



KUDZ ZE KAYAH PROJECT

ENVIRONMENTAL MONITORING, SURVEILLANCE AND REPORTING PLAN

REV 01

June 2026

BMC Minerals Ltd.

This Management Plan has been developed to meet the appropriate subject objectives based on existing regulatory requirements, current or planned site activities, existing and expected site conditions, and designed outcomes at the time of writing. Operational processes/practices for achievement of licence terms and conditions may be updated from time to time as appropriate due to changes to relevant legislation and regulations, changes to site activities or conditions, differences from expected objective outcomes, or improvement of management practices. All rates, capacities, dimensions, weights, volumes and durations in text or figures are based on current feasibility level designs and are subject to change based on final design, licence conditions or site conditions encountered. Updates will be resubmitted to government authorities and/or stakeholders as required.

LIST OF REVISIONS

Issue Date	Revision Number	Description of Revision
April 19, 2024	Rev 0	For Issue to Agencies
June 6, 2026	Rev 01	Administrative updates in response to EMR completeness check, and minor updates to reflect the 2026 Decision Document

SUMMARY OF REVISIONS

Information Request/Intervention	Document	Exhibit	Section	Revision
EMSRP Revision 00				
YG Intervention (Exhibit 5.2) Recommendation 32: Install staff gauges or alternative visible markings on storage ponds.	Environmental Monitoring, Surveillance and Reporting Plan (EMSRP)	TBD	4.1	Added discussion of pond level markings.
YG Intervention (Exhibit 5.2) Recommendation 33: Add a list of all ponds and associated water level sensors in the EMSRAMP.	EMSRP	TBD	11.2	All ponds are listed in Table 4-1 along with monitoring details.
YG Intervention (Exhibit 5.2) Recommendation 34: Discuss plans for monitoring and taking actions on sediment accumulation in water management ponds and describe what is meant by 'maintaining adequate capacity'.	EMSRP	TBD	11.1	Added discussion of sediment management.
YG Intervention (Exhibit 5.2) Recommendation 59: Include flow monitoring near the Class C storage facility and overburden discharge point to Geona Creek (KZ-41), as well as at the nearby non-contact diversion (KZ-40) and un-impacted creek (KZ-18).	EMSRP	TBD	4.2	Flow monitoring includes KZ-18, KZ-40 and KZ-41 near these locations.
YG Intervention (Exhibit 5.2) Recommendation 61: Report on reagent use in the mill annually and adapt the monitoring requirements accordingly to monitor for the reagent and potential by-products in the effluent.	EMSRP	TBD	5.2, 5.4	Updated to discuss reporting of reagent use in the Process Plant and to list all analytes.
YG Intervention (Exhibit 5.2) Recommendation 62: Describe what monitoring measures are in place related to hydrocarbons (e.g., visual inspections, seep survey, water samples) near the Landfill Treatment Facility.	EMSRP	TBD	11.4	Added discussion of monitoring of the Land Treatment Facility.
YG Intervention (Exhibit 5.2) Recommendation 66:	EMSRP	TBD	6.2	Organized groundwater monitoring table as requested. This table will be updated as needed as part of EMSRP updates.

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The license should require that groundwater monitoring be conducted in specific hydrogeological settings; that is, in specific aquifers in specific locations relative to mine site components. To operationalize this requirement, the schedule in the licence that lists stations where groundwater monitoring is required should list the stations based on the specific aquifer and location (relative to a specific mine site component), to be monitored (for example, the unconsolidated aquifer down gradient of the Class A storage facility). The schedule should also list the codes of the stations being used to fulfill the monitoring requirements at the time of issuance of the licence. A table proposing how this schedule of the licence could be drafted is included as Appendix 1 of this intervention. The EMSRAMP should be updated annually to reflect when wells are destroyed or decommissioned and replaced and to confirm that there are active monitoring wells at each setting for which groundwater monitoring is required by the licence.				
YG Intervention (Exhibit 5.2) Information Request 67: Wells that will have continuous (i.e. data logger) water level monitoring should be identified and included in the monitoring table.	EMSRP	TBD	6.2	All wells will be equipped with dataloggers, as detailed in Table 6-3.
YG Intervention (Exhibit 5.2) Information Request 68: Clarify the list of proposed groundwater monitoring wells.	EMSRP	TBD	6.2	Table 6-3 summarizes proposed groundwater monitoring wells.
YG Intervention (Exhibit 5.2) Recommendation 71: The EMSRAMP should include discussion of how wells will be protected (e.g. jersey barriers, fencing, caps, locking lids, etc.) and how they will ensure the collection of representative samples.	EMSRP	TBD	6.2, 6.3	Added additional details of well protection and sampling methods.
YG Intervention (Exhibit 5.2) Information Request 74: a. What will be the frequency of visual inspection of water management infrastructure that has been lined?	EMSRP	TBD	5.2 and 11.1	Added additional details of pond monitoring.

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b. Other than visual inspection of pond liners, what other monitoring systems are in place to identify leaks or seeps from water management infrastructure early on? c. What is the proposed frequency for seep investigations?				
YG Intervention (Exhibit 5.2) Comment 93: In the EMSRAMP (Exhibit 1.30.1, section 5.3.2), a reference to sampling procedures for dissolved metals includes the use of 45 µm filter. Please confirm that this is a typographical error and that the SOP includes a 0.45 µm filter.	EMSRP	TBD	5.3, 6.3	Corrected erroneous filter size from 45 µm to 0.45 µm.
LFN Intervention (Exhibit 5.6.4): Memo- WQ Model, WTP Predictions, WQO's Report, EQS.pdf Monitoring plans for vegetation, including riparian and wetland plants important for Kaska use, are very limited and lacking adequate detail	EMSRP	TBD	9	Added additional details of vegetation monitoring.
LFN Intervention (Exhibit 5.6.4): Memo- WQ Model, WTP Predictions, WQO's Report, EQS.pdf Permanent ecosystem plots will only be remeasured every three years, for example, and the frequency of vegetation sampling at other locations is unspecified.	EMSRP	TBD	9	Added additional details of vegetation monitoring.
EMR Phase 5a IR 25 If sediment accumulation was not included in the design of the collection ponds provide the monitoring and management methods that will be put in place to ensure sufficient capacity in these ponds are available.	EMSRP	TBD	11.1	Added discussion of sediment management.
EMR Phase 5a IR 38 Prepare and submit a standalone Environmental Monitoring Plan (EMP) for the construction and operation periods of the project that reflects the comments throughout this information request, previous information requests issued by Mineral Resources Branch and YG's WL Intervention.	EMSRP	TBD	Whole document	The EMSRP has been prepared as a standalone document for Project construction and operation, including revisions relating to information requests issued by YG.

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EMR Phase 5a IR 39 Monitoring needs to be clearly laid out with schedules for each monitoring method including who is responsible for the data collection and how data will be analyzed. A clear monitoring schedule will ensure adaptive management methods can be implemented appropriately.	EMSRP	TBD	1.2.1 and all Chapters	Added additional details of roles and responsibilities, and monitoring schedules in each Chapter, where applicable.
EMR Phase 5a IR 40 The plan does not include any discussion of wetland impacts, mitigations or monitoring. Update EMP to include characterization of the area and a map of wetlands to be disturbed during mining activities, and the avoidance, minimization and reclamation actions undertaken, as well as the area of reclaimed or constructed wetlands post-mining.	EMSRP	TBD	12	Monitoring of wetlands has been added.
EMR Phase 5a IR 41 Standard Operating Protocols are referenced throughout the plan but are not included as appendices. In the updated EMP ensure all applicable Standard Operating Protocols are appended.	EMSRP	TBD	Appendix A to D	As discussed with EMR, the Standard Operating Procedures (SOPs) that are currently available have been included as appendices in the EMSRP. All other SOPs, or equivalent management documents (OMS Manual, GCMP etc.) will be developed and provided to EMR prior to Project construction.
EMR Phase 5a IR 42 Monitoring and reporting of project-related impacts on climate change are not included in the EMP. The updated EMP should include monitoring of scope I and II emissions (i.e., fuel use on site) and indirect scope II emissions (i.e., fuel for transportation of ore, emissions from mine waste). Reporting requirements should be consistent with the annual reporting requirements for quartz mines concerning greenhouse gas emissions.	EMSRP	TBD	11.5	Added discussion of emissions monitoring.
EMR Phase 5a IR 43 Ensure the ambient air quality standards being used and referenced throughout this section of the plan are those identified in Yukon Ambient Air Quality Standards.	EMSRP	TBD	3	Updated with Yukon Air Quality Standard for Nitrogen Dioxide (NO ₂).

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EMR Phase 5a IR 44 As required in Decision Document term and condition 37, ensure the ambient air monitoring plan bases all Criteria Air Contaminants (CACs) on the 2025 YAAQS. This should also be included in the concordance table required at the front of each plan.	EMSRP	TBD	3	All Criteria Air Contaminants are based on the 2025 YAAQS.
EMR Phase 5a IR 45 Predicted NO₂ concentrations presented in Table 4-10 of the air dispersion model report did not exceed the 2014 YAAQS however, when compared to the 2025 YAAQS, NO₂ exceedances are present in the construction, operation and closure phases. Update the EMP to include NO₂ within the suite of monitored contaminants to ensure proper responses are initiated under the adaptive management approach, should the predicted exceedances occur.	EMSRP	TBD	3	Updated the suite of monitored air quality contaminants to include NO ₂ .
EMR Phase 5a IR 46 Update the EMP to include continuous air quality monitoring to allow air quality to be viewed and assessed in real time, which will allow for adaptive management responses to be undertaken as necessary.	EMSRP	TBD	3	Updated to include continuous monitoring for TSP, PM ₁₀ and PM _{2.5} .
EMR Phase 5a IR 47 Provide clarification on the standard presented for chromium in Table 3-2. Based on the standard presented, the chromium form presented in the table is metallic, divalent and trivalent and does not include hexavalent chromium.	EMSRP	TBD	3.4	Updated to specify that the standard for chromium applies to chromium compounds (metallic, divalent, and trivalent forms) only.
EMR Phase 5a IR 48 Monitoring and understanding groundwater quality and quantity is an important aspect for long-term stability of mine waste and water management infrastructure as well as understanding the effectiveness of containment methods for	EMSRP	TBD	6.2	Organized groundwater monitoring table as requested. This table will be updated as needed as part of EMSRP updates.

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these facilities. The updated EMP must consider the recommendations identified in YG's Intervention #66.				
EMR Phase 5a IR 49 Provide additional information regarding well locations and placement as this is integral to capturing representative data to support stability assessments. Consideration must be given to placement relative to mine infrastructure, depth, monitoring measures, and reporting.	EMSRP	TBD	6.2, 11.3	Added additional details of monitoring well locations for groundwater quality and quantity. Also added additional details of monitoring to support stability evaluation. It should be noted that wells for monitoring groundwater quantity and quality are very different in terms of construction, locations and instrumentation than monitoring stations for stability.
EMR Phase 5a IR 50 To ensure environmental monitoring is conducted in a manner that supports implementation of adaptive measures, continuous water level monitoring should be included in groundwater wells installed near mine waste management infrastructure or water conveyance and storage infrastructure.	EMSRP	TBD	6.2	All monitoring wells will be equipped with dataloggers, as detailed in Table 6-3.
EMR Phase 5a IR 51 There is an annotation on Figure 6-1 that refers to a "paste plant" on the southeast side of the ABM pit. From previous plan reviews, it was assumed that paste would be created in the process plant, and not have its own separate facility. Provide clarification on where the paste plant will be located and ensure the EMP includes appropriate monitoring measures relevant to its location.	EMSRP	TBD	Figure 6-1	The paste plant has been removed from the figure.
EMR Phase 5a IR 52 In the updated EMP include the following clarifications or corrections to open pit waste rock geochemical monitoring (section 7.4.1): - The first point in the bulleted list in this section references waste rock boundaries. Will these boundaries be defined by use of a pit block model? - Correct the reference to Table 3-3 in the fourth bullet. - The fifth point in the bulleted list in this section references visual inspections and laboratory analysis. Provide clarification on the frequency of these	EMSRP	TBD	7	Updated in response to these comments.

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inspections and analysis and the threshold for classification. d. The fifth point in the bulleted list in this section references "the latter", but only mentions one mafic volcanic unit. Clarify if there are multiple rock types that rely on visual monitoring. e. The sixth point in the bulleted list in this section references "the mining software package" but does not clarify what that is. Provide additional information on this software including ownership of any databases and reliance on third-party contracts to maintain and operate the software. f. The ninth point in the list references a laboratory QA/QC program. Provide additional details of this program.				
EMR Phase 5a IR 54 Section 7.5 should also reference that an analysis of the geochemical data collected will also be provided in the annual report.	EMSRP	TBD	7.4	Updated to include analysis of geochemical data in annual reporting requirements.
EMR Phase 5a IR 55 Proponent commitments with respect to the management of aquatic invasive species are not represented in the submitted EMSRAMP. The actions and measures identified in those commitments must be included in the updated EMSRP.	EMSRP	TBD	Appendix E	Added details of management of aquatic invasive species.
EMR Phase 5a IR 56 Update the EMP to expand monitoring and surveillance for fish and aquatic resources including spawning surveys for Arctic grayling in both Geona Creek and Finlayson.	EMSRP	TBD	0	Added additional details of monitoring for fish and aquatic life.
EMR Phase 5a IR 57 Increase in aquatic sediments and therefore total dissolved solids, can impact survivability of juvenile fish, as well as decrease spawning success. Section 8.3 of the EMP does not provide details of when samples were taken, in relation to predicting potential sediment during key spawning windows. Include additional detail on the temporal scale of when	EMSRP	TBD	8.1	Added additional details of monitoring for aquatic sediments.

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aquatic sediments are sampled to allow for a more accurate presentation of the impacts to the aquatic system.				
EMR Phase 5a IR 58 Invasive species are not addressed in this plan. Invasive species may become established, particularly within areas disturbed or impacted by mining activities. There is also a proponent commitment to developing an invasive species management plan that should be included in the updated EMSRP and provide clear monitoring and mitigations or controls for invasive species.	EMSRP	TBD	9.2 and Appendix E	Updated to include discussion of invasives species and an Invasive Species Management Plan has been added.
EMR Phase 5a IR 59 Proponent commitments with respect to development of a chance finds procedure for rare plants have not been fulfilled. The actions and measures identified in those commitments must be included in the updated EMSRP.	EMSRP	TBD	9.1	Updated to include a chance find procedure for rare plants.
EMR Phase 5a IR 60 Describe what monitoring measures are in place related to hydrocarbons (e.g., visual inspections, seep survey, water samples) near the Landfill Treatment Facility.	EMSRP	TBD	11.4	Added discussion of monitoring of the Land Treatment Facility.
EMR Phase 5a IR 61 Monitoring of ecosystem plots and change through time, and characterization of vegetation communities and ecosystems must be conducted in accordance with the Field Manual for Describing Yukon Ecosystems when characterizing vegetation communities or ecosystems.	EMSRP	TBD	12.1	Updated to specify that ecological community surveys will be conducted in accordance with the Field Manual for Describing Yukon Ecosystems.
EMR Phase 5a IR 62 There is currently no detailed commitment to monitoring vegetation change at control or impacted sites. Include monitoring and surveillance measures to monitor vegetation change at permanent sample plots, both at control sites, and within the zone of influence of work in the updated EMSRP.	EMSRP	TBD	9, 12	Updated to describe procedures for monitoring vegetation at control and potentially impacted sites.

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EMR Phase 5a IR 63 The plan references trying to sample all vegetation types, with little detail on how this could be accomplished, to allow for more informative comparison of control sites against impacted sites in the same ecosite, the EMSRP should be updated to focus sampling on ecosystem mapping information, based on ecosite's present. This would provide a metric for ensuring that sampling of all major ecosites is completed.	EMSRP	TBD	9	Added additional details of vegetation sampling.
EMR Phase 5a IR 64 The updated EMSRP should utilize ecosite classification to guide sampling and permanent plot establishment to determine and compare impacted and control sites.	EMSRP	TBD	9	Added additional details of vegetation sampling.
EMR Phase 5a IR 65 The updated EMSRP must include additional information with respect to monitoring in wetlands including vegetation communities and vegetation and soil contaminants.	EMSRP	TBD	9, 12	Added additional details of vegetation monitoring (Chapter 9) and wetlands monitoring (Chapter 12)
EMR Phase 5a IR 68 YG's WL Intervention information request 74 and 75 with respect to seepage monitoring applies to our review of the EMSRAMP as well. The updated EMSRP must address the comments and observations raised in YG's Intervention.	EMSRP	TBD	5.2, 11.1	Added additional details of pond monitoring.
EMR Phase 5a IR 69 Mine infrastructure monitoring needs to be clearly laid out with schedules for each monitoring method including who is responsible for the data collection and how data will be analyzed. A clear monitoring schedule will ensure emergency response and adaptive management measures can be implemented appropriately.	EMSRP	TBD	1.2.1, 11	Added additional details of roles and responsibilities, and details of mine infrastructure monitoring.
EMR Phase 5a IR 70	EMSRP	TBD	11.2	Added additional details of open pit geotechnical monitoring.

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A monitoring program for the open pit must be included, the monitoring program must include, but is not limited to: a) Slope monitoring and surveying; b) tension crack mapping and monitoring; c) groundwater monitoring in adjacent to final pit walls; and d) emergency response measures.				
EMR Phase 5a IR 71 Updated the EMSRP to include a monitoring plan for all mine waste management facilities. This plan must include potential run out zones with respect to roads and infrastructure adjacent to the facilities and include these as potential failure outcomes.	EMSRP	TBD	11.3	Added additional details of mine waste management facilities monitoring.

LIST OF ACRONYMS AND ABBREVIATIONS

%	Percent
+CN	Full water quality suite with weak acid dissociable cyanide analysis
ABA	Acid Base Accounting
AMP	Adaptive Management Plan
AP	Acidification potential
ARD	Acid Rock Drainage
BACI	Before-After-Control-Impact
BC ENV	British Columbia Ministry of Environment & Climate Change Strategy
BMC	BMC Minerals Ltd.
°C	Degrees Celsius
CALA	Canadian Association for Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
Cmol	Centimole
COPI	Constituent of Potential Interest
CES	Critical Effect Size
DFO	Fisheries and Oceans Canada
DL	Detection Limit
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQR	Data quality review
dS	Decisiemens
EPP	Emergency Preparedness Plan
EEM	Environmental Effects Monitoring
EMR	Energy, Mines and Resources (Yukon)
EMSRP	Environmental Monitoring, Surveillance and Reporting Plan
EOR	Engineer of Record
EQS	Effluent Quality Standards
FAA	<i>Fisheries Act</i> Authorization
g	Gram
GCMP	Groundwater Control Management Plan
GHG	Greenhouse gas
ICP	Inductively Coupled Plasma (mass, atomic absorption, or optical emission spectroscopy)
InSAR	Interferometric Synthetic Aperture Radar
IP	Invasive Plant
ISMP	Invasive Species Management Plan
HCl	Hydrochloric acid
kg	Kilogram
kPa	kilopascal, a unit of pressure measurement

KZK	Kudz Ze Kayah
LFN	Liard First Nation
LWMP	Lower Water Management Pond
LoMWBM	Life of Mine Water Balance Model
LTF	Land treatment facility
m	Metre
m ²	Square metre
masl	Metres Above Sea Level
MDMER	Metal and Diamond Mining Effluent Regulations
mg/kg	Milligrams per kilogram
mg/L	Milligrams per litre
ML	Metal Leaching
ML/ARD	Metal Leaching and/or Acid Rock Drainage
MS	Mass spectrometry
NO ₂	Nitrogen Dioxide
NP	Neutralization Potential
ORP	Oxidation-Reduction Potential
OMS	Operations, Maintenance and Surveillance
PM _{2.5}	Fine Particulate Matter (less than 2.5 micrometre diameter)
PM ₁₀	Coarse Particulate Matter (less than 10 micrometre diameter)
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
QML	Quartz Mining Licence
RCP	Reclamation and Closure Plan
RPD	Relative Percent Difference (mean repeatability)
RRDC	Ross River Dena Council
SEPA	Socio-Economic Participation Agreement
SD	Standard Deviation
SOP	Standard Operating Protocol
TBD	To be Determined
TARP	Trigger action response plan
TIC	Total inorganic carbon
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
µg	Micrograms
µg/m ³	Micrograms Per Cubic Metre
µm	Micrometre
VWP	Vibrating wire piezometer
WAD	Weak acid dissociable
WMP	Water Management Plan
WQM	Water Quality Model

WQO	Water Quality Objective
WUL	Water Use Licence
YAAQS	Yukon Ambient Air Quality Standards
YG	Yukon Government
YWB	Yukon Water Board
YCDC	Yukon Conservation Data Centre

GLOSSARY

Acid Rock Drainage: Drainage with acidic pH from material having an insufficient capacity to neutralize acidic products of sulphide and elemental sulphur oxidation and dissolution products of acidic material.

Active Closure: Post mining removal of Operations Water Management Ponds, Overburden Stockpile, collection ponds, removal of all pipeworks and structures, and the removal and re-grading of all access roads, ditches and borrow areas not required during closure phases.

Bathymetry: The measurement of depth of water in oceans, seas, or lakes.

Bioassay: Analytical method to determine concentration or potency of a substance by its effect on living cells or tissues.

Bray-Curtis Index: Statistic used to quantify the compositional dissimilarity between two different sites, based on counts at each site. The Bray-Curtis dissimilarity is bounded between 0 and 1, where 0 means the two sites have the same composition (that is they share all the species), and 1 means the two sites do not share any species.

Construction Phase: Project phase that will last approximately two years and includes Project site preparation and clearing and establishment of Project infrastructure.

