentration leached relative to initial sample m							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		3.7	30.2	15.7	4.2	5.1
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		<DL	0.2	0.2	<DL	0.2
Barium Ba	mg/kg		1.9	7.2	8.7	2.3	2.4
Beryllium Be	mg/kg		<DL	0.01	<DL	<DL	<DL
Bismuth Bi	mg/kg		<DL	<DL	<DL	<DL	<DL
Boron B	mg/kg		<DL	<DL	<DL	<DL	<DL
Cadmium Cd	mg/kg		0.01	0.02	0.02	0.00	<DL
Calcium Ca	mg/kg		464.0	714.4	1589.5	701.6	3295.0
Chromium Cr	mg/kg		0.2	0.2	0.2	0.2	0.2
Cobalt Co	mg/kg		0.0	0.1	0.0	0.1	0.0
Copper Cu	mg/kg		<DL	<DL	<DL	<DL	<DL
Iron Fe	mg/kg		5.1	27.5	5.5	5.5	10.2
Lead Pb	mg/kg		<DL	<DL	<DL	<DL	<DL
Lithium Li	mg/kg		0.1	0.3	0.4	0.1	0.1
Magnesium Mg	mg/kg		NA	NA	NA	NA	NA
Manganese Mn	mg/kg		7.1	3.8	9.1	11.3	8.4
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		<DL	<DL	0.2	<DL	<DL
Nickel Ni	mg/kg		0.2	0.5	0.2	0.2	0.0
Phosphorus P	mg/kg		<DL	<DL	<DL	<DL	<DL
Potassium K	mg/kg		29.2	22.0	31.4	57.2	41.8
Selenium Se	mg/kg		<DL	0.1	0.2	<DL	<DL
Silicon Si	mg/kg		18.6	50.4	27.7	23.1	60.3
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		32.5	27.5	32.3	36.9	88.2
Strontium Sr	mg/kg		3.8	4.0	8.5	2.2	5.7
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		<DL	0.0	0.0	<DL	<DL
Tin Sn	mg/kg		<DL	<DL	<DL	<DL	<DL
Titanium Ti	mg/kg		<DL	1.5	0.3	0.1	0.2
Uranium U	mg/kg		0.01	0.03	0.05	0.01	0.01
Vanadium V	mg/kg		0.1	0.2	0.1	0.1	0.1
Zinc Zn	mg/kg		<DL	<DL	<DL	<DL	<DL
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Exchangeable Metals
Reagent: 15 mL of 1 M MgCl2 (pH 7)

Sample			B-6 6"-18"	B-6 5'-7'	Blank
Concentration leached relative to initial sample m					
Parameter	**Units**	**RDL**			
Aluminum Al	mg/kg		24.0	2.8	
Antimony Sb	mg/kg		<DL	<DL	
Arsenic As	mg/kg		0.1	0.1	
Barium Ba	mg/kg		8.6	0.5	
Beryllium Be	mg/kg		0.00	<DL	
Bismuth Bi	mg/kg		<DL	<DL	
Boron B	mg/kg		<DL	<DL	
Cadmium Cd	mg/kg		0.01	0.00	
Calcium Ca	mg/kg		2307.2	2507.6	
Chromium Cr	mg/kg		0.2	0.2	
Cobalt Co	mg/kg		0.0	0.0	
Copper Cu	mg/kg		<DL	<DL	
Iron Fe	mg/kg		32.4	7.8	
Lead Pb	mg/kg		<DL	<DL	
Lithium Li	mg/kg		0.6	0.1	
Magnesium Mg	mg/kg		NA	NA	
Manganese Mn	mg/kg		4.2	7.7	
Mercury Hg	ug/kg		<DL	<DL	
Molybdenum Mo	mg/kg		<DL	<DL	
Nickel Ni	mg/kg		0.1	0.1	
Phosphorus P	mg/kg		<DL	<DL	
Potassium K	mg/kg		43.9	31.6	
Selenium Se	mg/kg		0.0	0.0	
Silicon Si	mg/kg		64.7	36.7	
Silver Ag	mg/kg		<DL	<DL	
Sodium Na	mg/kg		46.2	32.1	
Strontium Sr	mg/kg		12.5	4.8	
Sulphur (S)	mg/kg		<DL	<DL	
Thallium Tl	mg/kg		0.0	<DL	
Tin Sn	mg/kg		<DL	<DL	
Titanium Ti	mg/kg		1.3	0.1	
Uranium U	mg/kg		0.05	0.05	
Vanadium V	mg/kg		0.1	0.1	
Zinc Zn	mg/kg		<DL	<DL	
Zirconium Zr	mg/kg		<DL	<DL	

Tessier Extraction

Metals Bound to Carbonates

Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Initial sample weight (g)			1.0842	1.0847	1.0730	1.0794	1.0792
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	117	309	4700	608	382
Aluminum Al	mg/L	0.001	3.25	1.52	2.36	3.24	43.1
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	0.01
Arsenic As	mg/L	0.0002	0.007	0.013	0.004	0.016	0.134
Barium Ba	mg/L	0.00008	0.132	0.0521	0.352	0.139	2
Beryllium Be	mg/L	0.000007	0.00101	0.00026	0.00086	0.00041	0.0136
Bismuth Bi	mg/L	0.00001	0.0003	0.0003	0.0005	0.0004	0.0024
Boron B	mg/L	0.002	< 0.02	0.03	0.03	0.03	0.1
Cadmium Cd	mg/L	0.000003	0.0004	0.00017	0.00102	0.00031	0.00091
Calcium Ca	mg/L	0.01	1.5	49	1330	125	71
Chromium Cr	mg/L	0.00008	0.0173	0.0175	0.0184	0.0413	0.141
Cobalt Co	mg/L	0.000004	0.00512	0.00584	0.0214	0.00957	0.0181
Copper Cu	mg/L	0.001	< 0.01	< 0.01	0.03	< 0.01	0.11
Iron Fe	mg/L	0.007	21.6	36.5	11	74.6	20
Lead Pb	mg/L	0.00009	0.0055	0.0067	0.0241	0.0106	0.0575
Lithium Li	mg/L	0.0001	0.003	0.002	0.009	0.003	0.036
Magnesium Mg	mg/L	0.001	27.4	45.4	333	72.1	49.8
Manganese Mn	mg/L	0.00001	0.0802	1.44	3.15	3.1	0.218
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	< 0.004	< 0.004	0.005
Nickel Ni	mg/L	0.0001	0.016	0.016	0.026	0.032	0.043
Phosphorus P	mg/L	0.003	0.03	0.15	0.13	0.25	1.49
Potassium K	mg/L	0.009	1.33	1.41	2.79	2.3	2.98
Selenium Se	mg/L	0.00004	0.0066	< 0.0004	< 0.0004	< 0.0004	0.0881
Silicon Si	mg/L	0.02	4.1	2.7	4.1	6.2	41.7
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	6820	6610	6440	6810	6440
Strontium Sr	mg/L	0.00008	0.0231	0.0271	1.02	0.0937	2.98
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00382	< 0.00005	0.00006	0.00005	0.00498
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	0.0016
Titanium Ti	mg/L	0.0001	0.0435	0.009	0.0078	0.0182	0.3
Uranium U	mg/L	0.000002	0.00576	0.00033	0.00486	0.00059	0.0204
Vanadium V	mg/L	0.00001	0.0018	0.0162	0.0162	0.0228	0.108
Zinc Zn	mg/L	0.002	0.02	0.17	0.03	0.06	0.18
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Carbonates

Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Initial sample weight (g)			1.0775	1.0918	1.0821	1.0833	1.0774
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	407	352	763	407	2550
Aluminum Al	mg/L	0.001	1.46	3.66	5.13	2.7	2.42
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.009	0.029	0.13	0.009	0.024
Barium Ba	mg/L	0.00008	0.0532	0.201	0.368	0.103	0.164
Beryllium Be	mg/L	0.000007	0.0003	0.00273	0.00394	0.00037	0.0004
Bismuth Bi	mg/L	0.00001	0.0003	0.0005	0.0008	0.0002	0.0003
Boron B	mg/L	0.002	0.03	0.04	0.05	0.04	< 0.02
Cadmium Cd	mg/L	0.000003	0.0004	0.00068	0.00146	0.00034	0.00017
Calcium Ca	mg/L	0.01	65.2	68.4	183	60.2	849
Chromium Cr	mg/L	0.00008	0.0205	0.0252	0.0565	0.0481	0.0364
Cobalt Co	mg/L	0.000004	0.00434	0.0101	0.00809	0.00857	0.0108
Copper Cu	mg/L	0.001	< 0.01	0.07	0.02	< 0.01	< 0.01
Iron Fe	mg/L	0.007	24	8.44	24	75.8	67
Lead Pb	mg/L	0.00009	0.0117	0.0161	0.0232	0.0118	0.0081
Lithium Li	mg/L	0.0001	0.002	0.005	0.006	0.002	0.004
Magnesium Mg	mg/L	0.001	59.2	44.1	74.6	62.4	104
Manganese Mn	mg/L	0.00001	0.491	0.274	1.44	1.11	7.8
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	< 0.004	< 0.004	0.005
Nickel Ni	mg/L	0.0001	0.016	0.038	0.035	0.036	0.03
Phosphorus P	mg/L	0.003	0.12	0.34	0.37	0.17	0.2
Potassium K	mg/L	0.009	1.55	1.31	2.02	2.86	2.07
Selenium Se	mg/L	0.00004	< 0.0004	0.0019	0.0076	< 0.0004	< 0.0004
Silicon Si	mg/L	0.02	2.4	4.1	6.3	5.8	5.5
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	6680	6580	6720	6640	6010
Strontium Sr	mg/L	0.00008	0.0354	0.0846	0.202	0.0314	0.57
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00005	0.00119	0.00224	0.00005	< 0.00005
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.0058	0.0628	0.0762	0.0094	0.008
Uranium U	mg/L	0.000002	0.00077	0.00221	0.00535	0.00069	0.00134
Vanadium V	mg/L	0.00001	0.0116	0.0117	0.0591	0.0209	0.024
Zinc Zn	mg/L	0.002	0.07	0.06	0.07	0.08	0.04
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Carbonates					
Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Initial sample weight (g)			1.0814	1.0907	0.0000
Reagent volume (mL)			15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50
Parameter	**Units**	**RDL**			
Hardness CaCO3	mg/L	0.05	1600	3230	2.1
Aluminum Al	mg/L	0.001	6.72	1.55	< 0.01
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.012	0.003	< 0.002
Barium Ba	mg/L	0.00008	0.494	0.103	0.0012
Beryllium Be	mg/L	0.000007	0.00226	0.0005	< 0.00007
Bismuth Bi	mg/L	0.00001	0.0008	0.0002	< 0.0001
Boron B	mg/L	0.002	0.07	0.03	< 0.02
Cadmium Cd	mg/L	0.000003	0.0008	0.00024	< 0.00003
Calcium Ca	mg/L	0.01	498	1140	0.6
Chromium Cr	mg/L	0.00008	0.0364	0.0212	0.0013
Cobalt Co	mg/L	0.000004	0.0116	0.00973	0.00004
Copper Cu	mg/L	0.001	0.02	< 0.01	< 0.01
Iron Fe	mg/L	0.007	33.1	24.8	< 0.07
Lead Pb	mg/L	0.00009	0.0221	0.0122	< 0.0009
Lithium Li	mg/L	0.0001	0.014	0.003	< 0.001
Magnesium Mg	mg/L	0.001	86.3	91.8	0.17
Manganese Mn	mg/L	0.00001	0.997	5.97	0.0012
Mercury Hg	ug/L	0.01	< 0.1	< 0.1	< 0.1
Molybdenum Mo	mg/L	0.0004	< 0.004	< 0.004	< 0.004
Nickel Ni	mg/L	0.0001	0.032	0.019	< 0.001
Phosphorus P	mg/L	0.003	0.27	0.12	0.04
Potassium K	mg/L	0.009	2.41	1.63	0.76
Selenium Se	mg/L	0.00004	0.001	< 0.0004	0.0006
Silicon Si	mg/L	0.02	9.1	3.2	< 0.2
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	6600	6970	6850
Strontium Sr	mg/L	0.00008	0.447	0.823	< 0.0008
Sulphur (S)	mg/L	5	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00091	0.00008	< 0.00005
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.0795	0.0065	< 0.001
Uranium U	mg/L	0.000002	0.00457	0.00192	0.00002
Vanadium V	mg/L	0.00001	0.0279	0.0072	< 0.0001
Zinc Zn	mg/L	0.002	0.12	0.03	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Carbonates

Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Concentration leached relative to initial sample mass (no correction for blank is included)							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		149.9	70.1	110.0	150.1	1996.8
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	0.5
Arsenic As	mg/kg		0.3	0.6	0.2	0.7	6.2
Barium Ba	mg/kg		6.1	2.4	16.4	6.4	92.7
Beryllium Be	mg/kg		0.05	0.01	0.04	0.02	0.63
Bismuth Bi	mg/kg		0.01	0.01	0.02	0.02	0.11
Boron B	mg/kg		<DL	1.4	1.4	1.4	4.6
Cadmium Cd	mg/kg		0.02	0.01	0.05	0.01	0.04
Calcium Ca	mg/kg		69.2	2258.7	61975.8	5790.3	3289.5
Chromium Cr	mg/kg		0.8	0.8	0.9	1.9	6.5
Cobalt Co	mg/kg		0.2	0.3	1.0	0.4	0.8
Copper Cu	mg/kg		<DL	<DL	1.4	<DL	5.1
Iron Fe	mg/kg		996.1	1682.5	512.6	3455.6	926.6
Lead Pb	mg/kg		0.3	0.3	1.1	0.5	2.7
Lithium Li	mg/kg		0.1	0.1	0.4	0.1	1.7
Magnesium Mg	mg/kg		1263.6	2092.7	15517.2	3339.8	2307.3
Manganese Mn	mg/kg		3.7	66.4	146.8	143.6	10.1
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		<DL	<DL	<DL	<DL	0.2
Nickel Ni	mg/kg		0.7	0.7	1.2	1.5	2.0
Phosphorus P	mg/kg		1.4	6.9	6.1	11.6	69.0
Potassium K	mg/kg		61.3	65.0	130.0	106.5	138.1
Selenium Se	mg/kg		0.3	<DL	<DL	<DL	4.1
Silicon Si	mg/kg		189.1	124.5	191.1	287.2	1932.0
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		NA	NA	NA	NA	NA
Strontium Sr	mg/kg		1.1	1.2	47.5	4.3	138.1
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.2	<DL	0.0	0.0	0.2
Tin Sn	mg/kg		<DL	<DL	<DL	<DL	0.1
Titanium Ti	mg/kg		2.0	0.4	0.4	0.8	13.9
Uranium U	mg/kg		0.3	0.0	0.2	0.0	0.9
Vanadium V	mg/kg		0.1	0.7	0.8	1.1	5.0
Zinc Zn	mg/kg		0.9	7.8	1.4	2.8	8.3
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Metals Bound to Carbonates

Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Concentration leached relative to initial sample m							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		67.7	167.6	237.0	124.6	112.3
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		0.4	1.3	6.0	0.4	1.1
Barium Ba	mg/kg		2.5	9.2	17.0	4.8	7.6
Beryllium Be	mg/kg		0.01	0.13	0.18	0.02	0.02
Bismuth Bi	mg/kg		0.01	0.02	0.04	0.01	0.01
Boron B	mg/kg		1.4	1.8	2.3	1.8	<DL
Cadmium Cd	mg/kg		0.02	0.03	0.07	0.02	0.01
Calcium Ca	mg/kg		3025.5	3132.4	8455.8	2778.5	39400.4
Chromium Cr	mg/kg		1.0	1.2	2.6	2.2	1.7
Cobalt Co	mg/kg		0.2	0.5	0.4	0.4	0.5
Copper Cu	mg/kg		<DL	3.2	0.9	<DL	<DL
Iron Fe	mg/kg		1113.7	386.5	1109.0	3498.6	3109.3
Lead Pb	mg/kg		0.5	0.7	1.1	0.5	0.4
Lithium Li	mg/kg		0.1	0.2	0.3	0.1	0.2
Magnesium Mg	mg/kg		2747.1	2019.6	3447.0	2880.1	4826.4
Manganese Mn	mg/kg		22.8	12.5	66.5	51.2	362.0
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		<DL	<DL	<DL	<DL	0.2
Nickel Ni	mg/kg		0.7	1.7	1.6	1.7	1.4
Phosphorus P	mg/kg		5.6	15.6	17.1	7.8	9.3
Potassium K	mg/kg		71.9	60.0	93.3	132.0	96.1
Selenium Se	mg/kg		<DL	0.1	0.4	<DL	<DL
Silicon Si	mg/kg		111.4	187.8	291.1	267.7	255.2
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		NA	NA	NA	NA	NA
Strontium Sr	mg/kg		1.6	3.9	9.3	1.4	26.5
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.0	0.1	0.1	0.0	<DL
Tin Sn	mg/kg		<DL	<DL	<DL	<DL	<DL
Titanium Ti	mg/kg		0.3	2.9	3.5	0.4	0.4
Uranium U	mg/kg		0.0	0.1	0.2	0.0	0.1
Vanadium V	mg/kg		0.5	0.5	2.7	1.0	1.1
Zinc Zn	mg/kg		3.2	2.7	3.2	3.7	1.9
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Metals Bound to Carbonates					
Reagent: 15 mL of 1 M NaOAc (adjusted to pH 5.0 with Acetic Acid)					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Concentration leached relative to initial sample m					
Parameter	**Units**	**RDL**			
Aluminum Al	mg/kg		310.7	71.1	
Antimony Sb	mg/kg		<DL	<DL	
Arsenic As	mg/kg		0.6	0.1	
Barium Ba	mg/kg		22.8	4.7	
Beryllium Be	mg/kg		0.10	0.02	
Bismuth Bi	mg/kg		0.04	0.01	
Boron B	mg/kg		3.2	1.4	
Cadmium Cd	mg/kg		0.04	0.01	
Calcium Ca	mg/kg		23025.7	52260.0	
Chromium Cr	mg/kg		1.7	1.0	
Cobalt Co	mg/kg		0.5	0.4	
Copper Cu	mg/kg		0.9	<DL	
Iron Fe	mg/kg		1530.4	1136.9	
Lead Pb	mg/kg		1.0	0.6	
Lithium Li	mg/kg		0.6	0.1	
Magnesium Mg	mg/kg		3990.2	4208.3	
Manganese Mn	mg/kg		46.1	273.7	
Mercury Hg	ug/kg		<DL	<DL	
Molybdenum Mo	mg/kg		<DL	<DL	
Nickel Ni	mg/kg		1.5	0.9	
Phosphorus P	mg/kg		12.5	5.5	
Potassium K	mg/kg		111.4	74.7	
Selenium Se	mg/kg		0.0	<DL	
Silicon Si	mg/kg		420.8	146.7	
Silver Ag	mg/kg		<DL	<DL	
Sodium Na	mg/kg		NA	NA	
Strontium Sr	mg/kg		20.7	37.7	
Sulphur (S)	mg/kg		<DL	<DL	
Thallium Tl	mg/kg		0.0	0.0	
Tin Sn	mg/kg		<DL	<DL	
Titanium Ti	mg/kg		3.7	0.3	
Uranium U	mg/kg		0.2	0.1	
Vanadium V	mg/kg		1.3	0.3	
Zinc Zn	mg/kg		5.5	1.4	
Zirconium Zr	mg/kg		<DL	<DL	