Engineer of Record: Provides technical knowledge related to the safety of the facility and verifies whether or not the facility (and components thereof): has been designed in accordance with performance objectives and indicators, applicable guidelines, standards and regulatory requirements; and is being constructed or has been constructed and is performing, throughout the life of the facility, in accordance with the documented design intent and requirements.

Evapotranspiration: The process by which water is transferred from the land to the atmosphere by evaporation from land and water surfaces and by transpiration from plants.

Gravimetric Analysis: Gravimetric analysis describes a set of methods used in analytical chemistry for the quantitative determination of an analyte based on its mass.

Hess sampler: Samplers intended for sampling macrobenthos in shallow, flowing waters. They are cylindrical with enclosed sides and an open top. They function similarly to the surber-type samplers but are capable of sampling gravel and small cobble bottoms.

Hydrograph: A hydrograph is a graph showing the rate of flow versus time past a specific point in a river, channel, or conduit carrying flow. The rate of flow is typically expressed in cubic metres per second.

Inductively Coupled Plasma (ICP): Analytical spectroscopy technique used for the detection of chemical elements. The ICP source converts the atoms of the elements in the sample to ions. These ions are then separated and detected by the spectrometer.

Kinetic Testing: A procedure used to analyze dynamic physical and chemical processes of materials over time, including reaction rates, mineral alteration and drainage chemistry and loading resulting from the interaction between water and mine material. Kinetic tests are most often performed in controlled laboratory settings where environmental conditions are simplified (e.g., trickle leach columns and humidity cells) but can also be conducted at study sites under conditions that would be encountered in the field (e.g., field bin leaching tests).

Metal Leaching: Extraction of soluble metals by solvents. Leaching can be natural or induced in a laboratory procedure.

Operations Phase: Project phase that will last approximately 10 years and includes ABM open pit and underground development, and ore processing.

Pedon: Basic unit of soil in the Canadian soil classification system. It is the smallest, three-dimensional unit at the surface of the earth that is considered as soil.

Rating Curve: Graph of discharge versus stage for a given point on a stream, usually at gauging stations, where the stream discharge is measured across the stream channel manually.

Riparian: The interface between terrestrial and river or stream ecosystems.

Salt Dilution Gauging: A salt slug injection involves dissolving a known mass of salt into a volume of water to create a salt tracer solution, and then dumping the tracer into the stream. As the salt slug moves downstream, it disperses and travels as a function of stream discharge. At a point downstream, the concentration of the salt through time (measured through conductivity) can be observed and plotted. The curve can be used to compute discharge by considering continuity equations for the volumetric flow rate of water (discharge) and the mass flow rate of the solute.

Specific Threshold: A defined amount, level, or limit of a quantifiable constituent that when reached, triggers a management response.

Unit Runoff: Direct runoff hydrograph resulting from one unit (e.g. one cm) of constant intensity uniform rainfall occurring over the entire watershed. The concept of unit hydrograph is based on linear systems theory and follow the principles of superposition and proportionality.

Valued Component: Element of the environmental and/or socio-economic systems valued for environmental, scientific, social, aesthetic, or cultural reasons. For the purpose of this environmental assessment, Valued Components are defined to include both environmental and socio-economic aspects.

Velocity-area Method: A method of stream gauging in which depth and vertically averaged velocity measurements are taken at successive locations along a stream cross-section and are numerically integrated to give the streamflow discharge.

Vibrating Wire Piezometer: A piezometer designed such that a change in pressure on the diaphragm causes a change in tension of the wire. An electro-magnetic coil is used to excite the wire, which then vibrates at its natural frequency. It is a device used to measure liquid pressure in a system

by measuring the height to which a column of the liquid rises against gravity, or to measure the pressure (more precisely, the piezometric head) of groundwater at a specific point.

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1 INTRODUCTION

The Kudz Ze Kayah (KZK) Project (the Project) is located on the northern flank of the Pelly Mountain Range, approximately 260 km northwest of Watson Lake and 115 km southeast of Ross River, Yukon, as shown in Figure 1-1. The Project area lies approximately 24 km south of Finlayson Lake and 25 km west of the Wolverine Mine, in the upper portion of the Geona Creek valley, at an elevation of approximately 1,400 metres above sea level (masl). The Project is located in the Traditional Territory of the Kaska Nations.

BMC Minerals Ltd. (BMC) is the owner of the Project. Since acquiring the Project in 2015, BMC has actively engaged in assessing historical work, optimizing design, resource drilling, economic assessment, baseline environmental studies, and First Nations and community engagement as well as the successful completion of the Executive Committee Screening by the Yukon Environmental and Social-economic Assessment Board (YESAB).

The Project encompasses the ABM Deposit, comprising two mineralized zones, the ABM Zone and the Krakatoa Zone. The ABM Deposit is a polymetallic volcanogenic massive sulphide deposit containing economic concentrations of zinc, copper, lead, silver, and gold. Mining of the ABM Deposit will be conducted via both open pit and underground mining methods, with ore processed into separate copper, High Precious Metals (silver, gold and lead), and zinc concentrates via sequential flotation through a nominal 2 million tonnes per annum processing plant. Dry stack (filtered) tailings will be co-disposed with waste rock in the Class A Storage Facility on the western slope of the Geona Creek Valley. Waste rock will be stored in separate storage facilities according to its acid generation and metal leaching potential. Strongly acid generating material will be co-disposed with tailings and/or stored in mined out areas of the open pit and underground workings. Other waste rock material will be placed on the surface in managed facilities. The Project site layout is presented in Figure 1-2.

Project phases are proposed to include:

- Construction: approximately 2 years;
- Operations: approximately 10 years;
- Active Closure: approximately 3 years;
- Transition Closure: approximately 12 years, ending when water discharges via the ABM lake spillway; and
- Post-closure: approximately 10 years.

1.1 OBJECTIVES

This Environmental Monitoring, Surveillance and Reporting Plan (EMSRP) is intended to track the performance and effects of the Project on the environment relative to its predicted performance and effects. It outlines monitoring and reporting for environmental resources, Project facilities, and Project activities during Construction and Operation of the Project. As the Project progresses, this Plan will be updated regularly to incorporate new activities, permit conditions, use of new technologies, and data from ongoing monitoring programs. This Plan is designed to be used in

conjunction with the Adaptive Management Plan (AMP) (BMC, 2026a). Monitoring and reporting during Project closure is described in the Reclamation and Closure Plan (RCP) (BMC, 2026b).

1.2 MONITORING PROGRAMS

Monitoring programs form the basis for data collection and analysis, the results of which inform the management of the environmental components of a project. The monitoring plans described herein are also derived from requirements outlined in the following territorial and federal guidance documents:

- Yukon Water Board (YWB), *Type A And B Quartz Mining Undertakings: Information Package for Applicants* (YWB, 2012);
- Yukon Government (YG), *Guidelines for Developing Adaptive Management Plans in Yukon: Water-related components of quartz mining projects* (Yukon, 2021);
- Environment Canada, *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada, 2012); and
- Environment Canada, *Environmental Code of Practice for Metal Mines* (Environment Canada, 2009).

This Plan outlines monitoring, surveillance and reporting procedures for the Construction and Operations phases of the Project for the following components:

- Chapter 2: Meteorology;
- Chapter 3: Air Quality;
- Chapter 4: Surface Water Quantity;
- Chapter 5: Surface Water Quality;
- Chapter 6: Groundwater Quality and Quantity;
- Chapter 7: Geochemistry;
- Chapter 8: Fish and Aquatic Resources;
- Chapter 9: Terrestrial Resources;
- Chapter 10: Wildlife and Wildlife Habitat;
- Chapter 11: Mine Infrastructure; and
- Chapter 12: Progressive Reclamation.

The following information is provided for each monitoring program, where applicable:

- A description of the program's design and objectives;
- Figures and descriptions of specific monitoring areas or locations;
- Schedules and procedures for monitoring activities, including responsibilities and reporting; and

- Quality control and quality assurance (QC/QA) processes.

1.2.1 Roles and Responsibilities

The Site General Manager will have ultimate accountability for the effective implementation of the EMSRP. The Environment Manager and/or the Mine Manager will be responsible for the implementation of individual monitoring programs, and will lead the teams of engineers, scientists and technicians conducting monitoring activities and analyzing and reporting results, as detailed in Table 1-1.

Monitoring program results will be provided to all applicable regulatory agencies as per specific permit requirements, BMC's commitments to Kaska and Decision Document requirements.

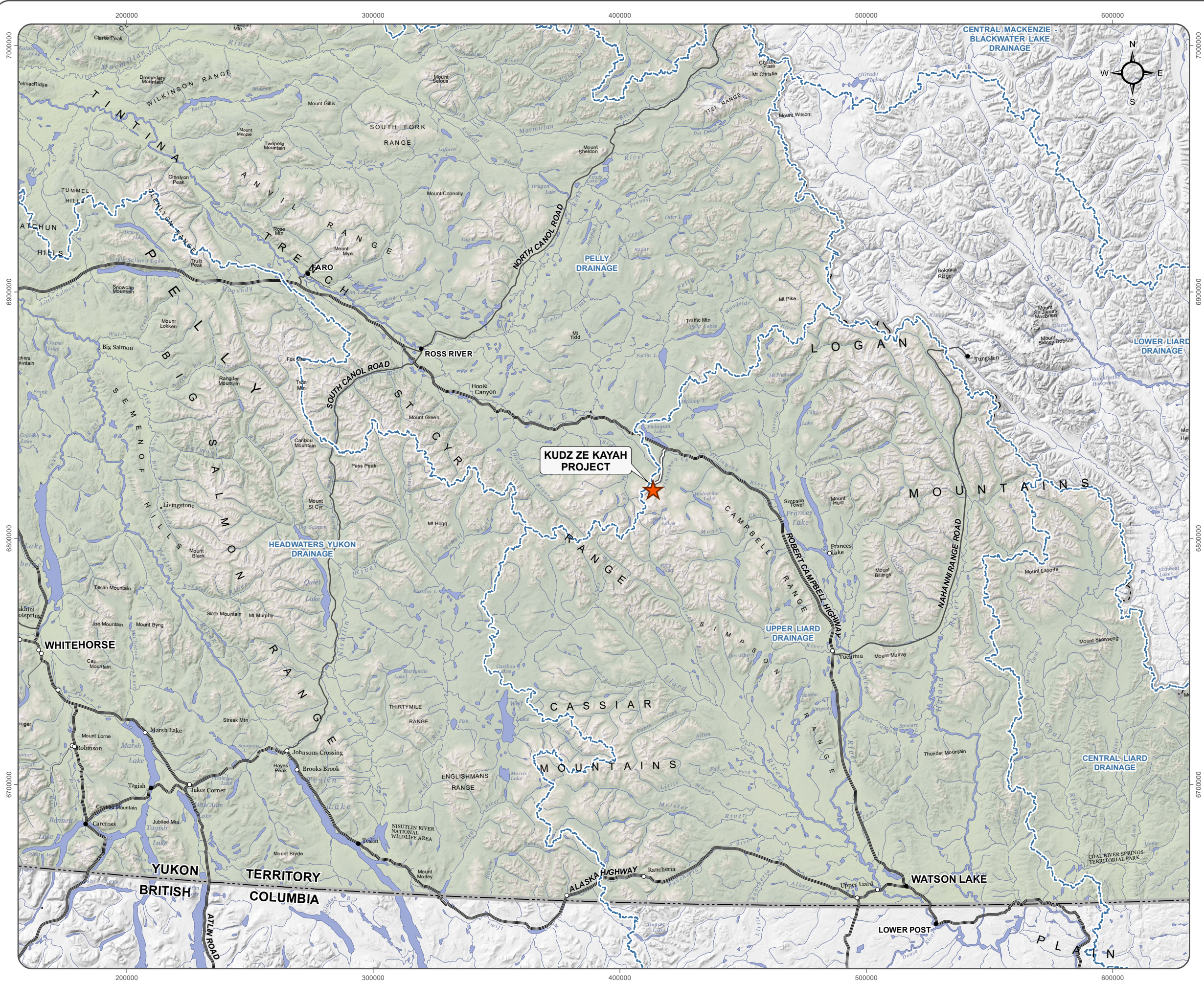
Table 1-1: Monitoring Program Roles and Responsibilities

Role	Responsibilities
General Manager	• Overall accountability for effective implementation of this EMSRP
Environment Manager or Mine Manager	• Overall implementation of individual monitoring programs • Review and disseminate reports and notification of AMP trigger events to regulatory bodies and First Nations
Environment Team and/or Mine Operations Team (Engineers, Environmental Scientists and Technicians)	• Collect data following the specified methods and schedule • Input and evaluate data and manage databases • Prepare and review internal and external reports, and disseminate internal reports • Review data against AMP triggers, and communicate trigger events to Managers • Inspect and maintain equipment • QA/QC activities • Verify compliance with licence requirements • Review and update monitoring program requirements

1.3 PLAN REVIEW AND EXECUTION

BMC has had extensive engagement with Ross River Dena Council (RRDC) including community meetings in Ross River, Elders Oversight Committee Meetings, meetings with Chief and Council and engagement with RRDC's wholly owned environmental consultancy, Dena Cho Environmental and Remediation Inc. (Dena Cho). As part of this ongoing engagement, prior to the initial Environmental Monitoring, Surveillance, Reporting and Adaptive Management Plan being finalized, Dean Cho conducted a detailed independent review of the draft plan. Issues raised during the Dena Cho review were addressed collaboratively through a number of workshops and where appropriate the plan was amended, and additional commitments added. At EMR's request, the plan was separated into two plans (this EMSRP and the AMP). BMC's commitments to RRDC/Dena Cho on the initial plan have been tracked in the Tables of Concordance in each respective updated plan.

BMC and Ross River Dena Council (in its role as lead community for the Kaska Nations, including Liard First Nation) are parties to an existing Socio-Economic Participation Agreement (SEPA) for the KZK Project. In 2019, BMC and RRDC (on behalf of all Kaska Nations) signed a Letter of Intent committing the parties to a modernization process for the existing SEPA. In March 2021, BMC tabled a proposed modernized SEPA with all Kaska leadership. The proposed SEPA includes provision for establishment of a Kaska/BMC Environmental Management Advisory Committee. Under the current proposal before Kaska, this committee will be tasked with, among other things, reviewing and providing input into environmental and socio-economic management plans, receiving and reviewing reports on implementation of those plans, reviewing monitoring plans/results, reviewing incident reports, and reporting back to Kaska members.

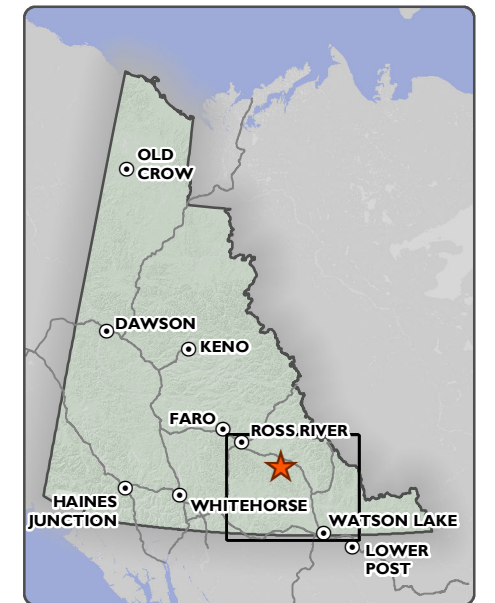


KUDZ ZE KAYAH PROJECT

FIGURE 1-1

PROJECT LOCATION

APRIL 2024



 KUDZ ZE KAYAH PROJECT



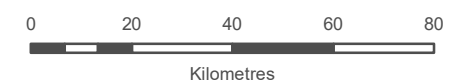
Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 1:50,000. Reproduced under license from Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada. All rights reserved. Drainage areas obtained from National Hydrology Network 2011

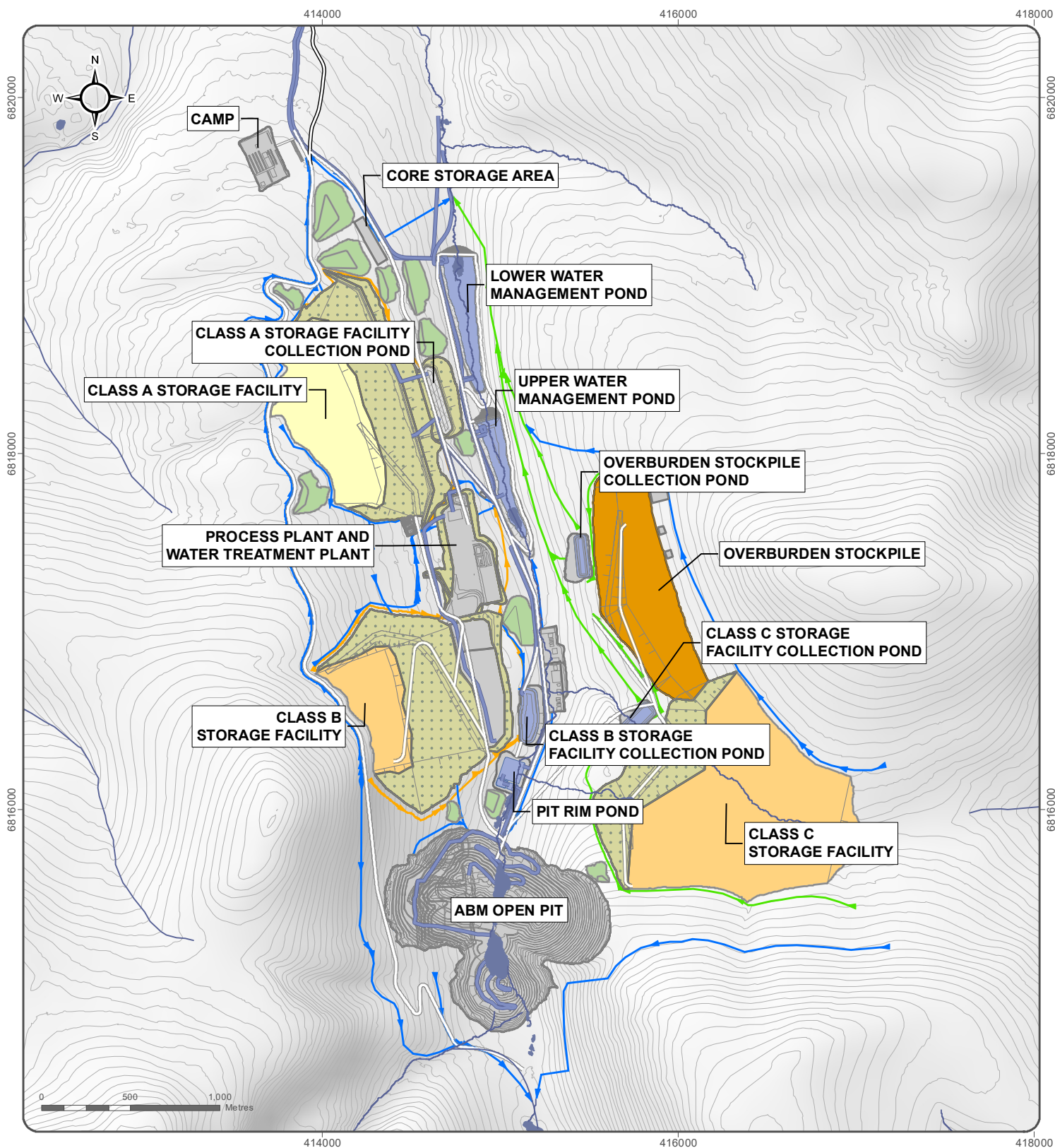
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- Class A Storage Facility
- Class B and C Storage Facility
- Overburden Stockpile

- Topsoil Stockpile
- Progressive Reclamation
- Liner
- Pond/Water

- Non Contact Diversion
- Contact Class A & B Collection
- Contact Class C & OB Collection

KUDZE KAYAH PROJECT

FIGURE 1-2 PROJECT SITE LAYOUT

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2 METEOROLOGY

Meteorological monitoring is conducted to provide the data needed to support Project design and environmental management. The data collected will be used to regularly update the Life of Mine Water Balance Model (LoMWBM) and Water Quality Model (WQM), and to evaluate and update, if justified, the design and operation of mine facilities and infrastructure.

Meteorological monitoring at the Project was conducted in 1995 and 1996, and continuously since 2015, including collection of data on temperature, relative humidity, wind, barometric pressure, solar radiation, precipitation, evaporation and snowpack. Detailed baseline meteorology data are provided in the Site Characterization Plan (BMC, 2026c).

2.1 METHODS

The Project's Campbell Scientific meteorological station is located immediately west of the proposed Class A Storage Facility (Figure 2-1) and includes a 10 m tower, data sensors and a datalogger to collect:

- Air temperature;
- Relative humidity;
- Wind speed and direction;
- Barometric pressure;
- Solar radiation;
- Total precipitation; and
- Evaporation.

The station is equipped with satellite communications to allow for weekly data transfers. The station also estimates evapotranspiration values, based on the measured meteorological parameters and by using the American Society of Civil Engineer's Penman-Monteith Standardized reference evapotranspiration equation (Walter et al., 2000). Evaporation is calculated using parameters from the station and the program RefET (Allen, 2016). Detailed methods for data collection and equipment maintenance are based on the Standard Operating Protocol (SOP) for Meteorological Data Collection (Ensero, 2024), provided in Appendix A.

Snow surveys consist of 10-point transects and will be carried out according to methods outlined in the British Columbia Snow Survey Sampling Guide (British Columbia Ministry of Environment (BC ENV), 1981).

2.2 LOCATIONS AND FREQUENCY

The meteorology monitoring program will be conducted at the meteorological station and snow survey stations shown in Figure 2-1 . Peak snow survey stations Peak West and Peak North will eventually fall within the footprint of the open pit and the Class C Storage Facility, and will be relocated at that time to the nearest undisturbed location that has similar characteristics to the original station in terms of aspect, elevation and vegetation type. Table 2-1 summarizes the monitoring locations for the meteorology monitoring program.

Table 2-1: Meteorology Monitoring Locations and Frequency

Station	Description	UTM Easting (m)	UTM Northing (m)	Frequency
Meteorology Station	Campbell Scientific meteorological station	413710	413710	Station logs hourly data and the data is sent weekly via remote connection
Peak North	Snow survey station	415548	6815732	Annually in March
Peak East ¹	Snow survey station	413911	6817866	Annually in March
Peak South	Snow survey station	415006	6815079	Annually in March
Peak West ¹	Snow survey station	416775	6816434	Annually in March
Baseline Low	Snow survey station	414349	6819874	Annually in March
Baseline Mid	Snow survey station	413586	6817866	Annually in March
Baseline High	Snow survey station	413319	6814476	Annually in March

¹ Station to be relocated during operations.

2.3 QA/QC

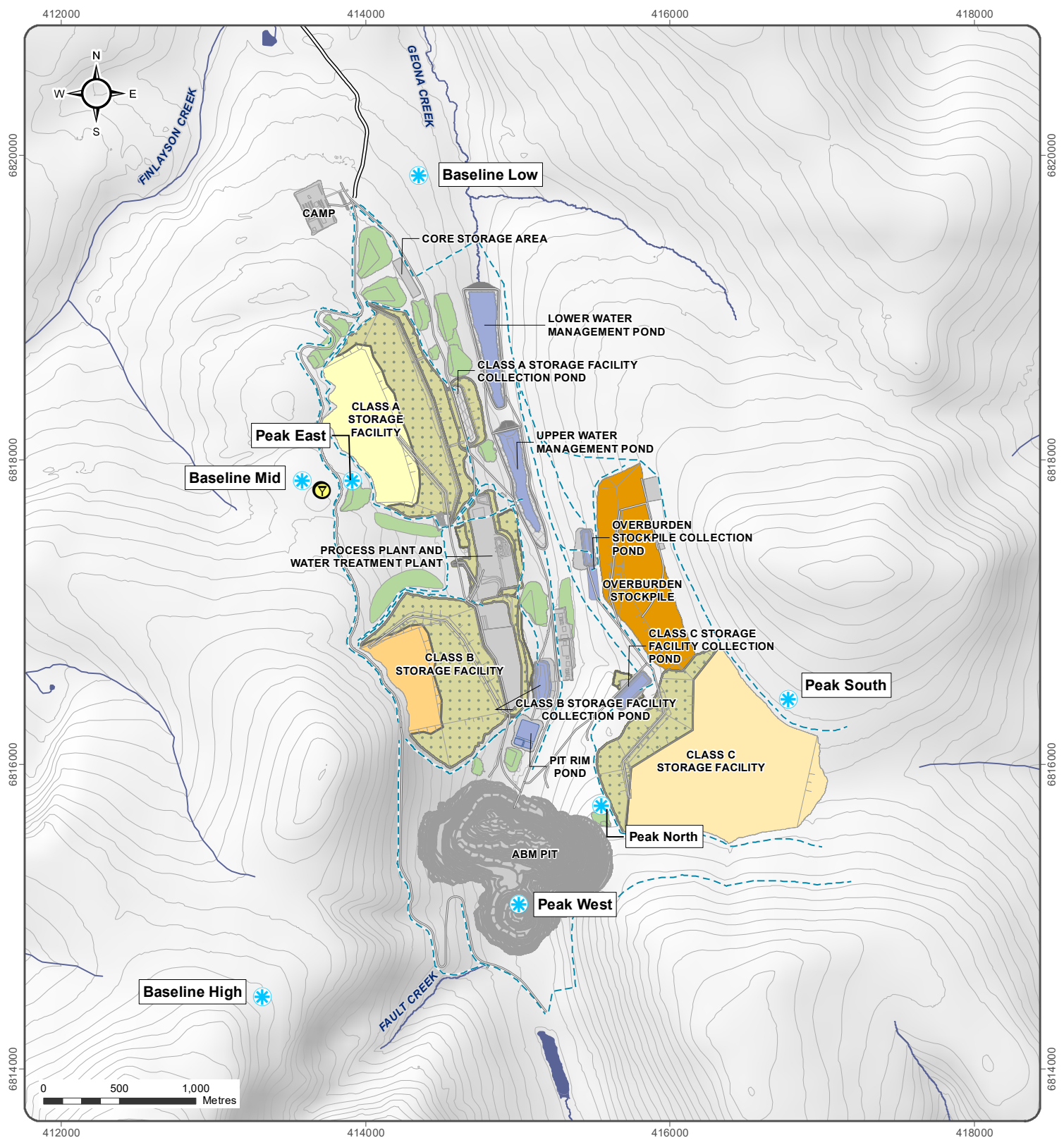
Data collected from the meteorological station are validated by searching for outliers or any unrealistic values, and by compared with data from regional stations as required. Diagnostic values can also be downloaded from the station to determine whether the data needs to be validated and the potential reasons for erroneous values. When suspicious values are noted, appropriate maintenance or troubleshooting actions will be conducted. The station will be inspected and maintained regularly, including:

- Ensuring that the solar panel is free of frost, snow and/or debris;
- Ensuring that the solar radiation sensor is free of frost, snow and/or debris. The sensor is wiped free of dust as needed, using a soft cloth dampened with water or alcohol. Condensation in the dome is also checked;
- Ensuring that the precipitation gauge opening is not obstructed by debris or snow. If clearing is necessary, the date and time when the clearing was completed is recorded;
- Ensuring wires are not damaged and are properly connected to the datalogger inside the enclosure;
- Periodically replacing the desiccant inside the enclosure;
- Periodic calibration of sensors per manufacture's recommendations; and

- Observing any sign of damage to the station by animals, wind. Particular attention is paid to the sensor cables and guy wires, and the guy wires are tightened, as necessary.

2.4 REPORTING

Meteorological data will be compiled, summarized, and submitted to the Yukon Water Board's (YWB's) Waterline monthly. Averages, extremes, totals, and/or other typical statistics will be provided for each parameter, with accompanying figures as applicable. Annual reports, including a summary all data collected in the previous year, will be submitted to both the YWB and Yukon Government, Energy, Mines and Resources Branch (EMR).



- | | | |
|--------------------------------|--------------------------------|--------------------------------|
| Current Meteorological Station | Class A Storage Facility | Diversion Ditch |
| Snow Survey Station | Class B and C Storage Facility | Tote Road/Proposed Access Road |
| | Overburden Stockpile | Proposed Road |
| | Topsoil Stockpile | |
| | Progressive Reclamation | |
| | Pond/Water | |

KUDZ ZE KAYAH PROJECT

FIGURE 2-1

METEOROLOGICAL AND SNOW SURVEY STATION LOCATIONS

APRIL 2024

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3 AIR QUALITY

Air quality monitoring is conducted to ensure that ambient concentrations of Total Suspended Particulate (TSP), coarse particulate matter (particulate matter less than 10 micrometres in diameter; PM₁₀), fine particulate matter (particulate matter less than 2.5 micrometres; PM_{2.5}), and metals do not exceed acceptable levels, and that unforeseen air quality conditions will be rapidly identified and responded to in concordance with the AMP. Baseline air quality monitoring was conducted in 2018 and 2019 at locations selected (in part) using the results of air dispersion modelling (BMC, 2017).

3.1 METHODS

Three air quality monitoring methods will be used to determine ambient concentrations of the different analytes:

- Concentrations of dust (TSP, PM₁₀ and PM_{2.5}) will be monitored continuously using Met One Environmental Beta Attenuation Mass Monitors (E-BAM model). E-BAMs continuously sample and record concentration data every minute.
- Concentrations of metals in TSP will be sampled using the discrete filter method of the BGI Omni Ambient Air Quality Sampler. TSP samples will be collected over a 24-hour period, on a quarterly basis, and sent to a certified laboratory (Canadian Association for Laboratory Accreditation; CALA) for analysis using Inductively Coupled Plasma (ICP) spectroscopy.
- Concentrations of NO₂ will be sampled using a passive/diffusive (non-continuous) method. Sample media, (cartridges) provided by a CALA certified analytical laboratory, will be installed at the sampling locations for one month at a time. Gaseous compounds (i.e., NO₂) are captured by diffusion through a static air layer or permeation of a membrane.

BMC's existing Ambient Air Quality Monitoring SOP was developed for the equipment used for baseline monitoring (BMC, 2019). A new SOP will be developed that is appropriate for new equipment to be used during Project construction and operations, following manufacturer guidance. This will describe data collection, sampler maintenance and calibration methods, including the detailed methods applicable to the air quality monitoring described above.

3.2 LOCATIONS AND FREQUENCY

The air quality monitoring program will be conducted at five existing stations and at one station to be established along the Access Road to assess dust levels generated by traffic, as shown in Figure 3-1. The five existing stations were positioned at sensitive receptors (the camp; AQ-04), downwind of potential dust sources (AQ-01, AQ-02 and AQ-03) and at a control location (AQ-05).

TSP, PM₁₀, PM_{2.5} will be collected continuously to determine concentrations of these suspended particulates generated by the Project's primary dust-generating activities. TSP samples for metals concentrations will be collected quarterly. NO₂ passive samplers will be collected monthly and sent for laboratory analysis. If NO₂ concentrations are found to be consistently well below the Yukon Ambient Air Quality Standards (YAAQS), sampling can be reduced to quarterly, on the same schedule as the TSP metals sampling.

Table 3-1 summarizes the monitoring locations and frequency for the air quality monitoring program.

Table 3-1: Air Quality Monitoring Locations and Frequency

Station	Description	UTM Easting (m)	UTM Northing (m)	Monitoring Frequency
AQ-01	Control station, ~4 km south of the open pit	416,401	6,811,553	Monthly (NO ₂), Quarterly (metals), Continuous (TSP, PM)
AQ-02	Near the open pit	414,671	6,815,184	
AQ-03	Near the process plant	414,130	6,817,797	
AQ-04	West of the camp area	413,250	6,819,450	
AQ-05	Control station, upwind of mine operations	417,403	6,827,543	
AQ-06	Near the Access Road	413,343	6,821,596	

3.3 QA/QC

The following QA/QC steps will be performed for the air quality monitoring program, depending on the sampling method.

For dust:

- Install the E-BAM ambient air samplers as per manufacturer's instructions. Calibrate on installation, and at the frequency specified in BMC's Ambient Air Quality Monitoring SOP (to be developed once the equipment is purchased);
- Verify operation and power supply daily;
- Verify continuous data collection is complete, daily. Investigate any data gaps and complete maintenance as needed. Keep details of data gaps and unscheduled maintenance in a maintenance log;
- Download and perform Level 0 data verification and validation, weekly (CCME, 2019). Level 0 data verification and validation tasks include:
 - Review of automated screening
 - Review 1-hour data for all sites, all parameters
 - Review diagnostics data, alarms and alerts
 - Review time stamps against correct time
 - Identify suspicious data;
- Perform scheduled instrument checks (one-point flow, temperature, pressure and leak check) and cleaning, every three months;
- Perform un-scheduled QC instrument checks (verification of flow rate, temperature, pressure and relative humidity, instrument zero, leak(s) and re-calibrate if necessary) or maintenance/troubleshooting if the data record is incomplete or shows unusual

concentrations. Record events or activities on-site that may have caused unusual concentrations; and

- Perform other routine sampler calibration, data verification and validation tasks as per BMC's Ambient Air Quality Monitoring SOP.

For metals in TSP:

- Install the BGI Omni Ambient Air Quality Sampler ambient air samplers as per manufacturer's instructions. Calibrate on installation, and at the frequency specified in BMC's Ambient Air Quality Monitoring SOP (to be updated);
- New pre-weighed filters received from the lab will be used within 60 days of the lab shipping them;
- Used filters will be analyzed by the lab within 60 days of being sampled;
- One travel blank will be included with the entire quarterly set being sent to the lab;
- A field blank will be collected similarly to a regular sample. At one station, during a 24-hour run, a second "new filter" will be recorded as if it was going to be put in the sampler. Instead, it will be left in its sealed cassette holder and placed with the other filter's cassette holder that will be used to collect the 24-hour run. The field blank will be stored in the same location as the empty cassette holder dish of the filter being used in the sampler;
- Once the run is complete the field blank filter will be removed from the cassette holder, placed in the clean sealable bag provided by the lab and sealed back into the cassette holder to be sent to the lab with the other filters that were run that quarter;
- The travel blank, field blank and the samples will be analyzed by the laboratory using ICP spectroscopy. The laboratory sample report will include QA/QC methods used in the analysis;
- Instrument calibration will be checked and/or performed as per manufacture's specifications; and
- Visual inspection of the instrument and maintenance will be performed as per the maintenance schedule.

For NO₂:

- Install and remove samples wearing latex gloves;
- Label samples (i.e., mine site name, station ID, start sample time and date, end sample time and date);
- Transport sample cartridges in airtight shipping containers between the field and the laboratory to maintain sample integrity; and
- Complete laboratory chain of custody form and submit to laboratory, monthly.

3.4 REPORTING

Ambient air quality data will be compiled, summarized, and submitted to YWB's Waterline monthly. Averages, extremes, totals, and/or other typical statistics will be provided for each parameter, with accompanying figures as applicable. Annual reports, including a summary of all data collected in the previous year, will be submitted to both the YWB and EMR. Additional reporting will be performed as required for compliance with the Project's Air Emissions Permit.

All TSP, PM₁₀, PM_{2.5}, and NO₂ results in monthly and annual will be compared to the YAAQS listed in Table 3-2. There are no ambient standards for metal concentrations in Yukon but monitoring results will be screened against Ontario's Ambient Air Quality Criteria for reference, listed in Table 3-3.

Table 3-2: Yukon Ambient Air Quality Standards

Parameter	Standard (µg/m ³)
Total Suspended Particulate (TSP)	
24-hour average	120
Annual mean	60
Fine Particulate Matter (PM _{2.5})	
24-hour average	27
Annual mean	8.8
Coarse Particulate Matter (PM ₁₀)	
24-hour average	50
Nitrogen Dioxide (NO ₂)	
1 hour	79
Annual	23

All ambient air quality measurements will be referenced to standard conditions of 25 °C and 101.3 kPa.

µg/m³ = micrograms per cubic metre.

Source: Yukon Government, 2024. (effective January 1, 2025)

Table 3-3: Ontario Ambient 24-Hour Air Quality Criteria

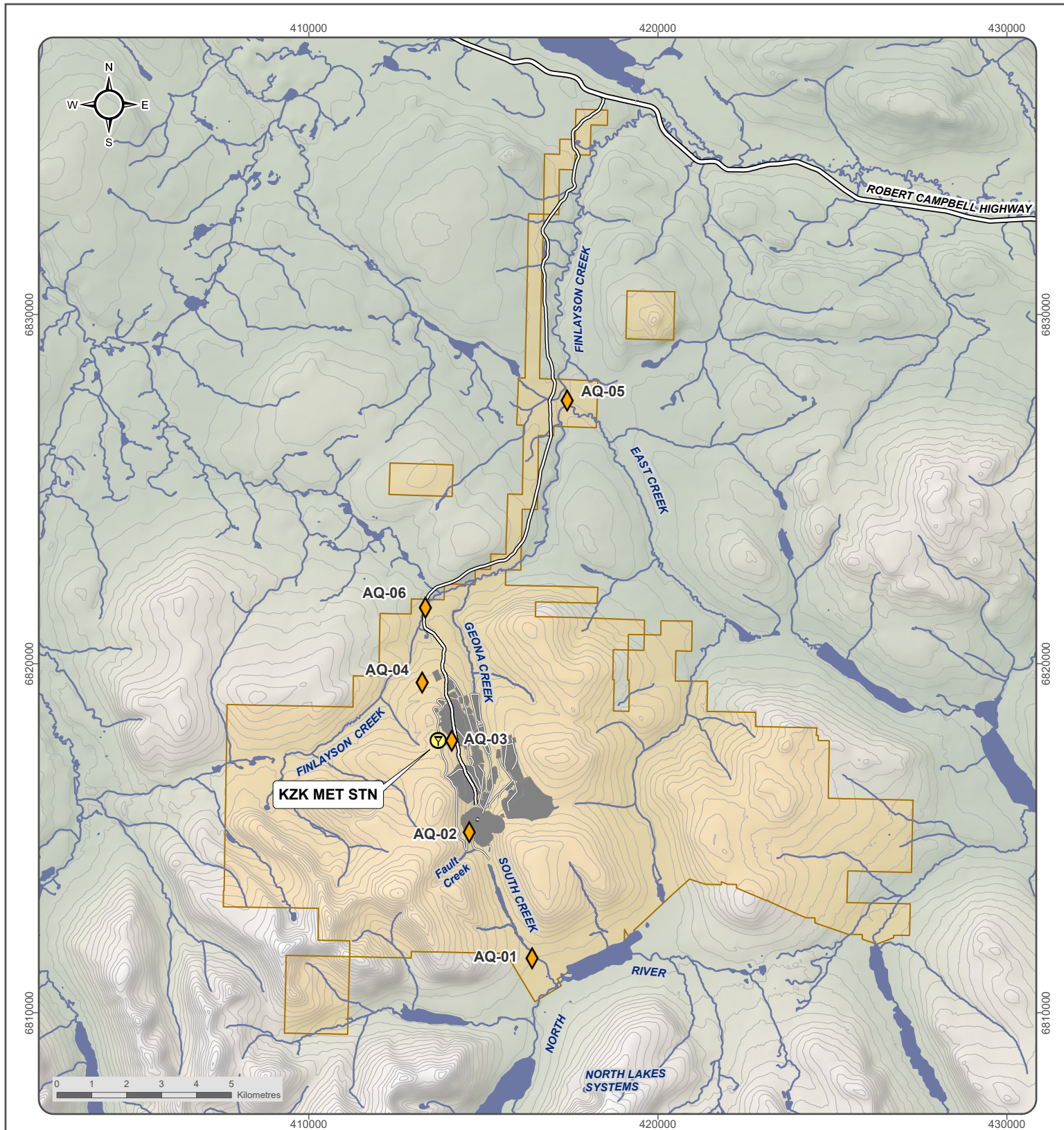
Parameter	Standard ($\mu\text{g}/\text{m}^3$)
Antimony (Sb)	25
Arsenic (As)	0.3
Barium (Ba)	10
Beryllium (Be)	0.01
Boron (B)	120
Cadmium (Cd)	0.025
Chromium (Cr)	0.5
Cobalt (Co)	0.1
Copper (Cu)	50
Iron (Fe)	4
Lead (Pb)	0.5
Manganese (Mn)	0.4
Molybdenum (Mo)	120
Nickel (Ni)	0.2
Selenium (Se)	10
Silver (Ag)	1
Strontium (Sr)	120
Tin (Sn)	10
Titanium (Ti)	120
Vanadium (V)	2
Zinc (Zn)	120

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metre.

Chromium standard applies to chromium compounds only (metallic, divalent and trivalent forms).

Source: Ontario Ministry of the Environment and Climate Change, 2019.

Ontario Ministry of the Environment, Conservation and Parks, 2020.



- Meteorological Station
- Air Quality Station
- Location of Proposed Infrastructure

- Tote Road/Proposed Access Road
- Proposed Road
- Watercourse

- Waterbody
- BMC Minerals Ltd. Mineral Claim Areas

KUDZE KAYAH PROJECT

FIGURE 3-1

AMBIENT AIR QUALITY MONITORING STATIONS

DECEMBER 2025

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4 SURFACE WATER QUANTITY

Surface water quantity is critical for maintaining the health and performance of aquatic and biophysical environments. Surface water flow monitoring is conducted upstream and downstream of the Project to characterize potential changes in flows that could adversely impact the environment, and to provide the data needed to update the LoMWBM and WQM. These data will also be used to evaluate and update, if justified, the design and operation of mine facilities and infrastructure, and to ensure that unforeseen water quantity conditions will be rapidly identified and responded to in concordance with the AMP.

The Project lies in the Geona Creek watershed, which is a north flowing tributary to Finlayson Creek. Finlayson Creek meets the outflow of Finlayson Lake north of the Robert Campbell Highway which flows east to the Frances River, and ultimately to the Mackenzie River. Baseline hydrometric monitoring at the Project took place in 1995 and from 2015 to present, and baseline data are provided in the Site Characterization Plan (BMC, 2026c).

4.1 METHODS

Surface water flow monitoring will be performed in accordance the SOP for Surface Water Hydrology, Data Collection and Management (Appendix B), as it has been throughout baseline data collection (Ensero, 2023a). Flow measurements will be collected using the velocity-area method with an electromagnetic flow meter, salt dilution gauging and/or alternative methods following industry standards. Calibration of the salt concentration–electrical conductivity relationship will be performed at the monitoring location for each measurement, pending weather and site conditions. Solinst Levelloggers and Barologgers (or equivalent) will take a recording of water level and barometric pressure every 30 minutes and will automatically send data daily to the Environment team responsible for data management and evaluation. Water levels and barometric data will be converted to estimated flows using a rating curve. Water level markings and/or staff gauges will be installed in ponds to facilitate manual confirmation of automatic levels data.

4.2 LOCATIONS AND FREQUENCY

Surface water quantity monitoring will be performed for water levels and/or flows at the locations listed in Table 4-1 and shown in Figure 4-1. These include 15 stations in creeks around the Project, and 18 stations in and around mine infrastructure. Certain stations will be discontinued or replaced during Project construction, while others will be established alongside the construction of specific Project infrastructure.

During freshet and significant rain events, discharge within the creeks may be monitored more frequently than shown in Table 4-1. This will include using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct spot checks to verify flow rates when significant fluctuations are suspected. More frequent monitoring may occur if an AMP trigger is reached.