Tessier Extraction

Metals Bound to Fe and Mn Oxides
Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Initial sample weight (g)			1.0842	1.0847	1.0730	1.0794	1.0792
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	26.6	180	3000	165	48.3
Aluminum Al	mg/L	0.001	41.6	6.91	9.07	11.2	84
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.044	0.027	0.014	0.027	0.419
Barium Ba	mg/L	0.00008	0.208	0.0511	0.0616	0.111	1.06
Beryllium Be	mg/L	0.000007	0.00415	0.00034	0.00245	0.00055	0.0173
Bismuth Bi	mg/L	0.00001	0.0008	0.0004	0.0014	0.0006	0.0021
Boron B	mg/L	0.002	0.11	0.05	0.06	0.04	0.36
Cadmium Cd	mg/L	0.000003	0.00024	0.0002	0.00014	0.00009	0.00067
Calcium Ca	mg/L	0.01	7.4	38.5	639	35.4	14.6
Chromium Cr	mg/L	0.00008	0.0614	0.0223	0.0402	0.0326	0.16
Cobalt Co	mg/L	0.000004	0.0149	0.00999	0.0259	0.0107	0.0267
Copper Cu	mg/L	0.001	< 0.01	0.01	0.03	0.02	0.03
Iron Fe	mg/L	0.007	177	33	52.2	44.4	60.3
Lead Pb	mg/L	0.00009	0.024	0.008	0.0507	0.0113	0.0232
Lithium Li	mg/L	0.0001	0.057	0.01	0.049	0.013	0.093
Magnesium Mg	mg/L	0.001	1.99	20.4	341	18.5	2.89
Manganese Mn	mg/L	0.00001	0.163	0.733	1.46	1.08	0.186
Mercury Hg	ug/L	0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.015	0.006	0.006	0.008	0.027
Nickel Ni	mg/L	0.0001	0.038	0.013	0.076	0.019	0.063
Phosphorus P	mg/L	0.003	0.55	0.87	1.91	1.07	3.05
Potassium K	mg/L	0.009	4.28	0.96	1.82	1.9	4.62
Selenium Se	mg/L	0.00004	0.0062	< 0.0004	0.0006	< 0.0004	0.0353
Silicon Si	mg/L	0.02	18.6	8.3	13.6	11.9	30
Silver Ag	mg/L	0.00005	0.0002	0.0017	0.001	0.0016	0.0008
Sodium Na	mg/L	0.01	15.6	12.8	35.1	18.4	32.3
Strontium Sr	mg/L	0.00008	0.227	0.0256	0.256	0.0489	0.958
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00766	0.00014	0.00016	0.00023	0.0107
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	0.0008	< 0.0006
Titanium Ti	mg/L	0.0001	0.151	0.024	0.017	0.029	0.389
Uranium U	mg/L	0.000002	0.00532	0.00039	0.00337	0.00064	0.0125
Vanadium V	mg/L	0.00001	0.139	0.0199	0.0713	0.0241	0.487
Zinc Zn	mg/L	0.002	0.06	0.07	0.11	0.06	0.13
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Fe and Mn Oxides
Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Initial sample weight (g)			1.0775	1.0918	1.0821	1.0833	1.0774
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	136	140	426	90.8	727
Aluminum Al	mg/L	0.001	7.77	39.8	39	12	9.36
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.024	0.067	0.276	0.024	0.026
Barium Ba	mg/L	0.00008	0.063	0.362	0.498	0.129	0.0609
Beryllium Be	mg/L	0.000007	0.0004	0.00905	0.0104	0.00042	0.00043
Bismuth Bi	mg/L	0.00001	0.0003	0.0007	0.001	0.0004	0.0009
Boron B	mg/L	0.002	0.05	0.21	0.21	0.06	0.02
Cadmium Cd	mg/L	0.000003	0.00014	0.00057	0.00094	0.00017	0.00009
Calcium Ca	mg/L	0.01	28.6	32.4	97.1	19.6	146
Chromium Cr	mg/L	0.00008	0.025	0.0642	0.12	0.0298	0.0283
Cobalt Co	mg/L	0.000004	0.00947	0.02	0.0192	0.0102	0.00927
Copper Cu	mg/L	0.001	< 0.01	0.04	0.01	0.01	0.01
Iron Fe	mg/L	0.007	31.4	55.3	72.7	37.5	43.4
Lead Pb	mg/L	0.00009	0.0116	0.0308	0.0418	0.0137	0.0098
Lithium Li	mg/L	0.0001	0.012	0.064	0.052	0.012	0.009
Magnesium Mg	mg/L	0.001	15.6	14.4	44.7	10.2	87.7
Manganese Mn	mg/L	0.00001	0.363	0.276	0.771	0.379	3.02
Mercury Hg	ug/L	0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.004	0.008	0.017	0.009	0.011
Nickel Ni	mg/L	0.0001	0.015	0.072	0.052	0.02	0.018
Phosphorus P	mg/L	0.003	0.96	1.29	0.89	1.03	< 0.03
Potassium K	mg/L	0.009	1.29	2.95	4.8	2.84	1.29
Selenium Se	mg/L	0.00004	0.0013	0.0016	0.0082	< 0.0004	< 0.0004
Silicon Si	mg/L	0.02	8.4	19.9	18	11.4	10.4
Silver Ag	mg/L	0.00005	0.0009	0.0008	0.0004	0.0013	0.0004
Sodium Na	mg/L	0.01	15.9	16	27.8	19	13.5
Strontium Sr	mg/L	0.00008	0.0297	0.338	0.564	0.038	0.0624
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00019	0.00421	0.0081	0.00025	0.00011
Tin Sn	mg/L	0.00006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.016	0.238	0.238	0.02	0.021
Uranium U	mg/L	0.000002	0.00046	0.00532	0.00668	0.00056	0.0008
Vanadium V	mg/L	0.00001	0.0183	0.116	0.256	0.0214	0.0284
Zinc Zn	mg/L	0.002	0.08	0.07	0.08	0.08	0.04
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Fe and Mn Oxides Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Initial sample weight (g)			1.0814	1.0907	0.0000
Reagent volume (mL)			15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50
Parameter	**Units**	**RDL**			
Hardness CaCO3	mg/L	0.05	301	430	1.5
Aluminum Al	mg/L	0.001	47.5	7.1	0.03
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.011	0.008	< 0.002
Barium Ba	mg/L	0.00008	0.738	0.0527	0.0008
Beryllium Be	mg/L	0.000007	0.00892	0.00069	< 0.00007
Bismuth Bi	mg/L	0.00001	0.002	0.0006	< 0.0001
Boron B	mg/L	0.002	0.12	0.04	< 0.02
Cadmium Cd	mg/L	0.000003	0.00148	0.00008	< 0.00003
Calcium Ca	mg/L	0.01	71.4	95.7	0.6
Chromium Cr	mg/L	0.00008	0.0781	0.03	0.0027
Cobalt Co	mg/L	0.000004	0.0204	0.00698	< 0.00004
Copper Cu	mg/L	0.001	0.05	0.02	< 0.01
Iron Fe	mg/L	0.007	127	65.8	< 0.07
Lead Pb	mg/L	0.00009	0.0685	0.0188	0.0018
Lithium Li	mg/L	0.0001	0.091	0.014	0.003
Magnesium Mg	mg/L	0.001	29.8	46.5	< 0.01
Manganese Mn	mg/L	0.00001	0.813	0.939	< 0.0001
Mercury Hg	ug/L	0.01	0.02	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.006	0.004	< 0.004
Nickel Ni	mg/L	0.0001	0.069	0.017	< 0.001
Phosphorus P	mg/L	0.003	0.47	0.38	0.09
Potassium K	mg/L	0.009	6.9	0.99	< 0.09
Selenium Se	mg/L	0.00004	0.005	0.001	< 0.0004
Silicon Si	mg/L	0.02	24	10.5	< 0.2
Silver Ag	mg/L	0.00005	0.0016	0.002	0.0018
Sodium Na	mg/L	0.01	21.7	12	0.9
Strontium Sr	mg/L	0.00008	0.623	0.0456	< 0.0008
Sulphur (S)	mg/L	5	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00655	0.00016	< 0.00005
Tin Sn	mg/L	0.00006	0.0007	< 0.0006	< 0.0006
Titanium Ti	mg/L	0.0001	0.141	0.02	< 0.001
Uranium U	mg/L	0.000002	0.00581	0.00089	< 0.00002
Vanadium V	mg/L	0.00001	0.159	0.0338	< 0.0001
Zinc Zn	mg/L	0.002	0.24	0.07	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Fe and Mn Oxides
Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Concentration leached relative to initial sample mass (no correction for blank is included)							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		1918.5	318.5	422.6	518.8	3891.8
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		2.0	1.2	0.7	1.3	19.4
Barium Ba	mg/kg		9.6	2.4	2.9	5.1	49.1
Beryllium Be	mg/kg		0.2	0.0	0.1	0.0	0.8
Bismuth Bi	mg/kg		0.04	0.02	0.07	0.03	0.10
Boron B	mg/kg		5.1	2.3	2.8	1.9	16.7
Cadmium Cd	mg/kg		0.01	0.01	0.01	0.00	0.03
Calcium Ca	mg/kg		341.3	1774.7	29776.3	1639.8	676.4
Chromium Cr	mg/kg		2.8	1.0	1.9	1.5	7.4
Cobalt Co	mg/kg		0.7	0.5	1.2	0.5	1.2
Copper Cu	mg/kg		<DL	0.5	1.4	0.9	1.4
Iron Fe	mg/kg		8162.7	1521.2	2432.4	2056.7	2793.7
Lead Pb	mg/kg		1.1	0.4	2.4	0.5	1.1
Lithium Li	mg/kg		2.6	0.5	2.3	0.6	4.3
Magnesium Mg	mg/kg		91.8	940.4	15890.0	857.0	133.9
Manganese Mn	mg/kg		7.5	33.8	68.0	50.0	8.6
Mercury Hg	ug/kg		<DL	<DL	0.9	<DL	<DL
Molybdenum Mo	mg/kg		0.7	0.3	0.3	0.4	1.3
Nickel Ni	mg/kg		1.8	0.6	3.5	0.9	2.9
Phosphorus P	mg/kg		25.4	40.1	89.0	49.6	141.3
Potassium K	mg/kg		197.4	44.3	84.8	88.0	214.0
Selenium Se	mg/kg		0.3	<DL	0.0	<DL	1.6
Silicon Si	mg/kg		857.8	382.6	633.7	551.2	1389.9
Silver Ag	mg/kg		0.01	0.08	0.05	0.07	0.04
Sodium Na	mg/kg		719.4	590.0	1635.6	852.3	1496.5
Strontium Sr	mg/kg		10.5	1.2	11.9	2.3	44.4
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.4	0.0	0.0	0.0	0.5
Tin Sn	mg/kg		<DL	<DL	<DL	0.0	<DL
Titanium Ti	mg/kg		7.0	1.1	0.8	1.3	18.0
Uranium U	mg/kg		0.2	0.0	0.2	0.0	0.6
Vanadium V	mg/kg		6.4	0.9	3.3	1.1	22.6
Zinc Zn	mg/kg		2.8	3.2	5.1	2.8	6.0
Zirconium Zr	mg/kg		<DL	<DL	0.9	<DL	<DL