Table 4-1: Water Quantity Monitoring Stations and Frequency

Station	Description	UTM Easting (m)	UTM Northing (m)	Water Level Monitoring Frequency	Flow Monitoring Frequency
Surface Water Stations					
KZ-2	Fault Creek	414,726	6,814,654	C + M	M
KZ-6*	Unnamed tributary to Geona Creek	415,325	6,816,659	C + M	M
KZ-9*	Geona Creek near proposed Lower Water Management Pond discharge location	414,686	6,819,717	C + M	M
KZ-13	South Creek near mouth	416,482	6,811,653	C + M	M
KZ-15	Finlayson Creek 100 m downstream of confluence with Geona Creek	414,802	6,822,418	C + M/Wd	M/Wd
KZ-16	Finlayson Creek immediately upstream of confluence with Geona Creek	414,622	6,822,352	C + M	M
KZ-17	Geona Creek at mouth	414,727	6,822,357	n/a	M
KZ-18	Unnamed East tributary to Geona Creek	414,698	6,819,726	n/a	M
KZ-21	East Creek at mouth (above confluence with Finlayson Creek)	417,494	6,827,454	n/a	M
KZ-22	Finlayson Creek 100 m downstream of East Creek	417,372	6,827,796	C + M	M
KZ-26	Finlayson Creek at Robert Campbell Highway	419,893	6,835,692	C + M	M
KZ-37	Geona Creek downstream of unnamed East tributary (KZ-18)	414,649	6,819,890	C + M/Wd	M/Wd
KZ-39	Finlayson Creek upstream of Tote Road and KZ-16	412,914	6,820,331	C + M	M
KZ-43	South Creek downstream of first South Lake	TBD	TBD	n/a	M
Reference	Reference location on Finlayson Creek >500 m upstream of Geona Creek	TBD	TBD	C + M	M
Mine Infrastructure Stations					
KZ-5	Lower Water Management Pond surface	414,818	6,818,748	C	n/a
KZ-5D	Lower Water Management Pond water column	414,818	6,818,748	n/a	n/a
KZ-8A	Lower Water Management Pond Discharge to Geona Creek	TBD	TBD	n/a	C
KZ-8B	Lower Water Management Pond Discharge to Finlayson Creek	TBD	TBD	n/a	C
KZ-36	Upper Water Management Pond	414,964	6,818,043	C	n/a
KZ-12A	Influent (Stream 1**) water to Water Treatment Plant	TBD	TBD	n/a	C
KZ-12B	Influent (Stream 2**) to Water Treatment Plant	TBD	TBD	n/a	C
KZ-12C	Treated water from Water Treatment Plant to Process Plant	TBD	TBD	n/a	C

Station	Description	UTM Easting (m)	UTM Northing (m)	Water Level Monitoring Frequency	Flow Monitoring Frequency
KZ-12D	Treated water from Water Treatment Plant to Lower Water Management Pond	414,964	6,818,043	n/a	C
KZ-38	ABM open pit dewatering	414,979	6,815,612	n/a	Cdw
KZ-32	Pit Rim Pond	415,038	6,816,152	C	n/a
KZ-34	Class A Storage Facility Collection Pond	414,681	6,818,239	C	n/a
KZ-3	Class B Storage Facility Collection Pond	415,158	6,816,570	C	n/a
KZ-30	Class C Storage Facility Collection pond, at outflow of pond	415,798	6,816,462	C	C
KZ-31	Overburden Stockpile Collection Pond, at outflow of pond	415,484	6,817,358	C	C
KZ-40	North non-contact diversion ditch upstream of confluence with Geona Creek	414,653	6,819,393	n/a	M
KZ-41	Class C Storage Facility and Overburden Stockpile diversion ditch upstream of confluence with Geona Creek	414,777	6,819,373	n/a	M
KZ-42	South diversion ditch downstream of confluence of Fault Creek and south non-contact diversion ditch	415,200	6,814,327	n/a	M

C=continuous logger.

Cdw=continuous when dewatering.

M=monthly manual measurement.

Md=monthly manual measurement (when discharging).

W=weekly manual measurement.

Wd=weekly manual measurement (when discharging).

Wnf=weekly when not frozen.

Qnf=quarterly when not frozen.

n/a=not applicable.

TBD=To be determined.

** KZ-6 will be discontinued during construction. KZ-9 will be discontinued once LWMP discharge feed station (KZ-8) is established during Operations.*

***Feed 1= Class A collection pond + Process water; Feed 2= Pit dewatering + LGO/ROM (Low Grade Ore / Run of Mine) Pad Sump.*

4.3 QA/QC

The procedures discussed in the SOP for Surface Water Hydrology (Appendix B) were developed to ensure that the data collected comply with the requirements for Grade A or Grade B data, as defined in the British Columbia Hydrometric Standards (RISC, 2018).

The objective for all stations will be the collection of Grade A data (RISC, 2018), though this can be challenging in small mountain streams, especially those that are too turbulent and/or narrow for velocity-area measurements, or where the dominant morphology may be step pools, such as at KZ-2. RISC (2018) criteria assume the use of the velocity-area method for discharge and require 20 or more panels, which is not possible at certain stations, including KZ-2, KZ-9, and KZ-13. Due to the morphology at these sites, they must be defined as data grade U for “*Undefined*”. However, other than dilution gauging it is the channel morphology itself that precludes a higher data grade. The channel should be a stable straight reach, free of boulders and vegetation. While the locations chosen for these stations are relatively stable and straight, they are not sufficient for accurate velocity-area measurements. KZ-22 would be Grade A and it meets all criteria; however, the channel has some very large boulders and is somewhat turbulent which lowers it to Grade B.

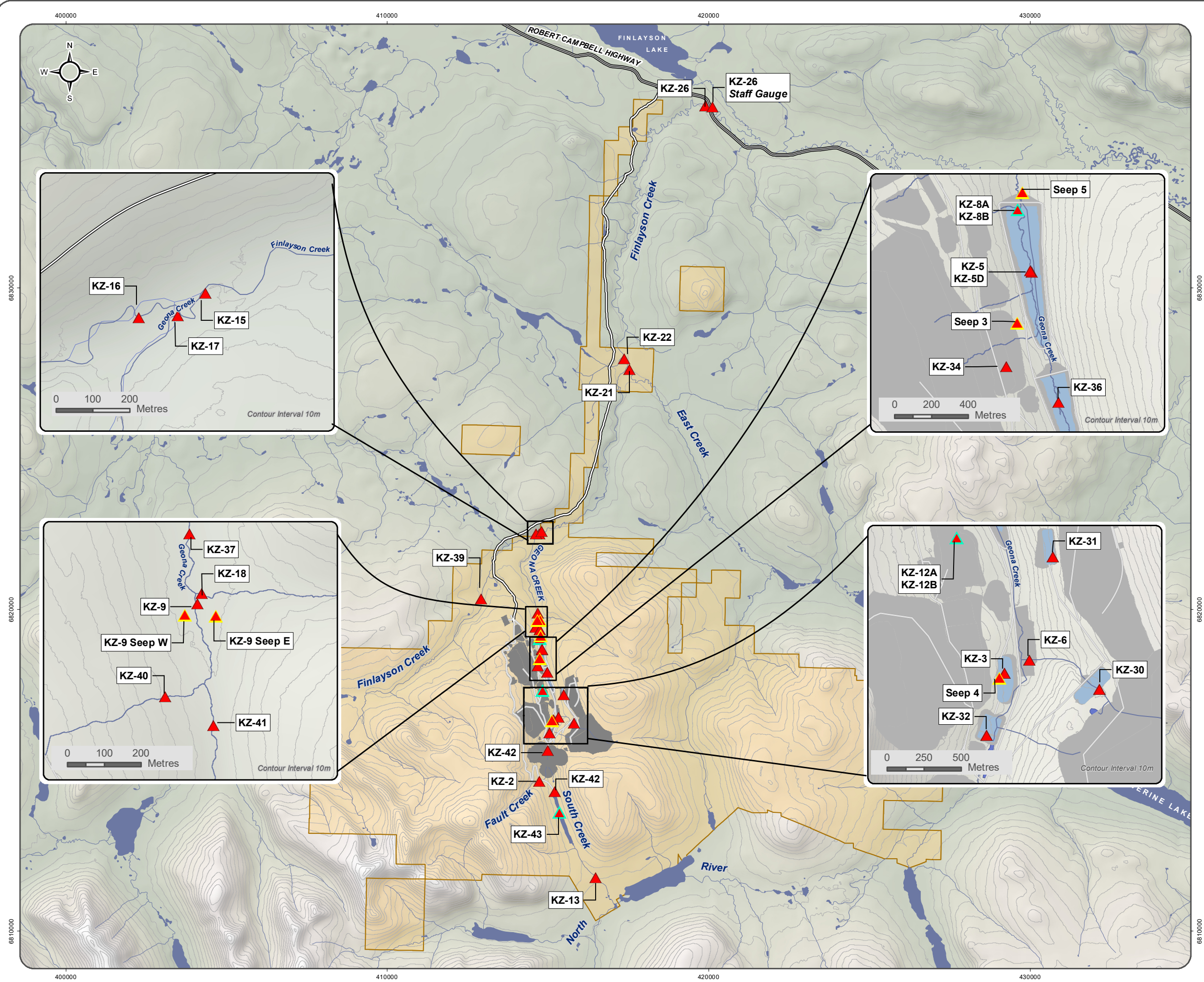
The SOP for Surface Water Hydrology recommends that two discharge measurements be collected at each site, such that the repeatability of the measurements can be calculated. The repeatability is calculated as the difference between the two measurements divided by their mean and expressed as a percent. The mean repeatability (Relative Percent Difference; RPD) will be applicable to all measurements; however, the uncertainty will be assumed to be 10% for the rating measurements. The rating accuracy is the mean of the percent deviation of each rating measurement from the rating curve (KP, 2018). “A” grade data must have an RPD of 7% or less (RISC, 2018).

Prior to developing rating curves, hydrographs and unit runoff comparisons for the Project, data will be reviewed in accordance with RISC (2018) to determine data grade.

4.4 REPORTING

Surface water quantity data will be compiled, summarized, and submitted to YWB’s Waterline monthly. Averages, extremes, totals, and/or other typical statistics will be provided for each station, with accompanying figures as applicable. Annual reports, summarizing all data collected in the previous year, rating curves and hydrographs, will be submitted to YWB and EMR.

Monthly effluent volume discharged from the Lower Water Management Pond (LWMP), along with calculated monthly mean concentrations and loading, will be recorded and reported quarterly to Environment and Climate Change Canada as per the *Metal and Diamond Mining Effluent Regulations* (MDMER; Government of Canada, 2023). Discharges to Finlayson Creek and Geona Creek will be reported separately.



KUDZ ZE KAYAH PROJECT

FIGURE 4-1

SURFACE WATER QUANTITY AND QUALITY MONITORING STATIONS

APRIL 2024

- ▲ Surface Water Quality Sampling Station, Active
- ▲ Surface Water Quality Sampling Station, Proposed
- ▲ Seep
- == Tote Road/Proposed Access Road
- Proposed Road
- Contour (40 m interval)
- Watercourse
- Waterbody
- Location of Proposed Infrastructure
- BMC Minerals Ltd. Mineral Claim Areas



Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 1:50,000. Reproduced under license from Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada. All rights reserved.

Datum: NAD 83; Projection UTM Zone 9N

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1:115,000 when printed on 11 x 17 inch paper



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5 SURFACE WATER QUALITY

Surface water quality is critical for maintaining the health and performance of aquatic and biophysical environments. Surface water quality monitoring is conducted upstream and downstream of the Project, and at reference locations that are hydraulically unrelated to the Project, to characterize potential changes in water quality that could adversely impact the environment, and to provide the data needed to update the WQM. These data will also be used to evaluate and support the improvement of the Project's water and waste management practices, described in the Water Management Plan (WMP) (BMC, 2026d), and to ensure that unforeseen water quality conditions will be rapidly identified and responded to in concordance with the AMP.

The WMP presents the Project's water management objectives, strategies, and design. The WMP was developed from site-specific design basis and criteria, supported by the integration of baseline studies and various waste- and water-related studies and models. Baseline surface water quality monitoring at the Project took place in 1994 and 1995, and from 2000 to present, and baseline data are provided in the Site Characterization Plan (BMC, 2026c).

5.1 METHODS

Surface water quality sampling will be performed in accordance with the SOP for Surface Water Monitoring (Ensero, 2023b), provided in Appendix C, as it has been throughout baseline data collection. This SOP is based on the *Standard Methods for the Examination of Water and Wastewater* (Rice et al., 2012) which was co-produced by the American Public Health Association, the American Water Works Association, and the Water Environment Federation.

At each surface water monitoring station, samples will be collected midstream for analysis of general parameters, total and dissolved metals, cyanide, and nutrients. All sample bottles, filters and preservatives will be supplied by a certified laboratory (CALA) and be analyte(s)-specific. Where required per laboratory sampling requirements, sample filtration and preservation will be conducted in the field or as soon as feasible if circumstances do not allow immediate filtration and preservation. Samples collected for nutrient and dissolved organic carbon (DOC) analyses will be preserved with sulphuric acid. Samples for total and dissolved metal analyses will be preserved with nitric acid and samples for cyanide analysis will be preserved in the field with sodium hydroxide.

A new, clean pair of nitrile gloves will be worn at each sampling station and bottles will be capped immediately after filling and, if required, preserved. All sample bottles will be prelabelled with the sample location, date and time of collection, field filtering and/or preservation, and analysis requested. Water and substrate appearance will also be noted for surface water stations. All samples will be stored in coolers with freezer packs to maintain a cold (4°C), but not frozen, temperature during sampling and transport to the laboratory. Table 5-1 and Table 5-2 provide the current Detection Limits (DLs) and analytical methods used for laboratory analysis of physical, anion, nutrient, and metal analytes.

At each sampling station, in-situ pH, specific conductance, temperature, oxidation-reduction potential (ORP) and dissolved oxygen (DO) will be measured using a multimeter and turbidity will be measured using a turbidity meter. Sampling will generally correspond with stream flow measurements, as discussed in Chapter 4.

Table 5-1: Surface Water Quality Detection Limits and Analytical Methods for Physical, Anion, and Nutrient Parameters

Parameter	Units	Reporting Detection Limit ¹	Analytical Method	Source Method
Acidity	mg/L	1	Titration	2310 B (Rice et al., 2012)
Alkalinity	mg/L	0.5	Titration	2320 B (Rice et al., 2012)
True Colour	Colour units	5	Visual Comparison	2120 B (Rice et al., 2012)
Dissolved Organic Carbon	mg/L	0.5	Persulphate Oxidation	5310 B (Rice et al., 2012)
Total Suspended Solids	mg/L	1	Dry to Constant Weight	2540 D (Rice et al., 2012)
Chloride	mg/L	0.5	Automated Colourimetry	4500-Cl- G (Rice et al., 2012)
Fluoride	mg/L	0.01	Ion Specific Electrode	4500-F C (Rice et al., 2012)
Sulphate	mg/L	0.5	Automated Colourimetry	4500-SO42- E (Rice et al., 2012)
Phosphorus	mg/L	0.002	Ascorbic Acid Method (Colourimetry)	4500-P E (Rice et al., 2012)
Nitrite-N	mg/L	0.002	Cadmium Reduction Flow Injection	4500-NO3- I (Rice et al., 2012)
Nitrate-N	mg/L	0.002		4500-NO3- I (Rice et al., 2012)
Ammonia-N	mg/L	0.005	Automated Phenate (Colourimetry)	4500-NH3- G (Rice et al., 2012)
Cyanide	mg/L	0.0005	Flow Injection	4500-CN O (Rice et al., 2012)

¹ Reporting Detection Limits are subject to change based on interferences at the time of analysis.

Table 5-2: Surface Water Quality Detection Limits and Analytical Methods for Element Constituents

Parameter	Units	Reporting Detection Limit ¹	Analytical Method	Source Method
Hardness	mg/L	0.5	ICP-MS	USEPA (2007)
Aluminum	mg/L	0.0005	ICP-MS	USEPA (2007)
Antimony	mg/L	0.00002	ICP-MS	USEPA (2007)
Arsenic	mg/L	0.00002	ICP-MS	USEPA (2007)
Barium	mg/L	0.00002	ICP-MS	USEPA (2007)
Beryllium	mg/L	0.00001	ICP-MS	USEPA (2007)
Bismuth	mg/L	0.000005	ICP-MS	USEPA (2007)
Boron	mg/L	0.01	ICP-MS	USEPA (2007)
Cadmium	mg/L	0.000005	ICP-MS	USEPA (2007)
Calcium	mg/L	0.05	ICP-MS	USEPA (2007)
Chromium	mg/L	0.0001	ICP-MS	USEPA (2007)
Cobalt	mg/L	0.000005	ICP-MS	USEPA (2007)
Copper	mg/L	0.00005	ICP-MS	USEPA (2007)
Iron	mg/L	0.001	ICP-MS	USEPA (2007)
Lead	mg/L	0.000005	ICP-MS	USEPA (2007)
Lithium	mg/L	0.0005	ICP-MS	USEPA (2007)
Magnesium	mg/L	0.05	ICP-MS	USEPA (2007)
Manganese	mg/L	0.00005	ICP-MS	USEPA (2007)
Molybdenum	mg/L	0.00005	ICP-MS	USEPA (2007)
Nickel	mg/L	0.00002	ICP-MS	USEPA (2007)
Phosphorus	mg/L	0.002	ICP-MS	USEPA (2007)
Potassium	mg/L	0.05	ICP-MS	USEPA (2007)
Selenium	mg/L	0.00004	ICP-MS	USEPA (2007)
Silicon	mg/L	0.05	ICP-MS	USEPA (2007)
Silver	mg/L	0.000005	ICP-MS	USEPA (2007)
Sodium	mg/L	0.05	ICP-MS	USEPA (2007)
Strontium	mg/L	0.00005	ICP-MS	USEPA (2007)
Sulphur	mg/L	3	ICP-MS	USEPA (2007)
Thallium	mg/L	0.000002	ICP-MS	USEPA (2007)
Tin	mg/L	0.0002	ICP-MS	USEPA (2007)
Titanium	mg/L	0.0005	ICP-MS	USEPA (2007)
Uranium	mg/L	0.000002	ICP-MS	USEPA (2007)
Vanadium	mg/L	0.0002	ICP-MS	USEPA (2007)
Zinc	mg/L	0.0001	ICP-MS	USEPA (2007)
Zirconium	mg/L	0.0001	ICP-MS	USEPA (2007)
Mercury	mg/L	0.000002	Cold Vapour Atomic Fluorescence	BC ENV (2013)

¹ Reporting Detection Limits are subject to change based on interference at the time of analysis.

5.2 LOCATIONS AND FREQUENCY

The stations monitored as part of the baseline program will, for the most part, continue to be monitored through the Construction and Operation phases of the Project. In some cases, monitoring stations that were included in the baseline program but will fall within the Project Footprint will be discontinued and superseded by stations to monitor contact water quality. Additional stations will also be monitored to better characterize reference and background water quality. The stations included in the monitoring program, the expected frequency and sampling requirements are described in Table 5-3 and shown in Figure 4-1. More frequent monitoring may occur as a result of an AMP trigger being reached.

It should be noted that while seep stations have been included in the baseline monitoring program, mine construction may impact the location and flow from seeps. Seep stations will be updated based on the presence of seeps as required over time. It is also noted that the establishment of stations that do not currently exist will depend on the construction of the particular features to be sampled, such as ponds and channels.

The surface water monitoring program requirements involve weekly, monthly, and quarterly measurements. Analytical requirements include in-situ field parameters, physical parameters, nutrients, cyanide, total and dissolved metals, DOC, and bioassays. Aside from in-situ measurements, all analyses will be performed by an external CALA accredited laboratory.

Weekly and quarterly sampling, required to meet the MDMER, will be conducted according to Schedule 5 of MDMER directives (Government of Canada, 2023); weekly sampling will be at least 24 hours apart from each other and quarterly sampling will be at least one month apart from each other. The LWMP discharge (KZ-8A/B) will act as the effluent characterization station for MDMER requirements. For MDMER water quality monitoring station requirements, the new site (KZ-39) will represent the reference area and KZ-15 will be the exposure area monitoring stations, downstream of all site discharge. The parameters required by MDMER Schedule 5 for effluent characterization and water quality monitoring - deleterious substances including specific total metals, total suspended solids and pH - are covered in the analytical suites outlined in Table 5-2.

Monitoring water quality in the LWMP at KZ-5 includes collecting a sample at depth to evaluate stratification. The water column sample will be collected within 5 m of the LWMP bottom and only when the LWMP depth exceeds 10 m.

Table 5-3: Surface Water Quality Monitoring Stations and Analysis Requirements

Station	Description	UTM	UTM	Field Parameters	External Analytical Suite		Radium 226	Acute Toxicity Testing		Sublethal Toxicity Testing
		Easting (m)	Northing (m)		Frequency	Analytical Suite		Rainbow Trout	Daphnia Magna	
Surface Water Stations										
KZ-2	Fault Creek	414,726	6,814,654	M	M	A, N, DOC	-	-	-	-
KZ-9*	Geona Creek near proposed discharge location	414,686	6,819,717	M	M	A, N, DOC, CN	-	-	-	-
KZ-13	South Creek near mouth	416,482	6,811,653	M	M	A, N, DOC, CN	-	-	-	-
KZ-15	Finlayson Creek 250 m downstream of confluence with Geona Creek	414,802	6,822,418	M/Wd	M/Wd	A, N, DOC, CN	-	-	-	-
KZ-16	Finlayson Creek immediately upstream of confluence with Geona Creek	414,622	6,822,352	M	M	A, N, DOC, CN	-	-	-	-
KZ-17	Geona Creek at Mouth	414,727	6,822,357	M	M	A, N, DOC, CN	-	-	-	-
KZ-18	Unnamed East tributary to Geona Creek	414,698	6,819,726	M	M	A, N, DOC, CN	-	-	-	-
KZ-21	East Creek at Mouth	417,494	6,827,454	M	M	A, N, DOC	-	-	-	-
KZ-22	Finlayson Creek 100 m downstream of East Creek	417,372	6,827,796	M	M	A, N, DOC, CN	-	-	-	-
KZ-26	Finlayson Creek at Robert Campbell Highway	419,893	6,835,692	M	M	A, N, DOC, CN	-	-	-	-
KZ-37	Geona Creek downstream of unnamed East tributary (KZ-18)	414,649	6,819,890	M/Wd	M/Wd	A, N, DOC, CN	-	-	-	-
KZ-39	Finlayson Creek upstream of	412,914	6,820,331	M	M	A, N, DOC, CN	-	-	-	-

Station	Description			Field Parameters	External Analytical Suite		Radium 226	Acute Toxicity Testing		Sublethal Toxicity Testing
		UTM Easting (m)	UTM Northing (m)		Frequency	Analytical Suite		Rainbow Trout	Daphnia Magna	
	Access Road and KZ-16									
KZ-43	South Creek downstream of first South Lake	TBD	TBD	M	M	A, N, DOC	-	-	-	-
Reference	Reference location on Finlayson Creek >500 m upstream of Geona Creek	TBD	TBD	M	M	A, N, DOC, CN	-	-	-	-
Seeps										
KZ-9 Seep East	Seep approximately 50 m east of Geona Creek at KZ-9	414,745	6,819,667	Mnf	Mnf	B, N	-	-	-	-
KZ-9 Seep West	Seep approximately 50 m west of Geona Creek at KZ-9	414,660	6,819,669	Mnf	Mnf	B, N	-	-	-	-
Seep 3	20 m wide seep located on west side of Geona Creek downstream of KZ-7	414,740	6,818,472	Mnf	Mnf	B, N	-	-	-	-
Seep 4	Wide seep network located on west side of Geona Creek upstream of KZ-7	415,123	6,816,537	Mnf	Mnf	B, N	-	-	-	-
Seep 5	Seep coming inside side channel of Geona Creek upstream of	414,767	6,819,178	Mnf	Mnf	B, N	-	-	-	-
	KZ-9									
Mine Site Stations										
KZ-3	Class B Storage Facility	415,158	6,816,570	Wnf	Wnf	A, N, DOC	-	-	-	-

Station	Description	UTM Easting (m)	UTM Northing (m)	Field Parameters	External Analytical Suite		Radium 226	Acute Toxicity Testing		Sublethal Toxicity Testing
					Frequency	Analytical Suite		Rainbow Trout	<i>Daphnia Magna</i>	
	Collection Pond, at outflow									
KZ-5	Lower Water Management Pond	414,818	6,818,748	M/Wd	M/Wd	A, N, CN	-	-	-	-
KZ-5D	Lower Water Management Pond	414,818	6,818,748	M/Wd	M/Wd	A, N, CN	-	-	-	-
KZ-8A	Lower Water Management Pond Discharge to Geona Creek	TBD	TBD	Wd	Wd	A, N, DOC, CN	Wd-Qd	Md-Qd	Md-Qd	SA
KZ-8B	Lower Water Management Pond Discharge to Finlayson Creek	TBD	TBD	Wd	Wd	A, N, DOC, CN	Wd-Qd	Md-Qd	Md-Qd	SA
KZ-12A	Influent (Feed 1**) water to Water Treatment Plant	TBD	TBD	Wd	Wd	A, N, DOC, CN	-	-	-	-
KZ-12B	Influent water (Feed 2**) to Water Treatment Plant	TBD	TBD	Wd	Wd	A, N, DOC, CN	-	-	-	-
KZ-12C	Treated water from Water Treatment Plant to Process Plant	TBD	TBD	Wd	Wd	A, N, DOC, CN	-	-	-	-
KZ-12D	Treated water from Water Treatment Plant to Lower Water Management Pond	414,964	6,818,043	Wd	Wd	A, N, DOC, CN	-	-	-	-
KZ-30	Class C Storage Facility Collection Pond, at outflow	415,798	6,816,462	Mnf	Mnf	A, N, DOC	-	-	-	-

Station	Description	UTM Easting (m)	UTM Northing (m)	Field Parameters	External Analytical Suite		Radium 226	Acute Toxicity Testing		Sublethal Toxicity Testing
					Frequency	Analytical Suite		Rainbow Trout	<i>Daphnia Magna</i>	
KZ-31	Overburden Stockpile Collection Pond, at outflow	415,484	6,817,358	Mnf	Mnf	A, N, DOC	-	-	-	-
KZ-32- construction phase**	Pit Rim Pond, at outflow	415,038	6,816,152	Wd	Wd	A, N, DOC, CN	Wd-Qd	Md-Qd	Md-Qd	SA
KZ-32 – operations phase	Pit Rim Pond, at outflow	415,038	6,816,152	Md	Md	A, N, DOC	-	-	-	-
KZ-34	Class A Storage Facility Collection Pond, at outflow	414,681	6,818,239	Wnf	Wnf	A, N, DOC, CN	-	-	-	-
KZ-36	Upper Water Management Pond	414,964	6,818,043	M/Wd	M/Wd	A, N, CN	-	-	-	-
KZ-40	North non-contact diversion ditch upstream of confluence with Geona Creek	414,653	6,819,393	M	M	A, N	-	-	-	-
KZ-41	Contact Class C Storage Facility and Overburden Stockpile diversion ditch upstream of confluence with Geona Creek	414,777	6,819,373	M	M	A, N, DOC	-	-	-	-
KZ-42	South diversion ditch downstream of confluence of Fault Creek and south non-contact diversion ditch	415,200	6,814,327	M	M	A, N	-	-	-	-
Class A Foundation Sumps	Sumps collecting seepage from			M	M	B	-	-	-	-

Station	Description	UTM Easting (m)	UTM Northing (m)	Field Parameters	External Analytical Suite		Radium 226	Acute Toxicity Testing		Sublethal Toxicity Testing
					Frequency	Analytical Suite		Rainbow Trout	Daphnia Magna	
	Class A Storage Facility drains									
Class B Foundation Sumps	Sumps collecting seepage from Class A Storage Facility drains			M	M	B	-	-	-	-

* KZ-9 Site to be discontinued once LWMP discharge feed station (KZ-8) is established during Operations.

**Sampling of Radium-226 and CN at KZ-32 will be discontinued once pit rim water discharge is redirected from Geona Creek (construction phase) to the Upper Water Management Pond (operations phase).

Wd: Weekly while discharging; Wnf: Weekly while not frozen; M: Monthly; Md: Monthly while discharging; Mnf: Monthly while not frozen;

Md-Qd: Monthly while discharging, reduced to quarterly while discharging if water is determined to not be acutely lethal for 12 consecutive months.

Wd-Qd: Weekly while discharging, reduced to quarterly while discharging if concentration is less than 0.037 Bq/L for 10 consecutive weeks.

SA: two times each calendar year for the first three years and once per calendar year afterwards as per MDMER directive.

Field Parameters: In situ pH, temperature, conductivity, oxidation/reduction potential.

A: Physical parameters, conductivity, TSS, TDS, hardness, alkalinity, sulphate, ICP-total metals, ICP-dissolved metals.

B: Physical parameters, conductivity, TDS, alkalinity, sulphate, ICP-dissolved metals.

N: Nutrients (Ammonia-N, Nitrate-N, Nitrite-N).

DOC: Dissolved organic carbon.

CN: Total and weak acid-dissociable cyanide.

Rainbow trout: 96-Hr LC₅₀ Pass/Fail.

Daphnia Magna: 48-Hr LC₅₀ Pass/Fail.

Chronic toxicity testing: early life stage fish species, invertebrate species, plant species and algal species.

5.3 QA/QC

Surface water quality monitoring program QA/QC practices will follow the methods described in Rice et al. (2012). The monitoring program will continue to include a robust set of QA/QC measures to ensure validity of the data collected, including the establishment of data quality objectives and assessment of variability due to natural and analytical factors. The following QA/QC measures will be included:

- All field staff will be trained in and follow work protocols for surface water monitoring and sample collection that are based on generally accepted practices (Rice et al., 2012). The sampling procedures will include measures to avoid sample contamination in the field during sample collection, as well as during sample handling and shipping;
- Clean, disposable nitrile gloves will be worn during collection;
- Water samples will be placed in analyte(s)-specific, laboratory-grade bottles provided by the analytical laboratory;
- Dissolved metals and dissolved organic carbon water samples will be filtered using a 0.45 μm filter and preserved in the field at the time of sample collection;
- Nutrient samples will be preserved in the field;
- Collection of blind field duplicates at a rate of one duplicate per 10 samples; the field duplicates will be clearly linked to one of the monitoring wells on sampling logs and field notes, but not on the chain of custody forms;
- A field and travel blank will be collected for each monthly sampling event;
- Samples will be stored on ice in a cooler and shipped to the laboratory via courier under chain of custody procedures;
- All samples will be sent to a CALA laboratory for analysis. The laboratory will also conduct an internal QA/QC program, including split duplicates (one per 10 samples); and
- Following each sampling event, a review of all analytical results and QA/QC results received from the laboratory will be conducted to ensure data quality and to flag any potential issues (e.g., data quality issues from the information provided by the lab, conduct an ion balance for each sample – typically $\leq 10\%$ is acceptable). Additionally, the QA/QC program will include a review of the RPD in duplicates and parameters measured in field blanks and trip blanks to assess data quality.

RPD is used to determine field variability and is equal to the difference between the sample and duplicate value, divided by the average of the sample and duplicate value, and expressed as a percentage. When the RPD is greater than 25%, a subsequent check is completed against the laboratory detection limit (DL) to determine if the practical quantitation limit (PQL) is met. The PQL is five times the DL and is defined as the minimum concentration that can be measured within specified limits of precision and accuracy. Both results of the sample and the duplicate need to be greater than the PQL for the analyte to meet the PQL. An analyte with results below the PQL indicates that the analyte is not present in a sufficient concentration to be reliably quantified. Typically, as parameters approach their detection limit, higher variability is more likely to occur. An RPD greater

than 25% result that is above is the PQL is flagged for further comment or consideration; a follow-up is also made with the laboratory.

5.4 REPORTING

The reporting of surface water quality data will be used to confirm compliance with WUL, QML and MDMER requirements and allow for evaluation of the AMP triggers.

Monthly and annual reports will be submitted to YWB's Waterline. Annual reports will also be issued directly to EMR. Monthly reports will provide all surface water quality data and comparison with applicable Effluent Quality Standards (EQS) and Water Quality Objectives (WQO) as discussed in the Water Management Plan (BMC, 2026d). Monthly reports will be submitted within 30 days of the end of the month in which data were collected. Annual reports will contain all surface water quality data from the previous year, including reporting required by MDMER (Section 5.4.1). Reagent use in the Process Plant will be included in annual reporting.

5.4.1 MDMER

The MDMER requires monitoring and reporting of effluent and receiving environmental effects monitoring (EEM).

Quarterly reports will be submitted to the Canadian Minister of the Environment and Climate Change documenting all tests and monitoring of effluent at the LWMP discharge (KZ-8A/B). The volume of effluent discharged each month, and monthly load of constituents of potential interest (COPIs) will be included in these reports. As per MDMER directives, quarterly effluent monitoring reports will be submitted no later than 45 days after the end of the quarter and will include (Government of Canada, 2023):

- The concentration and mean monthly concentration of arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids and radium 226 in effluent samples;
- The pH (measured in the field) of the effluent samples;
- Sample collection methodology (grab or composite);
- Number of days that effluent was discharged in each month of the quarter;
- Total volume of effluent discharged during each month of each quarter; and
- The mass loading of deleterious substances (calculated using the total volume of effluent deposited).

Annual reports will be submitted to the Canadian Minister of the Environment and Climate Change documenting all test results from the preceding year of effluent monitoring and acute toxicity testing in the format specified in Schedule 6 of MDMER (Government of Canada, 2023). Reporting of water quality monitoring data of the exposure area (monitored at KZ-15) and reference area (KZ-39) will

be provided on an annual basis, with effluent monitoring results. The parameters and sampling frequencies required to be reported at these stations are presented in Table 5-3.

As per MDMER, annual reports will be submitted by March 31 of the year following data collection and will include the following (Government of Canada, 2023):

- The dates on which each sample was collected for effluent characterization, sublethal toxicity testing and water quality monitoring;
- The locations of the final discharge points from which samples were collected for effluent characterization;
- The location of the final discharge point from which samples were collected for sublethal [acute] toxicity testing;
- The latitude and longitude of sampling areas for water quality monitoring, in degrees, minutes and seconds, and a description that is sufficient to identify the location of the sampling areas;
- The results of effluent characterization (mean monthly concentrations of deleterious substances), sublethal [acute] toxicity testing and water quality monitoring;
- The methodologies used to conduct effluent characterization and water quality monitoring, and the related method detection limits; and
- A description of quality assurance and quality control measures that were implemented and the data related to the implementation of those measures.

6 GROUNDWATER QUANTITY AND QUALITY

Groundwater at the Project site flows downgradient through overburden and bedrock, largely discharging into Geona Creek in the valley bottom. Groundwater baseflow constitutes the largest component of Geona Creek flow during the winter months and other periods of low runoff, and supplements runoff flows in Geona Creek during other periods. Groundwater quantity and quality are thus considered critical for maintaining the health and performance of aquatic and biophysical environments.

Groundwater quantity (i.e., well levels) and quality monitoring is conducted using wells located upgradient and downgradient of mine facilities and infrastructure. This monitoring is performed to characterize potential changes to groundwater flows and quality resulting from the Project, and is used to support updates to the LoMWBM, WQM and conceptual and numerical groundwater models. These data will also be used to evaluate and support the improvement of the Project's water and waste management practices, described in the Water Management Plan (WMP) (BMC, 2026d), and to ensure that unforeseen groundwater quality conditions will be rapidly identified and responded to in concordance with the AMP.

Baseline groundwater monitoring at the Project took place in 1995 and from 2015 to present, and baseline data are provided in the Site Characterization Plan (BMC, 2026c). While many of the monitoring wells used for baseline monitoring will be incorporated into the monitoring program for construction and operations, many wells are no longer functional or no longer needed, and additional wells will be added at key locations relative to mine infrastructure. Wells that are no longer in use will be decommissioned as per "*Protocol No. 7 Groundwater Monitoring Well Installation, Sampling and Decommissioning*" of the Contaminated Sites Regulation under the *Environment Act* (Yukon, 2019).

Note that this chapter of the EMSRP includes only groundwater monitoring performed for the purposes of characterizing the potential impacts of the Project on groundwater flow and quality. Monitoring of groundwater related to the geotechnical performance of the mine, waste storage facilities and other infrastructure are discussed in Chapter 11.

6.1 METHODS

Water levels in monitoring wells will be measured manually using an electric sounder, and automatically using submerged pressure transducers installed in all wells. Manual water level measurements will be collected each time a water sample is collected, including measuring the distance from the top of casing to the water surface in the well, and to ground. Automated water level data will be corrected for barometric pressure fluctuations recorded using a Barologger, or similar. Pressure transducers and Barologgers will be installed and operated in accordance with manufacturer's instructions.

Groundwater sample collection procedures are described in the groundwater SOP (Ensero, 2023c) provided in Appendix D. This SOP is based on the document entitled *Environment Yukon's Contaminated Sites Regulation, Protocol No. 7* (Yukon, 2019) which conforms to the *Standard Methods for Examination of Water and Wastewater* (Rice et al., 2012).

Prior to each sampling event, the static water level in the monitoring well will be measured using an electric sounder. Once the water level has been measured, the well will be purged prior to sampling. To ensure representative groundwater quality samples, when possible, a minimum of three well volumes will be purged using a Waterra pump, bailer or submersible pump. Field parameters (pH, specific conductance, ORP, DO, and temperature) will be measured during purging using a multimeter.

Once field parameters have stabilized and purging is complete, groundwater samples will be collected. All sample bottles, filters and preservatives will be supplied by a certified laboratory (CALA) and be analyte(s)-specific. Where required per laboratory sampling requirements, sample filtration and preservation will be conducted in the field or as soon as feasible if circumstances do not allow immediate filtration and preservation. Samples collected for nutrient and dissolved organic carbon (DOC) analyses will be preserved with sulphuric acid. Samples for total and dissolved metal analyses will be preserved with nitric acid and samples for cyanide analysis will be preserved in the field with sodium hydroxide.

A new, clean pair of nitrile gloves will be worn at each well during sampling and bottles will be capped immediately after filling and, if required, preserved. All sample bottles will be prelabelled with the sample location, date and time of collection, field filtering and/or preservation, and analysis requested. All samples will be stored in coolers with freezer packs to maintain a cold (4°C), but not frozen, temperature during sampling and transport to the laboratory.

A summary of analytical parameters and associated laboratory analysis techniques and reporting detection limits for groundwater samples are presented in Table 6-1 and Table 6-2. In addition to the analytical parameters listed in Table 6-1 and Table 6-2, in the event of a spill of reagents or fuel, COPIs associated with the spilled substance will be sampled in the closest wells to the spill as part of an Environmental Site Assessment and/or remediation program to address such an event, as per the *Yukon Contaminated Sites Regulation* (Yukon Regulations, 2002) and the Spill Contingency Plan (BMC, 2026e).

Table 6-1: Groundwater Quality Detection Limits Analytical Methods for Physical, Anion, and Nutrient Parameters

Parameter	Units	Reporting Detection Limit	Analytical Method	Source Method
Acidity	mg/L	0.5	Titration	2310 B (Rice et al., 2012)
Alkalinity	mg/L	0.5	Titration	2320 B (Rice et al., 2012)
Dissolved Organic Carbon	mg/L	0.5	Persulphate Oxidation	5310 C (Rice et al., 2012)
Chloride	mg/L	0.5	Automated Colourimetry	4500-Cl- G (Rice et al., 2012)
Fluoride	mg/L	0.01	Ion Specific Electrode	4500-F C (Rice et al., 2012)
Sulphate	mg/L	0.5	Automated Colourimetry	4500-SO42- E (Rice et al., 2012)
Phosphorus	mg/L	0.002	Ascorbic Acid Method (Colourimetry)	4500-P E (Rice et al., 2012)

Parameter	Units	Reporting Detection Limit	Analytical Method	Source Method
Nitrite-N	mg/L	0.002	Cadmium Reduction Flow Injection	4500-NO3- I (Rice et al., 2012)
Nitrate-N	mg/L	0.002		4500-NO3- I (Rice et al., 2012)
Ammonia-N	mg/L	0.005	Automated Phenate (Colourimetry)	4500-NH3- G (Rice et al., 2012)
Cyanide	mg/L	0.0005	Flow Injection	4500-CN O (Rice et al., 2012)

Table 6-2: Groundwater Quality Detection Limits and Analytical Methods for Element Constituents

Parameter	Units	Reporting Detection Limit	Analytical Method	Source Method
Hardness	mg/L	0.5	ICP-MS	USEPA (2007)
Aluminum	mg/L	0.0005	ICP-MS	USEPA (2007)
Antimony	mg/L	0.00002	ICP-MS	USEPA (2007)
Arsenic	mg/L	0.00002	ICP-MS	USEPA (2007)
Barium	mg/L	0.00002	ICP-MS	USEPA (2007)
Beryllium	mg/L	0.00001	ICP-MS	USEPA (2007)
Bismuth	mg/L	0.000005	ICP-MS	USEPA (2007)
Boron	mg/L	0.01	ICP-MS	USEPA (2007)
Cadmium	mg/L	0.000005	ICP-MS	USEPA (2007)
Calcium	mg/L	0.05	ICP-MS	USEPA (2007)
Chromium	mg/L	0.0001	ICP-MS	USEPA (2007)
Cobalt	mg/L	0.000005	ICP-MS	USEPA (2007)
Copper	mg/L	0.00005	ICP-MS	USEPA (2007)
Iron	mg/L	0.001	ICP-MS	USEPA (2007)
Lead	mg/L	0.000005	ICP-MS	USEPA (2007)
Lithium	mg/L	0.0005	ICP-MS	USEPA (2007)
Magnesium	mg/L	0.05	ICP-MS	USEPA (2007)
Manganese	mg/L	0.00005	ICP-MS	USEPA (2007)
Molybdenum	mg/L	0.00005	ICP-MS	USEPA (2007)
Nickel	mg/L	0.00002	ICP-MS	USEPA (2007)
Phosphorus	mg/L	0.002	ICP-MS	USEPA (2007)
Potassium	mg/L	0.05	ICP-MS	USEPA (2007)
Selenium	mg/L	0.00004	ICP-MS	USEPA (2007)
Silicon	mg/L	0.05	ICP-MS	USEPA (2007)
Silver	mg/L	0.000005	ICP-MS	USEPA (2007)
Sodium	mg/L	0.05	ICP-MS	USEPA (2007)
Strontium	mg/L	0.00005	ICP-MS	USEPA (2007)
Sulphur	mg/L	3	ICP-MS	USEPA (2007)

Parameter	Units	Reporting Detection Limit	Analytical Method	Source Method
Thallium	mg/L	0.000002	ICP-MS	USEPA (2007)
Tin	mg/L	0.0002	ICP-MS	USEPA (2007)
Titanium	mg/L	0.0005	ICP-MS	USEPA (2007)
Uranium	mg/L	0.000002	ICP-MS	USEPA (2007)
Vanadium	mg/L	0.0002	ICP-MS	USEPA (2007)
Zinc	mg/L	0.0001	ICP-MS	USEPA (2007)
Zirconium	mg/L	0.0001	ICP-MS	USEPA (2007)
Mercury	mg/L	0.000002	Cold Vapour Atomic Fluorescence	BC ENV (2013a)

6.2 LOCATIONS AND FREQUENCY

The groundwater monitoring program will utilize existing monitoring wells and new wells installed to replace non-functional wells or to fill gaps in the existing monitoring program. The program includes 27 wells at 17 locations, including 8 wells installed prior to 2024 and 19 new or replacement wells installed or planned to be installed in 2024 or after. Monitoring wells included in the groundwater monitoring program are summarized in Table 6-3 and shown in Figure 6-1. Additional wells were installed in 2024 in overburden upgradient of planned Project facilities, but these wells were found to be dry so are not included in the monitoring program. Overburden is thin at these locations and the water table occurs in the underlying bedrock, where it will be monitored by bedrock monitoring wells. All monitoring wells will be protected to minimize the risk of damage or contamination. Wells that become non-functional over time will be replaced by new wells to serve the same monitoring purpose.