Tessier Extraction

Metals Bound to Fe and Mn Oxides
Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Concentration leached relative to initial sample m							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		360.6	1822.7	1802.1	553.9	434.4
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		1.1	3.1	12.8	1.1	1.2
Barium Ba	mg/kg		2.9	16.6	23.0	6.0	2.8
Beryllium Be	mg/kg		0.0	0.4	0.5	0.0	0.0
Bismuth Bi	mg/kg		0.01	0.03	0.05	0.02	0.04
Boron B	mg/kg		2.3	9.6	9.7	2.8	0.9
Cadmium Cd	mg/kg		0.01	0.03	0.04	0.01	0.00
Calcium Ca	mg/kg		1327.1	1483.8	4486.6	904.6	6775.6
Chromium Cr	mg/kg		1.2	2.9	5.5	1.4	1.3
Cobalt Co	mg/kg		0.4	0.9	0.9	0.5	0.4
Copper Cu	mg/kg		<DL	1.8	0.5	0.5	0.5
Iron Fe	mg/kg		1457.1	2532.5	3359.2	1730.8	2014.1
Lead Pb	mg/kg		0.5	1.4	1.9	0.6	0.5
Lithium Li	mg/kg		0.6	2.9	2.4	0.6	0.4
Magnesium Mg	mg/kg		723.9	659.5	2065.4	470.8	4070.0
Manganese Mn	mg/kg		16.8	12.6	35.6	17.5	140.2
Mercury Hg	ug/kg		<DL	<DL	0.9	<DL	<DL
Molybdenum Mo	mg/kg		0.2	0.4	0.8	0.4	0.5
Nickel Ni	mg/kg		0.7	3.3	2.4	0.9	0.8
Phosphorus P	mg/kg		44.5	59.1	41.1	47.5	<DL
Potassium K	mg/kg		59.9	135.1	221.8	131.1	59.9
Selenium Se	mg/kg		0.1	0.1	0.4	<DL	<DL
Silicon Si	mg/kg		389.8	911.3	831.7	526.2	482.6
Silver Ag	mg/kg		0.04	0.04	0.02	0.06	0.02
Sodium Na	mg/kg		737.8	732.7	1284.5	877.0	626.5
Strontium Sr	mg/kg		1.4	15.5	26.1	1.8	2.9
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.0	0.2	0.4	0.0	0.0
Tin Sn	mg/kg		<DL	<DL	<DL	<DL	<DL
Titanium Ti	mg/kg		0.7	10.9	11.0	0.9	1.0
Uranium U	mg/kg		0.0	0.2	0.3	0.0	0.0
Vanadium V	mg/kg		0.8	5.3	11.8	1.0	1.3
Zinc Zn	mg/kg		3.7	3.2	3.7	3.7	1.9
Zirconium Zr	mg/kg		<DL	<DL	<DL	<DL	<DL

Tessier Extraction

Metals Bound to Fe and Mn Oxides					
Reagent: 15 mL of 0.04M NH2OH. HCl in 25% HOAc					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Concentration leached relative to initial sample m					
Parameter	**Units**	**RDL**			
Aluminum Al	mg/kg		2196.2	325.5	
Antimony Sb	mg/kg		<DL	<DL	
Arsenic As	mg/kg		0.5	0.4	
Barium Ba	mg/kg		34.1	2.4	
Beryllium Be	mg/kg		0.4	0.0	
Bismuth Bi	mg/kg		0.09	0.03	
Boron B	mg/kg		5.5	1.8	
Cadmium Cd	mg/kg		0.07	0.00	
Calcium Ca	mg/kg		3301.3	4387.1	
Chromium Cr	mg/kg		3.6	1.4	
Cobalt Co	mg/kg		0.9	0.3	
Copper Cu	mg/kg		2.3	0.9	
Iron Fe	mg/kg		5872.0	3016.4	
Lead Pb	mg/kg		3.2	0.9	
Lithium Li	mg/kg		4.2	0.6	
Magnesium Mg	mg/kg		1377.8	2131.7	
Manganese Mn	mg/kg		37.6	43.0	
Mercury Hg	ug/kg		0.9	<DL	
Molybdenum Mo	mg/kg		0.3	0.2	
Nickel Ni	mg/kg		3.2	0.8	
Phosphorus P	mg/kg		21.7	17.4	
Potassium K	mg/kg		319.0	45.4	
Selenium Se	mg/kg		0.2	0.0	
Silicon Si	mg/kg		1109.7	481.3	
Silver Ag	mg/kg		0.07	0.09	
Sodium Na	mg/kg		1003.3	550.1	
Strontium Sr	mg/kg		28.8	2.1	
Sulphur (S)	mg/kg		<DL	<DL	
Thallium Tl	mg/kg		0.3	0.0	
Tin Sn	mg/kg		0.0	<DL	
Titanium Ti	mg/kg		6.5	0.9	
Uranium U	mg/kg		0.3	0.0	
Vanadium V	mg/kg		7.4	1.5	
Zinc Zn	mg/kg		11.1	3.2	
Zirconium Zr	mg/kg		<DL	<DL	

Tessier Extraction

Metals Bound to Organics
Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2
+ 5 mL 1.2 M NH4OAc in 20% HNO3

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Initial sample weight (g)			1.0842	1.0847	1.0730	1.0794	1.0792
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	13.7	9.7	84.1	10.9	29.6
Aluminum Al	mg/L	0.001	21.2	2.46	17.2	3.53	39.2
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.208	0.023	0.019	0.024	0.357
Barium Ba	mg/L	0.00008	0.0904	0.0155	0.0352	0.0279	0.896
Beryllium Be	mg/L	0.000007	0.00159	< 0.00007	0.0007	< 0.00007	0.0077
Bismuth Bi	mg/L	0.00001	0.0001	< 0.0001	0.0001	< 0.0001	0.002
Boron B	mg/L	0.002	0.04	< 0.02	< 0.02	< 0.02	0.11
Cadmium Cd	mg/L	0.000003	0.00036	0.00017	0.0005	0.00018	0.0004
Calcium Ca	mg/L	0.01	4	2.6	17.5	2.8	8.4
Chromium Cr	mg/L	0.00008	0.0188	0.0121	0.0269	0.0155	0.0598
Cobalt Co	mg/L	0.000004	0.00868	0.00599	0.0122	0.00542	0.0185
Copper Cu	mg/L	0.001	0.11	< 0.01	0.04	0.02	0.3
Iron Fe	mg/L	0.007	372	3.39	22	5.01	14.8
Lead Pb	mg/L	0.00009	0.0083	0.003	0.02	0.0043	0.0804
Lithium Li	mg/L	0.0001	0.019	0.002	0.033	0.002	0.034
Magnesium Mg	mg/L	0.001	0.91	0.79	9.84	0.91	2.1
Manganese Mn	mg/L	0.00001	0.0637	0.0273	0.191	0.0345	0.0618
Mercury Hg	ug/L	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.011	0.005	0.01	0.005	0.026
Nickel Ni	mg/L	0.0001	0.02	0.009	0.052	0.009	0.047
Phosphorus P	mg/L	0.003	6.52	6.57	8.85	7	10.7
Potassium K	mg/L	0.009	1.8	0.44	1.02	0.63	4.5
Selenium Se	mg/L	0.00004	0.0513	0.0007	0.0019	0.0007	0.823
Silicon Si	mg/L	0.02	9.9	3.2	11.8	4.2	14.3
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	5.5	5.8	6	5.7	6.2
Strontium Sr	mg/L	0.00008	0.105	0.0108	0.0356	0.0155	0.659
Sulphur (S)	mg/L	5	433	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.0177	0.00015	0.0004	0.00013	0.0037
Tin Sn	mg/L	0.00006	0.893	0.359	0.197	0.67	1.58
Titanium Ti	mg/L	0.0001	1.25	0.508	0.72	0.68	7.23
Uranium U	mg/L	0.000002	0.00138	0.00036	0.00154	0.00033	0.0109
Vanadium V	mg/L	0.00001	0.0279	0.0078	0.0477	0.0085	0.158
Zinc Zn	mg/L	0.002	0.03	< 0.02	0.08	< 0.02	0.07
Zirconium Zr	mg/L	0.002	< 0.02	< 0.02	0.04	< 0.02	0.16

Tessier Extraction

Metals Bound to Organics
Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2
+ 5 mL 1.2 M NH4OAc in 20% HNO3

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Initial sample weight (g)			1.0775	1.0918	1.0821	1.0833	1.0774
Reagent volume (mL)			15	15	15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50	50	50
Parameter	**Units**	**RDL**					
Hardness CaCO3	mg/L	0.05	8.8	14.5	23.7	9.8	22.4
Aluminum Al	mg/L	0.001	2.72	14.6	28.7	4.31	6.77
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.018	0.042	0.278	0.015	0.024
Barium Ba	mg/L	0.00008	0.023	0.151	0.304	0.0385	0.0238
Beryllium Be	mg/L	0.000007	< 0.00007	0.00247	0.00513	< 0.00007	0.00007
Bismuth Bi	mg/L	0.00001	< 0.0001	0.0002	0.0007	< 0.0001	< 0.0001
Boron B	mg/L	0.002	< 0.02	0.06	0.07	< 0.02	< 0.02
Cadmium Cd	mg/L	0.000003	0.00012	0.00022	0.00032	0.00014	0.00011
Calcium Ca	mg/L	0.01	2.4	4.1	6.2	2.6	5.9
Chromium Cr	mg/L	0.00008	0.0157	0.0208	0.0593	0.0158	0.0161
Cobalt Co	mg/L	0.000004	0.00806	0.00745	0.0113	0.00385	0.00707
Copper Cu	mg/L	0.001	0.02	0.12	0.14	0.02	0.03
Iron Fe	mg/L	0.007	8.81	13.9	25.5	6.32	4.42
Lead Pb	mg/L	0.00009	0.004	0.016	0.0371	0.0041	0.004
Lithium Li	mg/L	0.0001	0.001	0.023	0.024	0.002	0.004
Magnesium Mg	mg/L	0.001	0.67	1.03	1.97	0.77	1.84
Manganese Mn	mg/L	0.00001	0.0268	0.0338	0.0625	0.0264	0.0645
Mercury Hg	ug/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.004	0.006	0.02	0.006	0.005
Nickel Ni	mg/L	0.0001	0.01	0.025	0.03	0.009	0.012
Phosphorus P	mg/L	0.003	7	7.86	7.97	7.06	7.18
Potassium K	mg/L	0.009	0.59	1.6	3.43	1.01	0.5
Selenium Se	mg/L	0.00004	0.0015	0.0179	0.134	0.0007	0.0006
Silicon Si	mg/L	0.02	3.3	8.3	10.7	5.6	7.1
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	5.4	5.6	6.1	6.1	6.1
Strontium Sr	mg/L	0.00008	0.0128	0.132	0.242	0.0164	0.0175
Sulphur (S)	mg/L	5	< 50	< 50	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00015	0.00173	0.00333	0.00009	0.00006
Tin Sn	mg/L	0.00006	1.04	1.07	1.03	0.763	0.503
Titanium Ti	mg/L	0.0001	0.389	1.98	2.35	0.546	0.619
Uranium U	mg/L	0.000002	0.00027	0.00264	0.00415	0.0004	0.00048
Vanadium V	mg/L	0.00001	0.0052	0.0323	0.0884	0.0066	0.0142
Zinc Zn	mg/L	0.002	< 0.02	0.02	0.04	0.02	< 0.02
Zirconium Zr	mg/L	0.002	< 0.02	0.05	0.09	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Organics Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2 + 5 mL 1.2 M NH4OAc in 20% HNO3					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Initial sample weight (g)			1.0814	1.0907	0.0000
Reagent volume (mL)			15	15	15
Final diluted solution volume after wash and preservation (mL)			50	50	50
Parameter	**Units**	**RDL**			
Hardness CaCO3	mg/L	0.05	26.2	17	4.3
Aluminum Al	mg/L	0.001	31.9	4.07	0.06
Antimony Sb	mg/L	0.0009	< 0.009	< 0.009	< 0.009
Arsenic As	mg/L	0.0002	0.035	0.012	< 0.002
Barium Ba	mg/L	0.00008	0.771	0.0241	0.0028
Beryllium Be	mg/L	0.000007	0.00356	0.00012	< 0.00007
Bismuth Bi	mg/L	0.00001	0.0007	< 0.0001	< 0.0001
Boron B	mg/L	0.002	0.04	< 0.02	< 0.02
Cadmium Cd	mg/L	0.000003	0.00036	0.0002	0.00007
Calcium Ca	mg/L	0.01	7.7	4.1	1.3
Chromium Cr	mg/L	0.00008	0.0403	0.0178	0.0106
Cobalt Co	mg/L	0.000004	0.00928	0.00314	0.0003
Copper Cu	mg/L	0.001	0.14	0.02	< 0.01
Iron Fe	mg/L	0.007	21.9	4.33	< 0.07
Lead Pb	mg/L	0.00009	0.0385	0.005	0.0016
Lithium Li	mg/L	0.0001	0.027	0.004	< 0.001
Magnesium Mg	mg/L	0.001	1.71	1.65	0.24
Manganese Mn	mg/L	0.00001	0.0654	0.0623	0.0013
Mercury Hg	ug/L	0.01	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	0.0004	0.017	0.005	< 0.004
Nickel Ni	mg/L	0.0001	0.029	0.01	0.006
Phosphorus P	mg/L	0.003	7.17	6.47	7.25
Potassium K	mg/L	0.009	2.75	0.55	0.12
Selenium Se	mg/L	0.00004	0.0191	0.0024	< 0.0004
Silicon Si	mg/L	0.02	14.6	4.8	< 0.2
Silver Ag	mg/L	0.00005	< 0.0005	< 0.0005	< 0.0005
Sodium Na	mg/L	0.01	6	5.6	5.5
Strontium Sr	mg/L	0.00008	0.25	0.0146	0.0052
Sulphur (S)	mg/L	5	< 50	< 50	< 50
Thallium Tl	mg/L	0.000005	0.00125	0.00008	< 0.00005
Tin Sn	mg/L	0.00006	1.38	0.279	3.97
Titanium Ti	mg/L	0.0001	3.1	0.87	0.001
Uranium U	mg/L	0.000002	0.00355	0.00043	0.00003
Vanadium V	mg/L	0.00001	0.0716	0.0149	0.0001
Zinc Zn	mg/L	0.002	0.04	0.02	< 0.02
Zirconium Zr	mg/L	0.002	0.1	< 0.02	< 0.02

Tessier Extraction

Metals Bound to Organics
Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2
+ 5 mL 1.2 M NH4OAc in 20% HNO3

Sample			B-1 12'-13'	B-1 16'-18'	B-2 8'-9'	B-2 13'-15'	B-3 11'-13'
Concentration leached relative to initial sample mass (no correction for blank is included)							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		977.7	113.4	801.5	163.5	1816.2
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		9.6	1.1	0.9	1.1	16.5
Barium Ba	mg/kg		4.2	0.7	1.6	1.3	41.5
Beryllium Be	mg/kg		0.07	<DL	0.03	<DL	0.36
Bismuth Bi	mg/kg		0.00	<DL	0.00	<DL	0.09
Boron B	mg/kg		1.8	<DL	<DL	<DL	5.1
Cadmium Cd	mg/kg		0.02	0.01	0.02	0.01	0.02
Calcium Ca	mg/kg		184.5	119.8	815.5	129.7	389.2
Chromium Cr	mg/kg		0.9	0.6	1.3	0.7	2.8
Cobalt Co	mg/kg		0.4	0.3	0.6	0.3	0.9
Copper Cu	mg/kg		5.1	<DL	1.9	0.9	13.9
Iron Fe	mg/kg		17155.5	156.3	1025.2	232.1	685.7
Lead Pb	mg/kg		0.4	0.1	0.9	0.2	3.7
Lithium Li	mg/kg		0.9	0.1	1.5	0.1	1.6
Magnesium Mg	mg/kg		42.0	36.4	458.5	42.2	97.3
Manganese Mn	mg/kg		2.9	1.3	8.9	1.6	2.9
Mercury Hg	ug/kg		0.9	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		0.5	0.2	0.5	0.2	1.2
Nickel Ni	mg/kg		0.9	0.4	2.4	0.4	2.2
Phosphorus P	mg/kg		300.7	302.8	412.4	324.3	495.7
Potassium K	mg/kg		83.0	20.3	47.5	29.2	208.5
Selenium Se	mg/kg		2.4	0.0	0.1	0.0	38.1
Silicon Si	mg/kg		456.6	147.5	549.9	194.6	662.5
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		253.6	267.4	279.6	264.0	287.2
Strontium Sr	mg/kg		4.8	0.5	1.7	0.7	30.5
Sulphur (S)	mg/kg		19968.6	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.8	0.0	0.0	0.0	0.2
Tin Sn	mg/kg		41.2	16.5	9.2	31.0	73.2
Titanium Ti	mg/kg		57.6	23.4	33.6	31.5	335.0
Uranium U	mg/kg		0.1	0.0	0.1	0.0	0.5
Vanadium V	mg/kg		1.3	0.4	2.2	0.4	7.3
Zinc Zn	mg/kg		1.4	<DL	3.7	<DL	3.2
Zirconium Zr	mg/kg		<DL	<DL	1.9	<DL	7.4