Manual groundwater level measurements will be collected each time a water sample is collected, ranging from monthly to quarterly. Automatic water level measurements will be recorded hourly and will be downloaded monthly, or less frequently in areas with minimal variability in water level.

Groundwater quality sampling frequency will range from monthly to quarterly, depending on the location and expected conditions. Sampling at new or replacement wells will initially be performed monthly for at least the first year, after which it may be decreased to quarterly once natural variation in water quality has been characterized or the relationship between replacement and replaced wells can be evaluated. More frequent monitoring may occur if an AMP trigger is reached.

Groundwater levels and quality will also be monitored in wells not included in this monitoring plan, as part of the operation and monitoring of the open pit dewatering system. These data will supplement the data collected as part of this groundwater monitoring program. The locations of these pumping and monitoring wells will initially be determined as part of detail design of the pit, and are expected to change throughout the operation in response to pit dewatering conditions and the observed behaviour of the pit's groundwater capture zone and dewatering water quality.

Table 6-3: Groundwater Monitoring Wells

Project Component	Position relative to Project Component	Unit Monitored	Location and Notes	Current Well ID	Water Level Monitoring Frequency	Water Quality	
						Sampling Frequency	Analysis
Whole Project Site	Downgradient	Bedrock	East of Camp	BH95G-2	H, Q	Q	WQ+CN
	Downgradient	Overburden	Approximately 500 m north of LWMP	MW24-08S	H, Q	Q	WQ+CN
	Downgradient	Bedrock contact	Approximately 500 m north of LWMP	A2-D	H, Q	Q	WQ+CN
LWMP	Downgradient	Overburden	Toe of LWMP	MW15-09S	H, Q	Q	WQ+CN
	Downgradient	Bedrock	Toe of LWMP	MW15-09D2	H, Q	Q	WQ+CN
Class A Storage Facility	Upgradient	Bedrock	West of Class A Storage Facility	MW24-03D	H, Q	Q	WQ+CN
	Downgradient	Overburden	East of Class A Storage Facility	MW16-14S	H, Q	Q	WQ+CN
	Downgradient	Bedrock	East of Class A Storage Facility	MW16-14D2	H, Q	Q	WQ+CN
	Downgradient	Overburden	East of Class A Storage Facility	BH95G-15S2	H, Q	Q	WQ+CN
	Downgradient	Bedrock	East of Class A Storage Facility	BH95G-15D	H, Q	Q	WQ+CN
Process Plant	Upgradient	Bedrock	West of Process Plant	MW16-17	H, Q	Q	WQ+CN
	Downgradient	Overburden	East of Process Plant	MW24-02S	H, Q	Q	WQ+CN
	Downgradient	Bedrock	East of Process Plant	MW24-02D	H, Q	Q	WQ+CN
Class B Storage Facility	Upgradient	Bedrock	West of Class B Storage Facility	MW24-01D	H, Q	Q	WQ
	Downgradient	Overburden	East of Class B Storage Facility	BH95G-33S2	H, Q	Q	WQ+CN
	Downgradient	Bedrock	East of Class B Storage Facility	BH95G-33D	H, Q	Q	WQ+CN
	Downgradient	Overburden	East of Class B Storage Facility and North of Workshop and Fuel Bay	MW24-04S	H, Q	Q	WQ
	Downgradient	Bedrock	East of Class B Storage Facility and North of Workshop and Fuel Bay	MW24-04D	H, Q	Q	WQ
Open Pit	Upgradient	Overburden	South of Open Pit, upgradient during operations	MW16-15S	H, Q	Q	WQ
	Upgradient	Overburden	South of Open Pit, upgradient during operations	BH95G-29S2	H, Q	Q	WQ
	Upgradient	Bedrock	South of Open Pit, upgradient during operations	BH95G-29D	H, Q	Q	WQ
Class C Storage Facility	Upgradient	Bedrock	East of Class C Storage Facility	MW24-07D	H, Q	Q	WQ
	Downgradient	Overburden	North of Class C Storage Facility	MW24-05S	H, Q	Q	WQ+CN
	Downgradient	Bedrock	North of Class C Storage Facility	MW24-05D	H, Q	Q	WQ+CN
Overburden Stockpile	Upgradient	Bedrock	East of Overburden Stockpile	MW24-06D	H, Q	Q	WQ
	Downgradient	Overburden	West of Overburden Stockpile	MW16-16S	H, Q	Q	WQ+CN
	Downgradient	Bedrock	West of Overburden Stockpile	MW16-16D	H, Q	Q	WQ+CN

WQ: In situ pH, temperature, specific conductance, oxidation, and reduction potential; external laboratory analysis of dissolved metals, pH, specific conductance, TDS, DOC, anions, nitrate, nitrite and ammonia, alkalinity.

+CN: Full water quality suite with weak acid dissociable cyanide analysis.

H: Hourly using pressure transducer, downloaded monthly to quarterly; M: Monthly; Q: Quarterly

Existing well

New or replacement well

6.3 QA/QC

The QA/QC measures for groundwater sampling are similar to those for surface water sampling (Chapter 5) and follow the methods described in Rice et al., 2012. As described in Chapter 5, the following QA/QC measures will be included for groundwater quality monitoring:

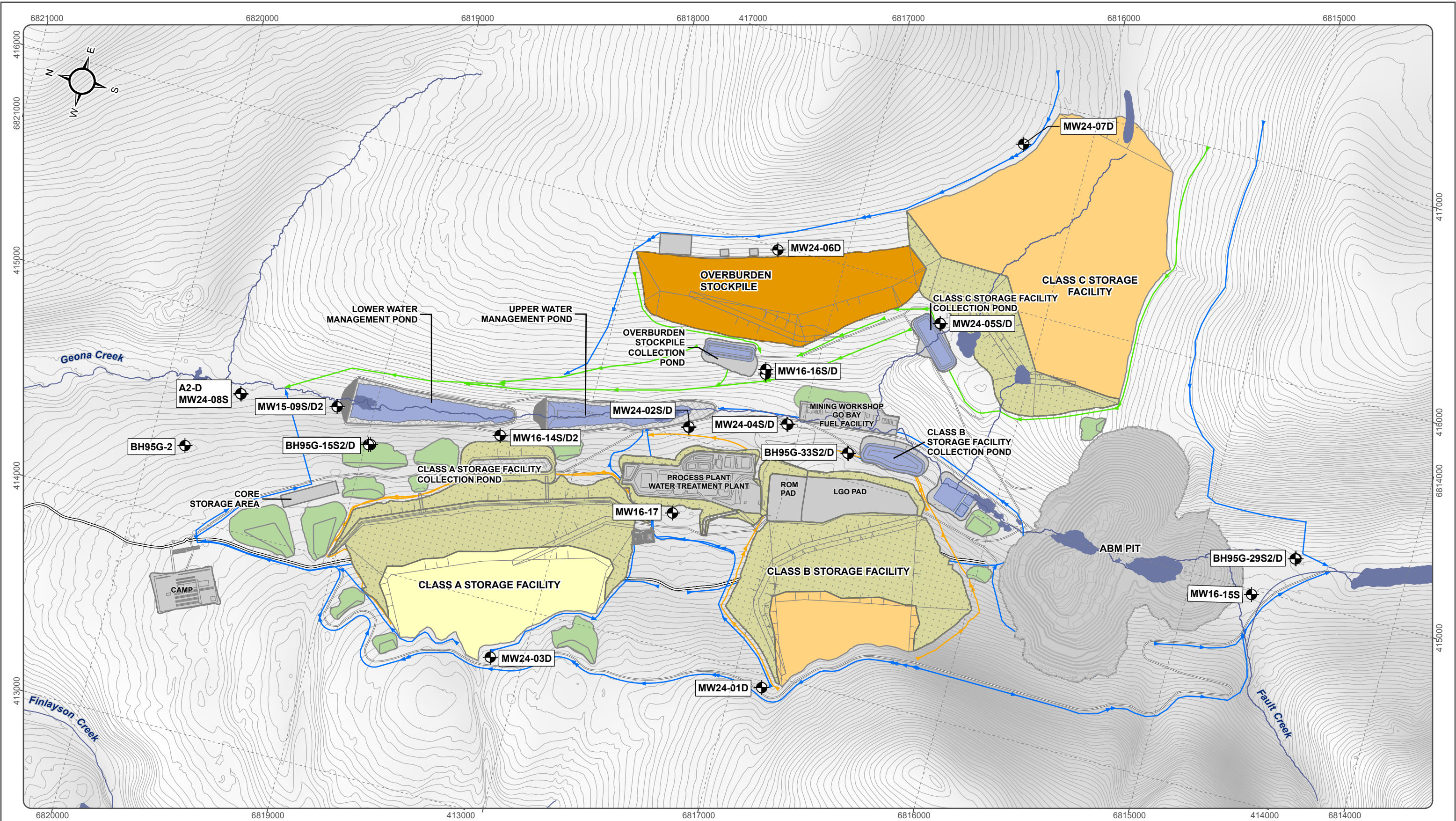
- All field staff will be trained in and follow the SOP (Ensero, 2023c) for groundwater monitoring and sample collection. The sampling procedures will include measures to avoid sample contamination in the field during sample collection, as well as during sample handling and shipping;
- Clean, disposable nitrile gloves will be worn during collection;
- Water samples will be placed in analyte(s)-specific, laboratory-grade bottles provided by the analytical laboratory;
- Dissolved metals and dissolved organic carbon water samples will be filtered using a 0.45 µm filter and preserved in the field at the time of sample collection;
- Nutrient samples will be preserved in the field;
- Blind field duplicates will be collected at a rate of one duplicate per 10 samples collected. The field duplicates will be clearly linked to one of the monitoring wells on sampling logs and field notes, but not on the chain of custody forms;
- A field and travel blank will be collected for each monthly sampling event;
- Samples will be stored on ice in a cooler and shipped to the laboratory via courier under chain of custody procedures;
- All samples will be sent to a CALA laboratory for analysis. The laboratory will also conduct an internal QA/QC program, including split duplicates (one per 10 samples); and
- Following each sampling event, a review of all analytical results and QA/QC results received from the laboratory will be conducted to ensure data quality and to flag any potential issues (e.g., data quality issues from the information provided by the lab, conduct an ion balance for each sample – typically ≤10% is acceptable). Additionally, the QA/QC program will include a review of the RPD in duplicates and parameters measured in field blanks and trip blanks to assess data quality.

RPD is used to determine field variability and is equal to the difference between the sample and duplicate value, divided by the average of the sample and duplicate value, and expressed as a percentage. When RPD is greater than 25%, the result will be checked against the laboratory DL to determine if the PQL is met. The PQL is five times the DL and is defined as the minimum concentration that can be measured within specified limits of precision and accuracy. Both results of the sample and the duplicate need to be greater than the PQL for the analyte to meet the PQL. An analyte with

results below the PQL indicates that the analyte is not present in a sufficient concentration to be reliably quantified. Typically, as parameters approach their detection limit, higher variability is more likely to occur. An RPD greater than 25% result that is above the PQL will be flagged for further comment or consideration; a follow-up will also be made with the laboratory.

6.4 REPORTING

Groundwater monitoring data will be compiled, summarized, and submitted to YWB's Waterline monthly, including groundwater levels and quality. Annual reports, summarizing all data collected in the previous year and any changes to the groundwater monitoring program will be submitted to YWB and EMR. This annual report will confirm that there are active wells in each setting for which groundwater monitoring is required, and provide a plan for replacing any non-functional wells.



- Groundwater Monitoring Location
- Class A Storage Facility
- Class B and C Storage Facility
- Overburden Stockpile
- Topsoil Stockpile

- Progressive Reclamation
- Liner
- Pond/Water
- Non Contact Diversion
- Contact Class A & B Diversion

- Contact Class C Diversion
- Tote Road/Proposed Access Road
- Proposed Road
- Existing Watercourse



KUDZ ZE KAYAH PROJECT

FIGURE 6-1

GROUNDWATER MONITORING WELLS

DECEMBER 2025

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(Last edited by: Jordan Yutuc; 2025-12-09/12:43 PM)

7 GEOCHEMISTRY

Geochemical monitoring will include routine testing of waste rock, tailings, overburden, and other geological materials across the Project area. These materials will be sourced from the Open Pit, Underground, Overburden, and Process Plant tailings, which have the potential to generate acid rock drainage and/or metal leaching (ARD/ML; Ensero, 2023d) or impact site surface or groundwater. Specific sampling procedures, sample selection, sample locations and sampling frequencies will be adapted spatially and temporally to ensure that all waste material is adequately characterized to ensure that it is transported to the appropriate waste storage facility. Analytical testing will follow standard methods used to date on the Project (e.g. Price, 2009).

Monitoring of drainage water quality from the Class A, B, and C Storage Facilities and the Overburden Stockpile will also occur, as described in Chapter 5. Adaptive management triggers regarding unforeseen water quality conditions are described in the Adaptive Management Plan (BMC, 2026a).

A sampling and analysis program will be maintained during the Operations phase to monitor the geochemical composition of waste rock and tailings placed within each waste storage facility.

7.1 METHODS

7.1.1 Waste Rock Classification and On-Site Testing

The waste rock classification boundaries in the Open Pit and Underground will be identified using the geological block model developed for the site and refined/confirmed using samples collected from both the grade control drilling program and blasthole drill cuttings. As part of the ARD grade control process, the different classes of waste rock will be delineated with different polygons for mine operations for planning and material handling purposes. For example, the polygons identifying the different classes of waste rock will be used by the excavator operator and site geologists to inform truck drivers as to the required destination for each load of waste. The blasted waste rock will be marked using appropriate visual markers, such as paint, to represent the boundaries of different waste classes.

Analysis of grade control and blasthole drill cuttings samples will include measurement of the following parameters at the on-site laboratory:

- Total sulphur via Leco analyzer or similar
- Total calcium via aqua regia digestion and ICP-AES (or similar) analysis

The results of these analyses will be used to calculate surrogate acidification potential (AP), neutralization potential (NP), and the NP/AP ratio values using Equations 1 and 2 obtained from ARD/ML testing described in Ensero (2023d):

$$\text{Surrogate NP (kg CaCO}_3\text{/t)} = (\text{ICP Ca (wt.\%)} * 30.4) + 4.09 \quad (\text{Equation 1})$$

$$\text{Surrogate AP (kg CaCO}_3\text{/t)} = \text{Leco S (wt.\%)} * 31.25 \quad (\text{Equation 2})$$

Surrogate NP and AP will then be used to classify the waste rock into one of the following three waste rock groups:

- Class A – Total sulphur greater than 2.9 wt.% or NP less than 10 kg CaCO₃/t;
- Class B – Material that does not meet the Class A criteria but has NP/AP ratio equal to or less than 1.9. All rock identified as the mafic volcanic unit CA CL MAF is also categorized as Class B; or
- Class C – Material that does not meet the Class A or B criteria.

The surrogate NP and AP relationships will be updated regularly (at least annually) with the data collected from the confirmatory laboratory testing described in Section 7.1.2. These results will also be used to refine and update the geological ARD model in terms of waste rock classification boundaries.

Visual examination will complement the laboratory analysis to adequately segregate the visually distinctive mafic volcanic unit CA CL MAF rocks. This unit will likely be able to be mapped visually in the open pit and automatically allocated to the Class B Facility due to its arsenic leaching potential.

7.1.2 External Laboratory Testing

A subset of samples collected as part of the Open Pit and Underground waste rock characterization described in Section 7.1.1 will also be submitted to an accredited external laboratory to validate the results from the on-site laboratory and confirm the ARD/ML potential of the waste rock. The same analysis will also be performed on Overburden samples and representative pulp sample composites from the Process Plant tailings. This analysis will comprise:

- Acid base accounting (ABA) to evaluate the ARD potential, including:
 - Paste pH;
 - Modified Sobek NP using the method described in Section 6.2.3 of Coastech Research (1991);
 - Sulphur speciation (total sulphur by Leco, sulphate-sulphur by hydrochloric acid [HCl] leach, and sulphide sulphur by difference); and
 - Total inorganic carbon (TIC) by HCl leaching.
- Bulk elemental analysis to determine overall metal content; and
- Shake flask extraction (MEND SFE) to determine soluble constituents associated with these materials (Price, 2009).

The bulk elemental content of the samples will be determined by aqua regia digestion, followed by ICP-MS and/or ICP-AES analysis of digestate, with detection limits in Table 7-1. While the full suite

of elements will initially be analyzed, it is anticipated that as mining progresses the element suite will be refined to include only the constituents of potential interest.

The SFE analysis will comprise the standard 3:1 water-solid ratio SFE as detailed by Price (2009) with analysis of pH, conductivity sulphate, fluoride, weak acid dissociable (WAD) cyanide, and dissolved metals indicated in Table 7-2. WAD cyanide analysis will only be performed on tailings samples since cyanide will be used in the Process Plant.

Following review of the analytical data by a geochemist/geologist, supplemental analysis such as Rietveld X-ray diffraction and net acid generation testing may also be considered to provide further information on ARD/ML potential.

Table 7-1: Aqua Regia Bulk Elemental Analytes and Detection Limits

Element	Units	Reporting Detection Limit ¹	Element	Units	Reporting Detection Limit ¹
Silver	ppm	0.01	Molybdenum	ppm	0.05
Aluminum	%	0.01	Sodium	%	0.01
Arsenic	ppm	0.1	Niobium	ppm	0.05
Gold	ppm	0.005	Nickel	ppm	0.2
Boron	ppm	10	Phosphorus	ppm	10
Barium	ppm	10	Lead	ppm	0.2
Beryllium	ppm	0.05	Rubidium	ppm	0.1
Bismuth	ppm	0.01	Rhenium	ppm	0.001
Calcium	%	0.01	Sulphur	%	0.01
Cadmium	ppm	0.01	Antimony	ppm	0.05
Cerium	ppm	0.02	Scandium	ppm	0.1
Cobalt	ppm	0.1	Selenium	ppm	0.2
Chromium	ppm	1	Tin	ppm	0.2
Cesium	ppm	0.05	Strontium	ppm	0.2
Copper	ppm	0.2	Tantalum	ppm	0.01
Iron	%	0.01	Tellurium	ppm	0.01
Gallium	ppm	0.05	Thorium	ppm	0.2
Germanium	ppm	0.05	Titanium	%	0.005
Hafnium	ppm	0.02	Thallium	ppm	0.02
Mercury	ppm	0.01	Uranium	ppm	0.05
Indium	ppm	0.005	Vanadium	ppm	1
Potassium	%	0.01	Tungsten	ppm	0.05
Lanthanum	ppm	0.2	Yttrium	ppm	0.05
Lithium	ppm	0.1	Zinc	ppm	2
Magnesium	%	0.01	Zirconium	ppm	0.5
Manganese	ppm	5			

¹ Reporting Detection Limits are subject to change based on interference at the time of analysis.

Table 7-2: SFE Analytes and Detection Limits

Parameter	Units	Reporting Detection Limit ¹	Parameter	Units	Reporting Detection Limit ¹
pH	pH units	Not applicable	Mercury ²	mg/L	0.00002
Electrical conductivity	µS/cm	1	Molybdenum ²	mg/L	0.00001
Sulphate	mg/L	1	Nickel ²	mg/L	0.00004
Fluoride	mg/L	0.1	Phosphorus ²	mg/L	0.01
Cyanide, Weak Acid Dissociable ¹	mg/L	0.001	Potassium ²	mg/L	0.02
Aluminum ²	mg/L	0.001	Selenium ²	mg/L	0.0001
Antimony ²	mg/L	0.00005	Silicon ²	mg/L	0.1
Arsenic ²	mg/L	0.00005	Silver ²	mg/L	0.00001
Barium ²	mg/L	0.0001	Sodium ²	mg/L	0.02
Beryllium ²	mg/L	0.00001	Strontium ²	mg/L	0.0001
Bismuth ²	mg/L	0.00001	Sulphur ²	mg/L	1
Boron ²	mg/L	0.002	Tellurium ²	mg/L	0.00005
Cadmium ²	mg/L	0.000002	Thallium ²	mg/L	0.000004
Calcium ²	mg/L	0.05	Thorium ²	mg/L	0.00001
Chromium ²	mg/L	0.0005	Tin ²	mg/L	0.00005
Cobalt ²	mg/L	0.000005	Titanium ²	mg/L	0.0002
Copper ²	mg/L	0.0001	Tungsten ²	mg/L	0.0002
Iron ²	mg/L	0.002	Uranium ²	mg/L	0.000001
Lead ²	mg/L	0.00005	Vanadium ²	mg/L	0.001
Lithium ²	mg/L	0.00005	Zinc ²	mg/L	0.001
Magnesium ²	mg/L	0.005	Zirconium ²	mg/L	0.00002
Manganese ²	mg/L	0.00005			

¹ Cyanide (weak acid dissociable) analysis only for tailings samples.

² Dissolved phase.