Tessier Extraction

Metals Bound to Organics
Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2
+ 5 mL 1.2 M NH4OAc in 20% HNO3

Sample			B-3 17'-19'	B-4 10'-12'	B-5 10'-15'	B-5 18'-20'	B-5 21 1/2'-22 1/2'
Concentration leached relative to initial sample ma							
Parameter	**Units**	**RDL**					
Aluminum Al	mg/kg		126.2	668.6	1326.1	198.9	314.2
Antimony Sb	mg/kg		<DL	<DL	<DL	<DL	<DL
Arsenic As	mg/kg		0.8	1.9	12.8	0.7	1.1
Barium Ba	mg/kg		1.1	6.9	14.0	1.8	1.1
Beryllium Be	mg/kg		<DL	0.11	0.24	<DL	0.00
Bismuth Bi	mg/kg		<DL	0.01	0.03	<DL	<DL
Boron B	mg/kg		<DL	2.7	3.2	<DL	<DL
Cadmium Cd	mg/kg		0.01	0.01	0.01	0.01	0.01
Calcium Ca	mg/kg		111.4	187.8	286.5	120.0	273.8
Chromium Cr	mg/kg		0.7	1.0	2.7	0.7	0.7
Cobalt Co	mg/kg		0.4	0.3	0.5	0.2	0.3
Copper Cu	mg/kg		0.9	5.5	6.5	0.9	1.4
Iron Fe	mg/kg		408.8	636.6	1178.3	291.7	205.1
Lead Pb	mg/kg		0.2	0.7	1.7	0.2	0.2
Lithium Li	mg/kg		0.0	1.1	1.1	0.1	0.2
Magnesium Mg	mg/kg		31.1	47.2	91.0	35.5	85.4
Manganese Mn	mg/kg		1.2	1.5	2.9	1.2	3.0
Mercury Hg	ug/kg		<DL	<DL	<DL	<DL	<DL
Molybdenum Mo	mg/kg		0.2	0.3	0.9	0.3	0.2
Nickel Ni	mg/kg		0.5	1.1	1.4	0.4	0.6
Phosphorus P	mg/kg		324.8	360.0	368.3	325.9	333.2
Potassium K	mg/kg		27.4	73.3	158.5	46.6	23.2
Selenium Se	mg/kg		0.1	0.8	6.2	0.0	0.0
Silicon Si	mg/kg		153.1	380.1	494.4	258.5	329.5
Silver Ag	mg/kg		<DL	<DL	<DL	<DL	<DL
Sodium Na	mg/kg		250.6	256.5	281.9	281.5	283.1
Strontium Sr	mg/kg		0.6	6.0	11.2	0.8	0.8
Sulphur (S)	mg/kg		<DL	<DL	<DL	<DL	<DL
Thallium Tl	mg/kg		0.0	0.1	0.2	0.0	0.0
Tin Sn	mg/kg		48.3	49.0	47.6	35.2	23.3
Titanium Ti	mg/kg		18.1	90.7	108.6	25.2	28.7
Uranium U	mg/kg		0.0	0.1	0.2	0.0	0.0
Vanadium V	mg/kg		0.2	1.5	4.1	0.3	0.7
Zinc Zn	mg/kg		<DL	0.9	1.8	0.9	<DL
Zirconium Zr	mg/kg		<DL	2.3	4.2	<DL	<DL

Tessier Extraction

Metals Bound to Organics Reagent: 3 mL of 0.02 M HNO3 + 5 mL 30% H2O2 + 5 mL 1.2 M NH4OAc in 20% HNO3					
Sample			**B-6 6"-18"**	**B-6 5'-7'**	**Blank**
Concentration leached relative to initial sample ma					
Parameter	**Units**	**RDL**			
Aluminum Al	mg/kg		1474.9	186.6	
Antimony Sb	mg/kg		<DL	<DL	
Arsenic As	mg/kg		1.6	0.6	
Barium Ba	mg/kg		35.6	1.1	
Beryllium Be	mg/kg		0.16	0.01	
Bismuth Bi	mg/kg		0.03	<DL	
Boron B	mg/kg		1.8	<DL	
Cadmium Cd	mg/kg		0.02	0.01	
Calcium Ca	mg/kg		356.0	188.0	
Chromium Cr	mg/kg		1.9	0.8	
Cobalt Co	mg/kg		0.4	0.1	
Copper Cu	mg/kg		6.5	0.9	
Iron Fe	mg/kg		1012.6	198.5	
Lead Pb	mg/kg		1.8	0.2	
Lithium Li	mg/kg		1.2	0.2	
Magnesium Mg	mg/kg		79.1	75.6	
Manganese Mn	mg/kg		3.0	2.9	
Mercury Hg	ug/kg		<DL	<DL	
Molybdenum Mo	mg/kg		0.8	0.2	
Nickel Ni	mg/kg		1.3	0.5	
Phosphorus P	mg/kg		331.5	296.6	
Potassium K	mg/kg		127.1	25.2	
Selenium Se	mg/kg		0.9	0.1	
Silicon Si	mg/kg		675.1	220.0	
Silver Ag	mg/kg		<DL	<DL	
Sodium Na	mg/kg		277.4	256.7	
Strontium Sr	mg/kg		11.6	0.7	
Sulphur (S)	mg/kg		<DL	<DL	
Thallium Tl	mg/kg		0.1	0.0	
Tin Sn	mg/kg		63.8	12.8	
Titanium Ti	mg/kg		143.3	39.9	
Uranium U	mg/kg		0.2	0.0	
Vanadium V	mg/kg		3.3	0.7	
Zinc Zn	mg/kg		1.8	0.9	
Zirconium Zr	mg/kg		4.6	<DL	

SGS proposal: 20676-PR1-R1
SGS project #: 2452

Sample receipt date: 2-Dec-24
Report date: 17-Jan-25

Version: Final

Metals - Multi-Acid Digestion with ICP-OES/MS Finish

Test	Residual wt	Al	Ba	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ni	P	S	Sr	Ti
Units	g	%	mg/kg	%	mg/kg	mg/kg	%	%	mg/kg	%	mg/kg	%	mg/kg	%	%	mg/kg	%
Method Code		ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12
Lower detection		0.01	1	0.01	1	0.5	0.01	0.01	1	0.01	2	0.01	1	0.01	0.01	0.5	0.01
Upper detection		15	10000	15	10000	10000	15	15	10000	15	10000	15	10000	15	5	10000	15
Measured concentration																	
B-1 12'-13'	0.9795	8.39	382	0.71	87	48.1	>15.00	1.14	102	0.32	151.00	0.14	56	0.04	0.27	377	0.45
B-1 16'-18'	1.0334	1.84	313	0.26	3	1.2	0.35	1.23	3	0.06	45.00	0.60	2	<0.01	<0.01	82.1	0.04
B-2 8'-9'	0.6845	5.37	412	0.38	42	13.9	2.48	2.58	39	0.70	171.00	0.79	20	0.03	<0.01	107	0.28
B-2 13'-15'	1.0066	1.89	289	0.28	5	1.4	0.49	1.18	4	0.08	70.00	0.61	2	<0.01	<0.01	82.1	0.06
B-3 11'-13'	0.9867	13.26	737	0.51	138	102.0	4.6	1.95	140	0.47	120.00	0.19	88	0.07	0.05	725	0.76
B-3 17'-19'	1.0279	2.04	360	0.27	3	1.1	0.29	1.46	3	0.06	48.00	0.63	2	<0.01	<0.01	89.6	0.05
B-4 10'-12'	1.0272	8.88	452	0.52	92	51.8	8.23	1.52	148	0.30	105.00	0.31	55	0.05	0.03	443	0.49
B-5 10'-15'	0.9708	6.74	368	0.3	62	32.0	3.91	1.48	60	0.24	70.00	0.37	34	0.02	0.04	217	0.33
B-5 18'-20'	1.023	1.99	345	0.27	3	1.1	0.33	1.38	3	0.06	52.00	0.62	2	<0.01	<0.01	87.2	0.05
B-5 21 1/2'-22 1/2'	0.8693	1.93	242	0.43	8	1.2	0.96	0.94	5	0.18	138.00	0.65	5	0.01	<0.01	70.9	0.08
B-6 6"-18"	0.9123	9.74	625	0.8	100	58.3	9.01	1.63	123	0.42	169.00	0.27	64	0.06	0.03	456	0.55
B-6 5'-7'	0.8359	1.86	284	0.27	6	1.6	0.62	1.16	4	0.09	79.00	0.56	3	0.01	<0.01	78.3	0.06
*Rep B-3 11'-13'		12.65	706	0.49	131	97.8	4.42	1.87	134	0.45	115.00	0.19	85	0.07	0.05	695	0.74
Concentration relative to initial mass																	
B-1 12'-13'	1.0842	7.58	345.1	0.64	79	43.5	>DL	1.03	92	0.29	136.42	0.13	51	0.04	0.24	341	0.41
B-1 16'-18'	1.0847	1.75	298.2	0.25	3	1.1	0.33	1.17	3	0.06	42.87	0.57	2	<DL	<DL	78	0.04
B-2 8'-9'	1.073	3.43	262.8	0.24	27	8.9	1.58	1.65	25	0.45	109.09	0.50	13	0.02	<DL	68	0.18
B-2 13'-15'	1.0794	1.76	269.5	0.26	5	1.3	0.46	1.10	4	0.07	65.28	0.57	2	<DL	<DL	77	0.06
B-3 11'-13'	1.0792	12.12	673.8	0.47	126	93.3	4.21	1.78	128	0.43	109.71	0.17	80	0.06	0.05	663	0.69
B-3 17'-19'	1.0775	1.95	343.4	0.26	3	1.0	0.28	1.39	3	0.06	45.79	0.60	2	<DL	<DL	85	0.05
B-4 10'-12'	1.0918	8.35	425.3	0.49	87	48.7	7.74	1.43	139	0.28	98.79	0.29	52	0.05	0.03	417	0.46
B-5 10'-15'	1.0821	6.05	330.1	0.27	56	28.7	3.51	1.33	54	0.22	62.80	0.33	31	0.02	0.04	195	0.30
B-5 18'-20'	1.0833	1.88	325.8	0.25	3	1.0	0.31	1.30	3	0.06	49.11	0.59	2	<DL	<DL	82	0.05
B-5 21 1/2'-22 1/2'	1.0774	1.56	195.3	0.35	6	1.0	0.77	0.76	4	0.15	111.35	0.52	4	0.01	<DL	57	0.06
B-6 6"-18"	1.0814	8.22	527.3	0.67	84	49.2	7.60	1.38	104	0.35	142.57	0.23	54	0.05	0.03	385	0.46
B-6 5'-7'	1.0907	1.43	217.7	0.21	5	1.2	0.48	0.89	3	0.07	60.54	0.43	2	0.01	<DL	60	0.05
QA/QC																	
Blank		<0.01	<1	<0.01	<1	<0.5	<0.01	<0.01	<1	<0.01	<2	<0.01	<1	<0.01	<0.01	<0.5	<0.01
Certified standards																	
*Std OREAS 609b		6.32	337.0	0.88	17	4883.0	2.90	2.55	30	0.14	212.00	1.84	8	0.03	2.30	207	0.12
*Std OREAS 681		7.50	388.0	5.48	1759	267.0	7.34	1.35	13	4.83	1200.00	1.59	475	0.14	0.11	438	0.56