7.2 LOCATIONS AND FREQUENCY

The sample collection will be conducted in the following Project locations with various sampling frequency:

7.2.1 Open Pit and Underground

Cuttings will be collected from each open pit blast hole for waste rock classification purposes and analyzed at the on-site laboratory for surrogate AP and NP determination (via Leco sulphur and aqua regia ICP-AES calcium analysis, respectively). At least 20% of samples analyzed in the first year of operations will also be submitted for confirmatory analysis at the accredited external laboratory.

This can be decreased to 10% should good agreement be demonstrated between the on-site and external laboratory data.

7.2.2 Overburden

Grab samples from excavated overburden will be used to create a composite sample from every 50,000 m³ of overburden that is excavated at Site. The composite sample will be submitted to an external accredited laboratory for the analysis indicated in Section 7.1.2.

7.2.3 Process Plant Tailings:

Tailings samples will be collected daily as part of Process Plant operations. The daily samples will be blended to produce a monthly composite which will be submitted to an external accredited laboratory for the analysis indicated in Section 7.1.2.

7.3 QA/QC

The QA/QC program for the site-based laboratory will include:

- Analysis of replicate splits of blast hole cuttings and/or grade control samples (10% of samples) to assess sample variability (in terms of waste rock classification); and
- Analysis of certified reference materials on at least a monthly basis to ensure analytical accuracy.

The submission of a proportion (10 to 20%) of waste rock samples to the accredited external laboratory also forms part of the QA/QC of the on-site laboratory, notably for comparison of the total sulphur and calcium results obtained between the two laboratories.

For the external laboratory, preparation and analysis of laboratory blanks, replicates, and certified reference materials will form part of the data reported by the laboratory as part of their internal QA/QC.

7.4 REPORTING

Geochemical monitoring program results will be submitted in annual reports to YWB and EMR. These reports will include all geochemical data collected over the previous year, relevant analyses, and discussion of results in relation to the management criteria outlined in the Tailings Management Plan (BMC, 2026f) and Waste Rock and Overburden Management Plan (BMC, 2026g).

8 FISH AND AQUATIC RESOURCES

Aquatic ecosystems and resources (e.g., sediment, benthic invertebrates, fish, and fish habitat) are critical for maintaining the function of aquatic and biophysical environments, and fish have significant cultural importance.

Baseline assessments of fish and aquatic resources have been conducted in the vicinity of the Project (i.e., in Geona Creek, Finlayson Creek, South Creek, and the North Lakes system) intermittently since 1994 (Cominco, 1996; Cominco, 2000; Laberge and Can-Nic-A-Nick, 2003 to 2017; AEG, 2016a; BMC, 2021; Minnow, 2025). These baseline data are used to characterize baseline conditions, as described in the Site Characterization Plan, and to support fish and aquatic resources monitoring that will be conducted during the life of the Project. Fish and aquatic resources monitoring will have two primary objectives: to determine the effectiveness of mitigations and offsetting measures, and to assess for potential residual effects of mine development and operations on aquatic biota in the receiving environment, allowing for unforeseen conditions to be identified and responded to in concordance with the AMP. Three separate but related fish and aquatic resources monitoring programs will be required for the Project:

1. **Environmental Effects Monitoring (EEM)** - under the *Metal and Diamond Mining Effluent Regulations* (MDMER) of the *Fisheries Act* (Government of Canada, 2023) is required once mine effluent discharge exceeds 50 m³ per day. Information to be collected under EEM includes effluent characterization, sublethal toxicity, receiving water quality, and biological data to assess for effluent-related effects on fish health, fish habitat (i.e., benthic invertebrate communities), and/or the use of fisheries resources by humans (i.e., fish tissue quality). Once triggered, biological monitoring studies are conducted in 36- or 72-month phases. The requirements for each study are dependent on the results of studies from the previous phase(s).
2. **Fisheries Offsetting Effectiveness Monitoring** – Effectiveness monitoring of offsetting measures that will be implemented to counterbalance residual harmful alteration, disruption, and destruction of fish habitat will be required as a condition of the *Fisheries Act* Authorization (FAA) issued for the Project under the *Fisheries Act*. This monitoring program will assess habitat structure, riparian and aquatic vegetation growth, benthic invertebrate community composition, and fish species composition and abundance in the offsetting habitat with findings compared to success criteria established for specific monitoring components.
3. **Type A Quartz Mining Water Use Licence (WUL) Monitoring** – WUL monitoring will be required as a condition of the Type A WUL issued for the Project under the *Waters Act* by the YWB. In addition to EEM and FAA Effectiveness Monitoring, this will include monitoring of sediments at the frequencies required by MDMER for EEM.

The monitoring programs described for fish and aquatic resources in this Plan will serve to support the requirements of the monitoring programs listed above. With respect to EEM, a specific study design for biological studies will need to be developed and submitted to Environment and Climate Change Canada for each EEM phase and specific monitoring requirements will be dependent on the results of previous phases, as described above.

To minimize the potential for inadvertent Project effects from oversampling fish and aquatic resources and to reduce costs associated with implementing multiple monitoring programs, BMC is proposing a monitoring schedule such that EEM, FAA, and WUL monitoring programs are harmonized to the extent possible. At the time of preparing this Plan, the Project is in the permitting phase (i.e., EEM monitoring has not been initiated and an FAA has not yet been issued) therefore, the monitoring programs proposed (including monitoring frequency and methods) may be modified to align with EEM and FAA requirements.

8.1 AQUATIC SEDIMENTS

8.1.1 Methods

Stream sediment samples will be collected downstream of riffle habitat in depositional environments (e.g. pools) to obtain fine-grained sediment samples. Triplicate samples will be collected from each site, with the first composite sample located at a downstream position and the others located consecutively upstream to avoid sampling downstream from disturbed substrate. Each sample will be a composite of five samples collected from micro sites at each sample site. Fine sediment will be collected using methods that consider site conditions and water depth (e.g. 2" Lexan core tube, stainless steel trowel, glass jars, clean hands or gloves). Samples will be placed into acid-washed glass sediment sample bottles and kept cool prior to delivery to a CALA certified laboratory.

Sediment samples will be sieved in the laboratory for analysis of total metals of the fine fraction (< 63 µm). For elemental abundance, sediments samples will be fire dried and then digested in an aqua regia cocktail (HCl and HNO₃) at 90°C for three hours according to the BC Strong Acid-Leachable Metals protocol to provide a measure of sediment components. Metals in the digest will then be measured using inductively coupled plasma mass spectrophotometry (ICP-MS) or optical emission spectrophotometry (ICP-OES), as appropriate. Mercury will be analyzed by cold vapour atomic fluorescence spectrophotometry. The sediment will also be analyzed for total organic carbon content and particle size distribution.

8.1.2 Locations and Frequency

The stream sediment quality monitoring locations and frequency are presented in Table 8-1 and shown in Figure 8-1.

Table 8-1: Sediment Monitoring Locations, Frequency and Timing

Station	Description	Frequency of Sampling	Timing
KZ-37 ¹	Geona Creek downstream of unnamed East Tributary	Construction: 1 year Operations: Annually for years 1-3, every 3 years starting year 6	Late August or September
KZ-17	Geona Creek at the mouth		
KZ-15 ¹	Finlayson Creek 100 m downstream of confluence with Geona Creek		
KZ-16 ¹	Finlayson Creek immediately upstream of confluence with Geona Creek		
KZ-21 ¹	East Creek at the mouth		

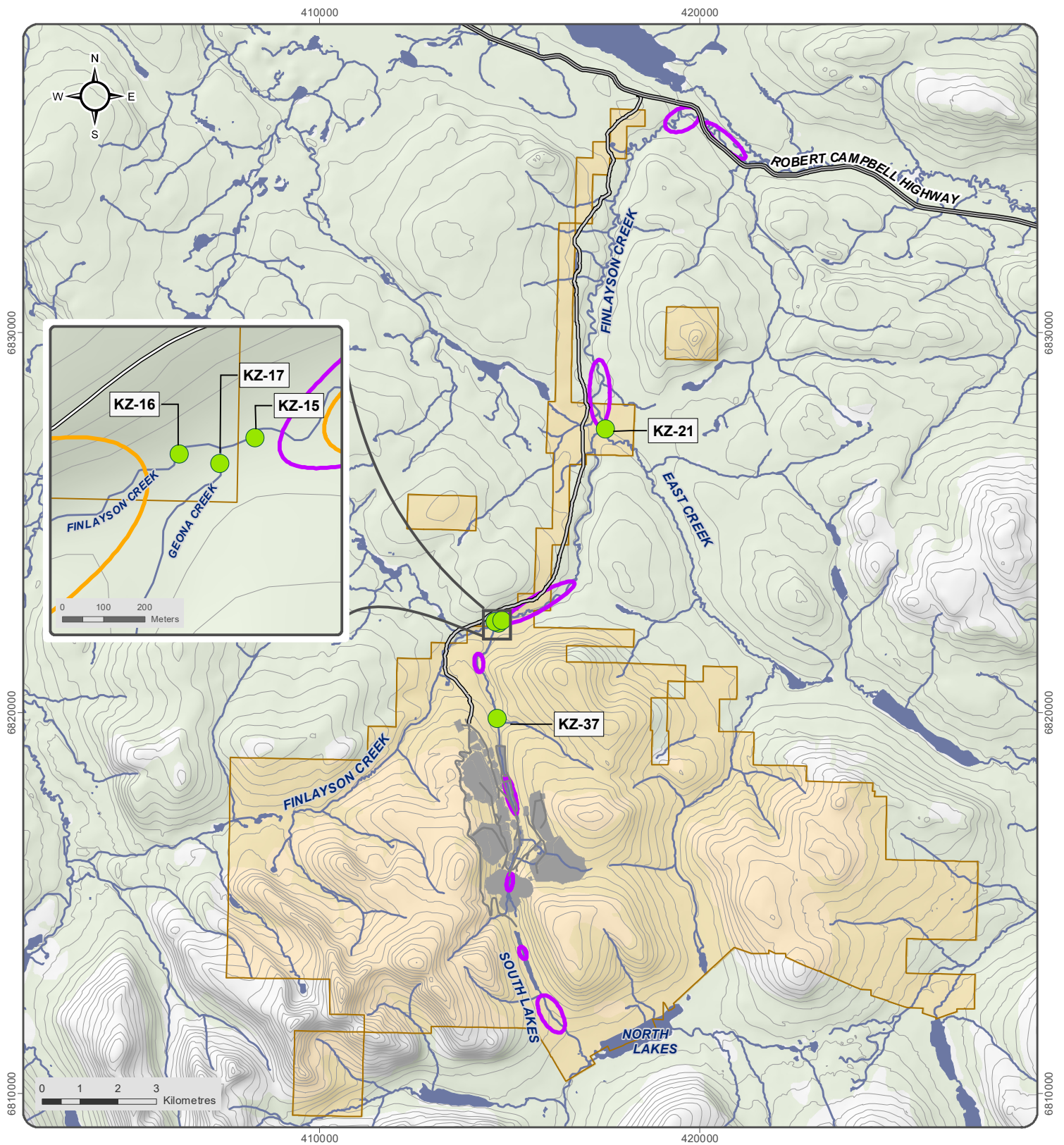
¹ Sites correspond with approximate locations of future EEM stations.

8.1.3 QA/QC

QA/QC protocols comprise standard procedures in the field to avoid sample contamination, review of laboratory QA/QC (certified reference materials and laboratory duplicates), and evaluation of the precision of field replicates. Quality assurance in the field will include cleaning the equipment (plastic collection pan, spatulas) with de-ionized water between sites, rinsing thoroughly with ambient water between replicates, and wearing nitrile gloves (clean gloves at each site) while sampling and preparing samples. Acid-washed glass sampling jars will be used for sediment sample collection. Upon collection, filled sample jars will be immediately placed in a clean cooler containing ice packs.

8.1.4 Reporting

Sediment quality data will be compared to pre-construction baseline sediment quality and the CCME Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1999a). Results of the sediment monitoring program will be reported to the YWB and EMR in an annual report in years the monitoring program is performed. All field data will be analyzed and provided in summary tables within the annual report. Raw data will be available upon request.



- | | | |
|--|--|---|
| ● Sediment and Benthic Invertebrate Monitoring Station | Location of Proposed Infrastructure | Waterbody |
| Proposed Closed Station Electrofishing Location Area | BMC Minerals Ltd. Mineral Claim Areas | — Watercourse |
| | | — Contours (40m interval) |

KUDZE KAYAH PROJECT

FIGURE 8-1

FISH AND AQUATIC RESOURCES MONITORING STATIONS

APRIL 2024

National topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from Her Majesty the Queen, as represented by the Minister of Natural Resources Canada. All rights reserved. Datum: NAD 83; Projection: UTM Zone 9N



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8.2 FISH AND AQUATIC LIFE

8.2.1 Methods, Locations and Frequency

8.2.1.1 *Benthic Invertebrates*

The Fish and Aquatic Life Monitoring Program will include benthic invertebrate sampling that is consistent with technical guidance for EEM (Environment Canada, 2012) and will facilitate statistical comparison (e.g., suitable replication of sub-samples and sample stations within areas) with baseline benthic invertebrate data. In particular, the sampling will facilitate the use of a Before-After-Control-Impact (BACI) study design for EEM which helps to distinguish effluent effects from natural differences between reference and exposure areas that may have existed before the initiation of effluent discharge.

Benthic invertebrates will be assessed at the same locations as during the 2024 baseline study: downstream of the future effluent discharge locations near KZ-37 in Geona Creek and KZ-15 in Finlayson Creek, respectively, and their associated reference areas in East Creek (KZ-21)) and Finlayson Creek upstream of the confluence with Geona Creek (KZ-16) as listed in Table 8-2 and shown in Figure 8-1. Targeting similar habitat characteristics (e.g., substrate characteristics, water depth, and water velocity) among areas and among replicates within areas, five replicate stations will be identified per area allowing a minimum separation of three times the bankfull width between stations (Environment Canada, 2012). At each station, one benthic sample representing a composite of three sub-samples will be collected to ensure a representative sample. Habitat at the sampling areas is expected to be erosional and therefore a Hess or Surber sampler equipped with 500 µm mesh will be used for benthic invertebrate sample collection, unless substrate size is too large, in which case benthic invertebrate sampling will be completed using a timed kick and sweep. Benthic invertebrate tissue samples (composite-taxa) will also be collected at each station using a combination of kick and-sweep and hand picking (i.e., turning over rocks in the streambed and collecting any benthic invertebrates observed). Supporting data collected for the benthic invertebrate monitoring will include water quality (one per area), sediment quality (in the nearest depositional habitat), and field-based measures of temperature, dissolved oxygen, pH, and conductivity (at each station). Substrate characterization (quantification of substrate diameter and embeddedness for all individual surficial materials located within the replicate Hess grab sampling area), water velocity, sample depth, and GPS coordinates will also be recorded at each station. Water quality and sediment sampling during benthic invertebrate monitoring will be coordinated with the Surface Water Quality and Aquatic Sediment Monitoring Programs to the extent feasible.

The frequency of benthic invertebrate monitoring varies by Project stage and is summarized in Table 8-2. Monitoring will be conducted once during Construction, after which monitoring during Operations will be conducted annually for the first three years followed by every three years thereafter. Monitoring may occur more frequently if an AMP trigger is reached. The sampling frequency indicated in Table 8-2 has been selected so that benthic invertebrate sampling coincides with EEM and FAA monitoring schedules to the extent feasible, to increase efficiency, reduce program costs, and to minimize potential for inadvertent impacts to aquatic habitat and aquatic life from disturbance associated with frequent sampling.

Table 8-2: Benthic Invertebrate Monitoring Locations, Frequency, and Timing

Station	Description	Frequency of Sampling	Timing
KZ-37 ¹	Geona Creek downstream of unnamed East Tributary	Construction: 1 year Operations: Annually for years 1-3, every 3 years starting year 6	Late August or September
KZ-17	Geona Creek at the mouth		
KZ-15 ¹	Finlayson Creek 100 m downstream of confluence with Geona Creek		
KZ-16 ¹	Finlayson Creek immediately upstream of confluence with Geona Creek		
KZ-21 ¹	East Creek at the mouth		

¹ Sites correspond with approximate locations of future EEM stations.

Benthic invertebrate community samples will be preserved to a level of 10% buffered formalin in ambient water following collection while benthic invertebrate tissue samples will be stored in a cooler with ice packs and transferred to a freezer at the end of each field day. At the conclusion of the field study, the benthic invertebrate community and tissue samples will be submitted to CALA certified laboratories for analysis. For benthic invertebrate community samples, the laboratory will follow standard sorting methods and incorporate recommended Environment Canada (2012) QA/QC procedures for assessing sub-sampling error and sorting recovery checks. Upon receipt of analytical data for benthic invertebrate community and tissue chemistry, a data quality review (DQR) will be completed including an examination of data completeness, laboratory accuracy, and laboratory precision. Following the DQR, analysis of benthic invertebrate community data will be completed at both family level, and lowest practical level of taxonomic identification. Although family level taxonomy is recommended for EEM (Environment Canada, 2012), lowest practical level taxonomy can provide greater resolution and allow a more comprehensive evaluation of benthic data.

Analysis of benthic invertebrate data will focus on measurable parameters representing productivity, community condition, and tissue quality. Benthic invertebrate communities will be assessed using biomass (dry weight/m²) and EEM primary metrics of mean taxonomic richness, mean invertebrate density, Simpson's Evenness, and Bray-Curtis dissimilarity as required under the MDMER (Environment Canada, 2012), as well as percent composition of dominant/indicator taxa (e.g., percent Ephemeroptera, Plecoptera, and Trichoptera), habitat preference groups, and functional feeding groups. Dominant/indicator taxon groups will be defined as those groups representing, on average, greater than 5% of total organism abundance for a study area or any groups considered to be important indicators of environmental stress. Benthic tissue quality will be assessed using mean tissue concentrations of metals evaluated for the Surface Water Quality Monitoring Program (Chapter 5).

Statistical analyses comparing measurable parameters between exposure and associated reference areas will be completed in accordance with EEM technical guidance (Environment Canada, 2012). A statistically significant difference in an endpoint between the effluent-exposed area and the reference area will be determined at $p = 0.10$ (Environment Canada, 2012). The magnitude of effect for density, taxon richness, and Simpson's Evenness (i.e., EEM primary metrics) will be calculated using MDMER formulas where these endpoints differ significantly between exposure and reference areas (Government of Canada, 2023) and compared to MDMER Critical Effect Size (CES) applicable to these endpoints (i.e., ± 2 reference area standard deviations [SD]). The CES define ecologically relevant 'effects', which are analogous to differences beyond those expected to occur naturally between two

areas that have not been influenced by anthropogenic inputs (i.e., between pristine reference areas; see Munkittrick et al., 2009; Environment Canada, 2012). Benthic invertebrate tissue quality data will also be screened against the British Columbia selenium guideline for the protection of aquatic life (for invertebrate tissue) of 4 mg/kg dry weight (BC ENV, 2014).

8.2.1.2 Fish and Fish Habitat

The Fish and Aquatic Life Monitoring Program will also include assessment of fish and fish habitat in the vicinity of the Project and will follow a similar design to the 2024 baseline study to facilitate temporal comparisons and allow for the detection of potential mine-related effects.

With respect to fish, closed-station electrofishing will be completed at stations established in Geona Creek, Finlayson Creek, and South Creek (Figure 8-1) in late August to generate estimates of density and biomass that can be compared to 2024 baseline data collected at the same locations. Note that only one of the closed-station electrofishing stations in Geona Creek from the 2024 baseline study is included in the Fish and Aquatic Life Monitoring Program (Reach 1) as the remaining stations will not be available due to the construction of mine infrastructure in the Geona Creek catchment.

Stations will be enclosed using mesh stop nets with care taken to ensure that total sampling area is documented. An electrofishing team, consisting of an electrofishing unit operator and a netter, will employ a multiple pass removal method at each station whereby one upstream pass (or “sweep”) of the enclosed reach will be repeated three times or more to yield a fish removal pattern (i.e., diminishing catches) that will be used to determine fish density. At the conclusion of each sweep or pass, shocking effort (i.e., electrofishing seconds) and fish count by species will be recorded. Fish captured during each closed station sweep will be placed in buckets of aerated water and allowed to recover before collection of physical measurements. The other non-destructive fish collection methods (e.g., seining, short set gill net sets, minnow trapping, etc.) will also be employed during monitoring. The monitoring methods, locations and effort will be consistent with the previous baseline programs to facilitate comparisons. For all captured fish for each capture method, fork and total length will be measured to the nearest millimeter using a measuring board, and weight will be measured to the nearest 0.01 g using an electronic balance or appropriately sized Pesola scale (i.e., 10 g). External abnormalities will be recorded and photographed (if necessary) prior to release at the location of capture. Incidental mortalities will be retained for aging and analysis of tissue metals concentrations.

For each fish collection method, supporting information including sampling effort and GPS coordinates will be recorded. Habitat characteristics will also be documented at each closed station electrofishing station and at the future effluent-exposed and corresponding reference areas (where these do not coincide with an electrofishing station) including *in situ* water quality, wetted and bankfull width and depth, substrate composition, riparian and aquatic vegetation types, types and proportions of instream cover for fish, as well as any potential confounding influences or other observations deemed relevant to interpretation of the fish survey data (e.g., presence of fish barriers).

Fish and fish habitat monitoring will be conducted at the same frequency as benthic invertebrate monitoring: once during Construction, then annually for the first three years, followed by every three years thereafter during Operations, as described in (Table 8-3). Fish and fish habitat monitoring for

the Fish and Aquatic Life Monitoring Program will coincide with EEM and FAA monitoring to the extent feasible, to increase efficiency, reduce costs, and minimize potential for inadvertent impacts to fish and fish habitat.