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Burnaby - British Columbia - V5A 4W4
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Test	V	Zn	Zr	Ag	As	Be	Bi	Cd	Ce	Co	Cs	Ga	Hf	In	La	Lu
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Method Code	ICP40Q12	ICP40Q12	ICP40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12
Lower detection	2	1	0.5	0.02	1	0.1	0.04	0.02	0.05	0.1	1	0.1	0.02	0.01	0.05	0.1
Upper detection	10000	10000	10000	100	10000	2500	10000	10000	1000	10000	1000	1000	500	1000	10000	1000
Measured concentration																
B-1 12'-13'	107	33	156	0.17	10	7.1	0.11	<0.02	94.52	23.9	8	11.9	4.6	0.03	44.30	0.64
B-1 16'-18'	7	4	28.7	0.04	1	0.3	<0.04	<0.02	8.64	0.7	<1	3.8	0.9	<0.02	5.60	0.06
B-2 8'-9'	71	40	99.3	0.1	5	1.4	0.07	0.14	39.96	6.7	4	13.9	3.1	0.05	20.90	0.22
B-2 13'-15'	10	5	32.6	0.04	1	0.4	<0.04	<0.02	9.69	1	<1	4.0	1.0	<0.02	6.20	0.07
B-3 11'-13'	189	76	209	0.35	26	15.6	0.66	0.08	175	42.7	10	45.4	6.4	0.11	84.50	1.12
B-3 17'-19'	6	4	29.5	0.04	<1	0.4	<0.04	<0.02	9.52	0.7	<1	4.5	0.9	<0.02	5.90	0.06
B-4 10'-12'	124	30	150	0.13	3	10.4	0.13	<0.02	104	20.7	6	18.2	4.5	0.03	52.80	0.70
B-5 10'-15'	73	32	94.4	0.2	11	5.8	0.19	0.06	69.79	14.1	6	15.4	2.8	0.05	34.20	0.40
B-5 18'-20'	7	4	31.9	0.04	<1	0.3	<0.04	<0.02	8.95	0.7	<1	4.4	0.9	<0.02	5.60	0.06
B-5 21 1/2'-22 1/2'	19	7	35.3	0.07	4	0.3	<0.04	<0.02	12.09	2.1	<1	4.7	1.1	<0.02	7.20	0.09
B-6 6"-18"	131	35	176	0.12	10	9.9	0.16	<0.02	118	28.1	8	18.1	5.2	0.04	58.20	0.79
B-6 5'-7'	11	6	30.2	0.03	3	0.4	<0.04	<0.02	9.77	1.1	<1	4.1	0.9	<0.02	6.00	0.07
*Rep B-3 11'-13'	183	72	200	0.35	23	15	0.62	0.26	171	40.9	9	42.1	6.0	0.12	82.20	1.10
Concentration relative to initial mass																
B-1 12'-13'	97	30	140.9	0.15	9	6.4	0.10	<DL	85.39	21.6	7	10.8	4.2	0.03	40.02	0.58
B-1 16'-18'	7	4	27.3	0.04	1	0.3	<DL	<DL	8.23	0.7	<DL	3.6	0.8	<DL	5.34	0.06
B-2 8'-9'	45	26	63.3	0.06	3	0.9	0.04	0.09	25.49	4.3	3	8.9	1.9	0.03	13.33	0.14
B-2 13'-15'	9	5	30.4	0.04	1	0.4	<DL	<DL	9.04	0.9	<DL	3.7	0.9	<DL	5.78	0.07
B-3 11'-13'	173	69	191.1	0.32	24	14.3	0.60	0.07	160.00	39.0	9	41.5	5.8	0.10	77.26	1.02
B-3 17'-19'	6	4	28.1	0.04	<DL	0.4	<DL	<DL	9.08	0.7	<DL	4.3	0.9	<DL	5.63	0.06
B-4 10'-12'	117	28	141.1	0.12	3	9.8	0.12	<DL	97.85	19.5	6	17.1	4.2	0.03	49.68	0.66
B-5 10'-15'	65	29	84.7	0.18	10	5.2	0.17	0.05	62.61	12.6	5	13.8	2.5	0.04	30.68	0.36
B-5 18'-20'	7	4	30.1	0.04	<DL	0.3	<DL	<DL	8.45	0.7	<DL	4.2	0.9	<DL	5.29	0.06
B-5 21 1/2'-22 1/2'	15	6	28.5	0.06	3	0.2	<DL	<DL	9.75	1.7	<DL	3.8	0.9	<DL	5.81	0.07
B-6 6"-18"	111	30	148.5	0.10	8	8.4	0.13	<DL	99.55	23.7	7	15.3	4.4	0.03	49.10	0.67
B-6 5'-7'	8	5	23.1	0.02	2	0.3	<DL	<DL	7.49	0.8	<DL	3.1	0.7	<DL	4.60	0.05
QA/QC																
Blank	<2	<1	<0.5	<0.02	<1	<0.1	<0.04	<0.02	<0.05	<0.1	<1	<0.1	<0.02	<0.02	<0.1	<0.01
Certified standards																
*Std OREAS 609b	13	1188	166.0	22.12	1378	2.5	104.00	8.35	74.67	5.3	6	23.1	5.0	2.16	36.90	0.08
*Std OREAS 681	237	78	54.6	0.13	2	1.4	0.09	0.07	40.23	51.5	4	18.0	1.7	0.04	19.00	0.29

Test	Mo	Nb	Pb	Rb	Sb	Sc	Se	Sn	Ta	Tb	Te	Th	Tl	U	W	Y	Yb
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ppm	ppm
Method Code	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12
Lower detection	0.5	0.2	0.05	0.5	2	0.3	0.05	0.05	0.05	0.2	0.02	0.05	0.1	0.1	0.1	0.05	0.1
Upper detection	10000	10000	10000	10000	1000	1000	10000	10000	1000	10000	10000	10000	10000	10000	1000	10000	100
Measured concentration																	
B-1 12'-13'	3.76	18.0	12.8	76.2	1.17	19.8	2	151	1.28	1.36	<0.05	13.8	0.86	5.3	2.4	43.8	4.1
B-1 16'-18'	0.08	1.0	6.2	34.2	0.13	0.9	<2	154	0.06	0.08	<0.05	1.1	0.19	0.3	0.2	2.5	0.3
B-2 8'-9'	0.56	8.9	8.5	92.5	0.48	8.0	<2	312	0.62	0.30	<0.05	5.8	0.54	1.9	0.9	10.0	1.3
B-2 13'-15'	0.13	5.3	5.3	34.9	0.16	1.3	<2	166	0.65	0.09	<0.05	1.2	0.19	0.3	0.2	2.8	0.4
B-3 11'-13'	3.64	28.9	55.6	127.0	3.88	35.8	9	139	2.07	2.42	0.07	28.3	3.08	9.6	3.5	77.0	7.4
B-3 17'-19'	0.06	1.5	7.2	42.3	0.15	1.1	<2	143	0.10	0.09	<0.05	1.0	0.24	0.3	0.1	2.7	0.4
B-4 10'-12'	1.91	17.9	20.1	89.8	1.15	22.5	<2	134	1.24	1.42	<0.05	15.4	1.29	6.2	1.7	47.5	4.4
B-5 10'-15'	1.29	12.0	19.6	79.6	1.12	13.7	<2	161	0.79	0.85	<0.05	10.5	1.56	3.0	1.8	28.0	2.6
B-5 18'-20'	0.09	1.3	5.8	40.1	0.15	1.2	<2	156	0.07	0.09	<0.05	1.1	0.22	0.3	0.1	2.9	0.4
B-5 21 1/2'-22 1/2'	0.17	1.8	3.9	28.9	0.14	2.6	<2	211	0.08	0.11	<0.05	1.4	0.15	0.5	0.4	3.8	0.6
B-6 6'-18"	3.73	19.9	18.1	99.6	1.53	23.3	<2	146	1.39	1.62	<0.05	18.1	0.80	6.7	2.3	53.9	5.1
B-6 5'-7'	0.19	1.6	5.4	34.2	0.16	1.5	<2	206	0.08	0.09	<0.05	1.4	0.19	0.4	0.1	3.0	0.4
*Rep B-3 11'-13'	3.49	28.1	54.4	119.0	3.69	34.5	8	127	2.00	2.31	0.05	27.3	2.99	9.3	3.4	75.7	7.0
Concentration relative to initial mass																	
B-1 12'-13'	3.40	16.3	11.6	68.8	1.06	17.9	2	136	1.16	1.23	<DL	12.5	0.78	4.8	2.2	39.6	3.7
B-1 16'-18'	0.08	1.0	5.9	32.6	0.12	0.9	<DL	147	0.06	0.08	<DL	1.0	0.18	0.3	0.2	2.4	0.3
B-2 8'-9'	0.36	5.7	5.4	59.0	0.31	5.1	<DL	199	0.40	0.19	<DL	3.7	0.34	1.2	0.6	6.4	0.8
B-2 13'-15'	0.12	4.9	4.9	32.5	0.15	1.2	<DL	155	0.61	0.08	<DL	1.1	0.18	0.3	0.2	2.6	0.4
B-3 11'-13'	3.33	26.4	50.8	116.1	3.55	32.7	8	127	1.89	2.21	0.06	25.9	2.82	8.8	3.2	70.4	6.8
B-3 17'-19'	0.06	1.4	6.9	40.4	0.14	1.0	<DL	136	0.10	0.09	<DL	1.0	0.23	0.3	0.1	2.6	0.4
B-4 10'-12'	1.80	16.8	18.9	84.5	1.08	21.2	<DL	126	1.17	1.34	<DL	14.5	1.21	5.8	1.6	44.7	4.1
B-5 10'-15'	1.16	10.8	17.6	71.4	1.00	12.3	<DL	144	0.71	0.76	<DL	9.4	1.40	2.7	1.6	25.1	2.3
B-5 18'-20'	0.08	1.2	5.5	37.9	0.14	1.1	<DL	147	0.07	0.08	<DL	1.0	0.21	0.3	0.1	2.7	0.4
B-5 21 1/2'-22 1/2'	0.14	1.5	3.1	23.3	0.11	2.1	<DL	170	0.06	0.09	<DL	1.1	0.12	0.4	0.3	3.1	0.5
B-6 6'-18"	3.15	16.8	15.3	84.0	1.29	19.7	<DL	123	1.17	1.37	<DL	15.3	0.67	5.6	1.9	45.5	4.3
B-6 5'-7'	0.15	1.2	4.1	26.2	0.12	1.1	<DL	158	0.06	0.07	<DL	1.1	0.15	0.3	0.1	2.3	0.3
QA/QC																	
Blank	<0.05	<0.1	0.500	<0.2	<0.05	<0.5	<2	<0.3	<0.05	<0.05	<0.05	<0.2	0.03	<0.05	<0.1	<0.1	<0.1
Certified standards																	
*Std OREAS 609b	5.87	14.8	428.0	105.0	167.00	3.9	13.00	13	1.08	0.62	22.09	12.4	1.49	4.3	4.5	12.0	0.6
*Std OREAS 681	1.46	6.4	10.5	77.7	0.23	29.5	<2	2	0.43	0.62	0.16	6.6	0.17	1.5	1.1	17.6	1.8

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Metals - Multi Acid Digestion with ICP-OES/MS Finish - CRM Expected Values and Tolerance

CRM	Test	Al	Ba	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ni	P	S	Sr	Ti	V
	Units	%	ppm	%	ppm	ppm	%	%	ppm	%	ppm	%	ppm	%	%	ppm	%	ppm
Method Code	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12	ICP40Q12
	Lower detection	0.01	1	0.01	1	0.5	0.01	0.01	1	0.01	2	0.01	1	0.01	0.01	0.5	0.01	2
	Upper detection	15	10000	15	10000	10000	15	15	10000	15	10000	15	10000	15	5	10000	15	10000
OREAS 905	Expected value	7.42	2699.0	0.59	19.2	1533	4.08	2.88	20	0.28	380	2.40	9.5	0.028	0.07	157	0.12	10.1
	Tolerance (%)	10.7	14.0	14.2	49.1	11.9	11.5	12.1	23.9	17.2	13.0	14.1	26.5	24.6	29.4	12.5	15.4	28.6
OREAS 601B	Expected value	6.63	BDL	0.887	23.7	1010	2.29	2.41	22.6	0.10	222	1.90	6.5	0.029	1.50	241	0.14	12.1
	Tolerance (%)	10.1		14.9	37.6	6.8	10.7	9.4	26.3	20.0	11.1	14.3	30.9	15.1	7.2	14.7	11.8	21.7
OREAS 609B	Expected value	6.71		0.939	19.9	4980	2.89	2.53	30.9	0.147	230	1.91	7.35	0.033	2.27	219	0.122	14.4
	Tolerance (%)	10.37		11.33	<=28	10.03	10.87	10.99	18.09	13.40	12.17	10.65	44.01	17.58	10.55	10.57	12.05	44.72
OREAS 681	Expected value	7.91	442	5.98	1642	264	7.47	1.35	13	5.19	1310	1.61	503	0.141	0.109	478	0.588	253
	Tolerance (%)	10.32	10.57	10.21	15.15	10.47	10.33	11.85	29.23	10.10	10.38	10.78	10.50	11.77	21.47	10.26	10.43	11.98

CRM	Test	Zn	Zr	Ag	As	Be	Bi	Cd	Ce	Co	Cs	Ga	Hf	In	La	Lu	Mo	Nb
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Method Code	ICP40Q12	ICP40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12
	Lower detection	1	0.5	0.02	1	0.1	0.04	0.02	0.05	0.1	1	0.1	0.02	0.02	0.1	0.01	0.05	0.1
	Upper detection	10000	10000	100	10000	2500	10000	10000	1000	10000	1000	1000	500	500	10000	1000	10000	1000
OREAS 905	Expected value	138	252.000	0.52	34.7	3.04	5.7	0.36	92	14.8	6.78	25.1	6.8	0.64	46	0.1	3.27	18.1
	Tolerance (%)	14.5	13.7	55.1	15.0	31.2	17.7	37.7	14.0	16.3	18.0	12.2	16.5	22.3	19.4	43.4	24.0	18.1
OREAS 601B	Expected value	318	186.000	50.10	284	2.24	18.0	2.05	70	2.97	4.88	23.4	5.1	0.47	33.5	0.0731	5.22	14.4
	Tolerance (%)	5.6	17.0	10.4	19.2	44.2	19.0	16.3	35.5	18.6	11.4	22.9	17.4	17.0	22.6	54.6	27.1	21.7
OREAS 609B	Expected value	1,308	181	24.6	1,500	2.43	110	8.16	71	5.43	5.28	23	5	2.05	35.3	0.083	5.54	14.6
	Tolerance (%)	10.19	10.69	10.20	10.17	15.14	10.02	10.61	10.18	14.60	12.37	10.54	11.00	10.61	10.35	40.12	12.26	11.71
OREAS 681	Expected value	88	58	0.118		1.41	0.098		40.6	51	4.02	17.6	1.7	0.042	18.8	0.27	1.38	6.17
	Tolerance (%)	12.84	12.16	52.37		18.87	35.51		10.31	10.49	13.11	10.71	12.94	39.76	10.66	19.26	19.06	14.05

CRM	Test	Pb	Rb	Sb	Sc	Se	Sn	Ta	Tb	Te	Th	Tl	U	W	Y	Yb
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Method Code	ICP40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	ICM40Q12	
	Lower detection	0.5	0.2	0.05	0.5	2	0.3	0.05	0.05	0.05	0.2	0.02	0.05	0.1	0.1	0.1
	Upper detection	10000	10000	10000	10000	1000	1000	10000	10000	1000	10000	10000	10000	10000	10000	1000
OREAS 905	Expected value	30.40	138	1.95	4.9	2.84	3.96	1.34	0.77	0.1	14.60	0.7	5.0	2.78	15.7	0.68
	Tolerance (%)	20.7	13.8	19.7	28.2	34.0	20.5	18.5	27.1	58.3	15.6	22.9	18.4	18.8	15.4	21.2
OREAS 601B	Expected value	318.0	98	22.9	3.8	10.6	3.36	1.11	0.52	12.6	11.90	1.4	4.6	6.13	11.1	0.54
	Tolerance (%)	14.7	10.9	27.4	19.0	31.2	15.8	20.6	40.4	22.8	20.7	19.2	14.0	16.6	13.7	30.4
OREAS 609B	Expected value	448	109	158	3.73	15.5	11.6	1.07	0.57	21.5	12.2		4.26	4.42	11.4	0.56
	Tolerance (%)	10.28	10.23	10.08	16.70	26.13	14.31	26.68	31.93	10.58	10.20		12.93	20.66	12.19	54.64
OREAS 681	Expected value	10.2	80	0.24	27.7		1.89	0.42	0.58		6.55		1.44	1.09	17.5	1.77
	Tolerance (%)	22.25	10.31	62.08	10.90		36.46	44.76	31.55		10.38		18.68	37.94	11.43	24.12

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