Table 8-3: Fish Monitoring Program Closed-Station Electrofishing Locations, Frequency, and Timing

Waterbody	Description	Sample Size	Frequency of Sampling	Timing
Finlayson Creek	Finlayson Creek downstream of the Robert Campbell Highway	n = 3	Construction: 1 year Operations: Annually for years 1-3, every 3 years starting year 6	Late August or September
	Finlayson Creek immediately upstream of the Robert Campbell Highway	n = 1		
	Finlayson Creek downstream of the confluence with East Creek	n = 1		
	Finlayson Creek downstream of the confluence with Geona Creek	n = 1		
Geona Creek	Reach 1	n = 1		
South Creek	Between South Lake A and South Lake B	n = 1		
	Downstream of South Lake	n = 2		

Note: The specific locations of closed-station electrofishing stations and other fish sampling locations (i.e., for minnow trapping, gill netting, seining, etc.) were determined during the 2024 baseline study based on assessments of available habitat.

Closed station electrofishing data will be used to determine fish density (number of fish per unit area) at sampling locations in Geona Creek, Finlayson Creek, and South Creek using the Carle and Strub method (Carle and Strub, 1978). Fish density at individual sites will then be standardized to the number of fish per 100 m² using the total capture area. Biomass will be calculated by multiplying density estimates by the mean mass of the captured fish. For the remaining fish collection methods, catch-per-unit-effort will be calculated separately for each fishing gear type (i.e., minnow trapping, seining, gill netting, etc.) for each area sampled. For each capture method, fish density, biomass, and/or catch-per-unit-effort will be compared to baseline data and within areas across years once more than one year of monitoring data has been collected. Reproduction or spawning success will be determined through evaluation of catch results and the presence of young of year fish; confirming spawning through direct observation of the presence and abundance of young of year gives an indication of spawning success and survival of young.

Results of baseline studies and compliance monitoring completed since 1995 suggest that densities of fish upstream of the Robert Campbell Highway are too low to reliably catch enough fish to conduct

robust statistical comparisons for fish health endpoints.¹ However, if sufficient numbers of Arctic grayling and/or slimy sculpin are captured during baseline and monitoring events, fish health will be evaluated for four endpoints. Body size will be evaluated with fork lengths and body weights, condition (weight-at-length) will be used as an indicator of energy storage, and cumulative relative frequency distributions of fork lengths (i.e., length frequency distributions) may be used as an indicator of survival if sufficient data is collected. Summary statistics (mean, SD, minimum and maximum value) will be calculated separately by area and year for each endpoint. Endpoints will be compared statistically among time periods for each area using procedures consistent with federal EEM technical guidance (Environment Canada, 2012). A statistically significant difference in an endpoint between monitoring and baseline data will be determined at $p = 0.10$ (Environment Canada, 2012). Where condition differs significantly between monitoring and baseline, the magnitude of difference will be calculated as described by Environment Canada (2012) and compared to the CES (10%; Munkittrick et al., 2009, Environment Canada, 2012).²

Fish habitat characterization measures will be summarized (i.e., mean, SD, minimum and maximum value) for all numerical parameters (i.e., wetted and bankfull width and depth) for each area within each year of monitoring. Habitat variables will then be compared to rearing habitat preferences for different life stages of Arctic grayling and slimy sculpin indicated in the literature, where available, and to baseline data. Bankfull channel width/depth ratio, which is an indicator for the AMP, will be calculated and compared statistically between the future effluent-exposed and reference areas ($p = 0.10$) with the effect size compared to the CES of ± 2 reference area SD, which is typical in aquatic environmental effects monitoring (Munkittrick et al., 2009, Environment Canada, 2012, Kilgour et al., 2017, Somers et al., 2018).

BMC recognizes that one of the commitments made during the environmental assessment (see table of commitments) was to have a robust Arctic grayling sampling program to address human health concerns for those traditional land users who have historically fished in Finlayson Creek. However, results of baseline studies and compliance monitoring completed since 1995 suggest that densities of Arctic grayling upstream of the Robert Campbell Highway are too low to reliably catch enough fish (i.e., $n = 8$ individuals greater than 20 cm in length and ideally of the same sex at each of the proposed future exposed and reference areas) to gain statistical certainty regarding effects on fish tissue. However, incidental mortalities during sampling for the Fish and Fish Habitat Monitoring Program will be retained for analysis of tissue metal concentrations and sufficiently sized Arctic grayling, if captured, will also be sampled non-lethally for fish tissue through collection of a tissue plug.

¹ A total of 113 Arctic grayling have been captured in Geona Creek across baseline studies (Cominco, 1996, AEG, 2016a, BMC, 2021). During WUL compliance monitoring in Finlayson Creek upstream of the Robert Campbell Highway in August from 2000 to 2014 and October in 2016, only one Arctic grayling was captured at stations KZ-15 (100 m downstream of the confluence with Geona Creek) and KZ-16 (upstream of the confluence with Geona Creek) over the eight monitoring events. Slimy sculpin (*Cottus cognatus*) have been caught more frequently in Finlayson Creek but have not been caught in Geona Creek except in small numbers near the confluence with Finlayson Creek.

² Of the four fish health endpoints that will be evaluated (dependent on sufficient data being collected during both baseline and monitoring periods), only condition has a corresponding EEM CES.

Additionally, under Environmental Effects Monitoring, a fish tissue study is triggered if the annual mean concentration of total mercury or selenium in effluent is equal to or greater than 0.10 µg/L and 5 µg/L, respectively, based on a calendar year, and/or effluent characterization reveals a concentration of total selenium in the effluent that is equal to or greater than 10 µg/L, as per the MDMER.³ If effluent characterization indicates that a fish tissue study is required, although sportfish species (e.g., Arctic grayling) are preferred for EEM fish tissue studies, slimy sculpin in Finlayson Creek may be used as an indicator, if effluent concentration in the receiving environment exceeds 1% in Finlayson Creek. The EEM study design will be developed in discussion with, and will be approved by, Environmental and Climate Change Canada.

8.2.2 Reporting

Monitoring data collected for the Fish and Aquatic Life Monitoring Program will be assessed in winter to early spring of the year following each monitoring event (i.e., monitoring data collected in late summer will be assessed in late winter to early spring of the following year). This considers the time required for laboratory analysis of benthic invertebrate, fish aging, and tissue samples, completion of a data quality review of laboratory data, and subsequent statistical analyses, as required. An interpretive report will then be prepared that details field and laboratory methods, data analyses, and monitoring results, including clear and concise figures and tables to enhance the presentation of all information. Summary data will be used as the basis of discussion and the formation of conclusions. Additional data (e.g., detailed catch results, supporting measures from sampling, etc.) will be appended to the report. The interpretive report will be submitted to YWB and EMR as part of the annual reporting requirements.

³ A study respecting fish tissue is also triggered if the method detection limit used in respect of mercury for the analysis of at least two of four effluent samples in a calendar year is equal to or greater than 0.10 µg/L and/or if the method detection limit used in respect of selenium for the analysis of any effluent sample is equal to or greater than 10 µg/L, and/or the method detection limit used in respect of selenium for the analysis of at least two of four effluent samples in a calendar year is equal to or greater than 5 µg/L.

9 TERRESTRIAL RESOURCES

Vegetation cover and composition play a crucial role in maintaining a healthy environment, encompassing both the biophysical and human aspects, and have significant cultural value. Project activities have the potential to impact vegetation cover and composition.

Vegetation and soils together regulate various biogeochemical cycles, such as water, carbon, and nitrogen, playing an integral role in aquatic habitat, wildlife habitat, and the hydrological system. The growth and decomposition of plants strongly influence soil characteristics, including nutrient levels, volume, structure, and stability. While metals naturally occur in the soils and vegetation at KZK, Project activities may increase concentrations of metals in the surrounding areas. Soils have the capacity to absorb metals, and specific plants, such as zinc and cadmium accumulators, can move these elements into the local food web. Monitoring the quantity and dispersal routes of these potentially released metals can provide data to determine the necessity of mitigative and/or adaptive management measures, as discussed in the Adaptive Management Plan.

Since the 1990s soil and vegetation baseline programs have focussed on on rare plants, invasive species, trace metals concentrations, nutrient levels, wetland and riparian ecosystems and forest productivity and timber volumes. Baseline data are summarized in the Site Characterization Plan (BMC, 2026c).

For the purposes of the Terrestrial Resources chapter of the EMSRP the subcomponents that will be monitored are:

1. Rare plants (Section 9.1);
2. Invasive plant species (Section 9.2); and
3. Trace metal concentrations in soil and plants (Section 9.3).

Through progressive reclamation and final reclamation, vegetation communities (including wetland and riparian ecosystems will be re-established). Therefore, the monitoring of vegetation communities has been included in Chapter 12 of this EMSRP.

9.1 RARE PLANTS

A Chance Find Procedure will be implemented for rare plant monitoring, adapted from the Chance Find Procedure used for heritage resources in British Columbia (Government of British Columbia, 2014). The Procedure will guide on-site personnel (i.e., equipment operators, construction workers), who will be trained to recognize and respond to the potential discovery of rare plant species.

Rare plants are most likely to be found in rare ecosystems, particularly near cliffs, steep south-facing slopes and wetlands. While no rare plants have been identified to date, some potential rare plant species in the Project area include: Parry's Arnica, also known as Nodding Leopardbane (*Arnica parryi*); Northern Beech Fern (*Phegopteris connectillis*); Leafy Thistle (*Cirsium foliosus*); Mount Sheldon Ragwort (*Senecio sheldonensis*); Spiny-spored Quillwort (*Isoetes echinospora*); Maritime Quillwort (*Isoetes maritima*); Water Mudwort (*Limosella aquatica*); Common River Grass (*Scolochloa festuacea*); Blunt-leaf Pondweed (*Potamogeton obtusifolius*).

9.1.1 Methods

At the beginning of Project construction equipment operators and site personnel will receive information (i.e., descriptive factsheets) aiding in the recognition and identification of rare plants with a high likelihood of occurring within the Project area. These resources will be integrated into the clearing protocols. The information provided will encompass species tracked by the Yukon Conservation Data Centre (YCDC) and those on the watch list that could potentially occur within the Project footprint.

If a suspected rare plant is encountered during construction and/or operations, the following procedures will be followed:

- Stop work in the area: cease all construction activity in the immediate area, as is safe to do so;
- Record the location of the find and do not disturb the area further. Cordon off the suspected rare plant and surrounding vegetation;
- Contact the site Environmental Department. The Environmental Department will have qualified personnel confirm the identification of the plant;
- If the plant is determined not to be rare, Environmental Department may approve the continuation of work in the area; and
- If the plant is confirmed to be rare, the Environmental Manager will contact the Yukon Department of Environment, YCDC Ross River Dena Council, and Liard First Nation environmental contacts to determine the appropriate mitigation measures to be implemented if avoiding the area is not feasible.

9.1.2 Locations and Frequency

The Chance Find Procedure for rare plants will be in place on an ongoing basis during construction and operations. Any clearing scheduled during the spring and summer will be required to implement the Procedure with extra diligence as these are the peak growing seasons for rare plants and the potential for chance encounters is greater.

9.1.3 QA/QC

The rare plant list for the Chance Find Procedure, along with the tracked and watched species lists, will be reviewed and updated annually to provide the latest information from the YCDC as territorial and federal plant rankings are frequently updated.

Any suspected rare plant encounters will be reported to the Environmental Department, who will then contact a qualified professional to verify the identification of the observed species.

9.1.4 Reporting

If any rare plant encounters are confirmed, the following information must be documented and provided to the Environmental Manager:

- Species identification;
- GPS location;
- Photos (habitat overview, surrounding vegetation, plus detailed photos of the plant showing relevant identification features [i.e., flowers, leaves, stems, roots, fruits]);
- Phenology (i.e., flowering, seed set, etc.);
- Number of individuals/population size;
- Area of extent of the population (square metres);
- Habitat; and,
- Name, contact information and credentials of the qualified person who confirmed the identification.

The Environmental Manager will notify the YCDC of any confirmed rare, tracked or watched species observations. These observations will also be included in annual reports to YWB and EMR.

9.2 INVASIVE PLANT SPECIES

An invasive plant species monitoring program is required as part of the Invasive Species Management Plan (ISMP) to identify, monitor and manage invasive plant species populations. The ISMP is provided in Appendix E. The ISMP aims to establish a systematic and annual survey schedule with a uniform methodology. This program will not only facilitate ongoing monitoring of invasive plant species but will also evaluate the effectiveness of implemented control methods.

9.2.1 Methods

Before each field investigation, a comprehensive review of available desktop data will be conducted to guide survey efforts. This will include the most recent versions of the following sources, as publicly available species lists are frequently updated:

- Existing data from surveys previously conducted for the Project (2015 through 2025);
- Yukon CDC Exotics List (Yukon Invasive Species Council, 2023); and,
- Yukon Invasive Species Council watchlist of Rank 1 Invasive Plants (Yukon Invasive Species Council 2014).

Surveys will involve a combination of roadside and ground surveys (i.e., walking), where appropriate. Roadside surveys, conducted from a slow-moving vehicle, will either involve a driver and two observers or a driver and one observer. If two observers are present, they will each observe different

sides of the road and the road will only be surveyed once. If there is only one observer, then the road will be driven in both directions with the observer observing from the front passenger side. If a potential invasive plant is observed from the vehicle, surveyors will exit the vehicle to confirm, identify and document the invasive plant occurrence. Appropriate safety measures will be implemented for the roadside surveys to reduce potential hazards for both the surveyors and road users. Ground surveys will be performed in a meandering search pattern by two people. One person will follow the perimeter of the area to be surveyed (i.e., disturbed area, borrow pit, etc.) using a GPS to track and record the area surveyed and search for any invasive species along the perimeter of the surveyed area. The other person will meander within the area being surveyed in search of any invasive species.

Any occurrences of invasive plants will be documented using established data sheets and naming protocols to provide consistency in data collection across years and ease of data interpretation and reporting for subsequent years. Starting in 2024, all sites will be named following the naming convention described below. Each year will start numbering anew for new observations, and if known plant locations are visited in subsequent years, the previous year's site name will be used. The data sheets will include the following information to be documented for invasive plant observations:

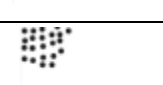
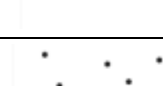
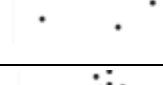
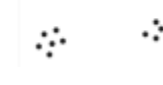
- Observation site number using the following format: IP (invasive plant)-chronological number of current year's site observation-year (e.g., IP-01-24, next observation IP-01-24);
- Identification to species (common and scientific names);
- Yukon invasiveness rank, from rank 1 (high invasiveness) to rank 7 (low to insignificant invasiveness) (Yukon Invasive Species Council, 2023);
- GPS location (UTM);
- Site description (i.e., laydown, stockpile, roadside, clearing, nearby infrastructure, etc. including a description of the surrounding plant community);
- Area of extent of invasive plants (m²);
- Density distribution code of invasive plant population (Table 9-1);
- Phenology (i.e., flowering, seed set, etc.);
- Photos (detailed photos of the plant, overview photos of location with a reference point so the location can be found in future surveys);
- Whether any treatment is applied and if so, the treatment method (hand pulled, removed with shovel);
- Area treated (m²); and,
- Any relevant notes.

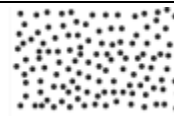
All listed invasive species observations will be recorded. Invasive species management will be focused on invasive species ranked as a high (Rating 1) or high to medium (Rating 5) invasiveness species by the Yukon Conservation Data Centre and the Yukon Invasive Species Council (Table 9-2).

Incidental observations may also be made during other surveys which may be conducted during the Construction and Operation phases of the Project (i.e., surveys not specifically targeted at invasive plant identification and documentation). These incidental observations should be reported to the Environmental Manager who will incorporate the findings into the Invasive Plant Monitoring Program.

Targeted removal of Rank 1 invasive species identified during the invasive plant surveys may be completed by the crew during the invasive plant survey depending on the extent of the infestation. For example, if the crew identifies a few individual invasive plants that can easily be hand-pulled or removed with a shovel, then those plants should be removed at that time, using appropriate removal and disposal methods. However, if the crew observes a large or complex infestation that cannot reasonably be removed during the invasive plant survey, then appropriate treatment will be recommended to the Environmental Manager.

Table 9-1: Density Distribution Classes for Invasive Plant Populations

Class	Density Distribution	No. of plants in 20 m x 20 m area	No. of plants/ha 100 m x 100 m	Diagram	Approximate % Cover Range
1	rare individual, a single occurrence	1	≤5		1-5
2	a few sporadically occurring individuals	2-5	5-50		1-5
3	a single patch or clump of species	1 patch (occupying an area smaller than one quadrant of the plot)	variable (3 patches)		1-10
4	several sporadically occurring individuals	≥6	≥50		5-10
5	a few patches or clumps of species	2-5 patches (each occupying an area smaller than one quadrant of the plot)	variable (3-10 patches)		10-30
6	several well-spaced patches or clumps	≥6 patches (each occupying less than one quadrant of the plot)	variable (10-many disjunct patches)		10-30

Class	Density Distribution	No. of plants in 20 m x 20 m area	No. of plants/ha 100 m x 100 m	Diagram	Approximate % Cover Range
7	continuous occurrence of a species with a few gaps in the distribution	many	many (some openings)		30-60
8	continuous dense occurrence of a species	many	many		>60

Notes: The density distribution class is determined over a sufficiently large area to account for normal variation in distribution pattern.
Luttmerding et al. (1990)

Table 9-2: Invasiveness Rating Codes and Descriptions

Invasiveness Rating ID	Invasiveness Rating Description	Comment
1	High Invasiveness	Most of these species are regularly occurring and are considered very persistent.
2	Medium Invasiveness	Most of these species are regularly occurring and are considered persistent and slow to spread.
3	Low Invasiveness	Most of the species listed are regularly occurring to having accidental occurrence and not known to easily spread.
5	High to Medium Invasiveness	Most of the species listed are regularly occurring and are considered persistent and can be quick to spread.
6	Medium to Low Invasiveness	Most of the species listed are regularly occurring and most can be considered persistent but slower to spread.
7	Low to Insignificant Invasiveness	Most of the species listed are regularly occurring to having accidental occurrence and isolated to certain areas of the Yukon.

9.2.2 Locations and Frequency

To inform management (i.e., control and evaluation of success of existing control methods), invasive plant surveys will be conducted annually within the Project area and along the Access Road. The areas to be surveyed each year will be refined based on specific areas of management concern or known invasive plant locations, but will generally remain within the Project area and along the Access Road.

Invasive plant surveys will be conducted annually during Project construction and operation to provide an overall assessment of invasive plant presence for the Project. The annual invasive plant survey will be conducted during the snow-free growing season (i.e., early summer) to allow for positive species identification and potential control of invasive plants prior to seed set. If invasive plant populations are observed to increase over time, then survey frequency will be increased to include both an early and late season survey each year. Survey frequency may be adjusted within reason during operations as determined by the outcomes of previous monitoring, incidental observations or in consideration of adaptive management.

Additionally, areas of previous infestations, previously treated infestations and areas identified with a high risk of invasive plant populations establishing will be investigated (i.e., treatment inspections) to evaluate the success of the treatment and the risk of populations spreading. These treatment inspections will be conducted once a year, at a minimum, in the late summer or early fall; however, the frequency and timing will be adjusted depending on the target species, the method of control and the severity of the infestation.

9.2.3 QA/QC

The invasive plant surveys will be conducted by qualified professionals with expertise in the identification of invasive plants and general plant taxonomy. If any plants cannot be identified to species during the field investigations, the plant should be thoroughly documented (and a specimen may be collected) to aid identification later by a qualified professional. The data collected will include:

- GPS location (UTM);
- Plant community description of location of observation;
- Habitat description (i.e., landscape position, slope, aspect, dry or wet conditions, disturbance type);
- Detailed photos of identification features (i.e., flowers, flower parts, fruits, leaves, stems, roots);
- Density distribution code of population;
- Area of extent of the population; and,
- Notes.

9.2.4 Reporting

After completion of the annual invasive plant surveys, a memo will be provided to the Environmental Manager summarizing the results of the surveys and treatment recommendations. An annual report will be developed at the end of each year, including methods, results, a discussion of changes in invasive plant populations from previous years, and treatment recommendations. Any control that was implemented at the time of the invasive plant surveys will be documented in the report(s) to support and inform further control and management efforts. Survey results will also be included in annual reports to YWB and EMR.

9.3 TRACE METAL CONCENTRATIONS

The Trace Metal Concentration Monitoring Program aims to assess potential impacts on vegetation health due to trace metal uptake from fugitive dust or other Project emissions. Elevated concentrations of trace metals may pose risks to wildlife and humans consuming affected plant material. Dust, depending on its chemical properties, frequency, and amount, can affect plant

transpiration, photosynthesis, and respiration within plant species (Walker and Everett, 1987). Although trace metals are elements that occur in natural environments, they may become toxic to living organisms when concentrations become excessive (Adriano, 2001).

The program's objective is to monitor trace metal concentrations in soil and select vegetation species, comparing them to baseline and reference conditions, ensuring that the Project does not exceed identified thresholds. The study design employs statistical methods to detect potential changes in trace metal concentrations in soil and select vegetation species over time. All baseline monitoring sites are located within two kilometres of the Project footprint as shown in Figure 9-1. Sampling locations beyond this distance are needed to determine the potential affects of mine activity on dust dispersion and metal uptakes by soils and vegetation.

The study design was developed using the following steps:

1. Comparison with the Project's Air Quality Dispersion Model – Baseline monitoring sites were compared to the Air Quality Dispersion Model and air quality monitoring results. The preliminary assessment indicates that most baseline sites occur either in 'high' or 'moderate' TSP concentration zones (as defined in Figure 9-1), or in areas between those zones (see below). Therefore, more sites will be needed. Rather than focusing on distance to the Project footprint, 'predicted dust-fall concentration zones' were used, derived from the Air Quality Dispersion Model. An additional 'reference' area will be chosen beyond the model's predictions (i.e., where air quality is not expected to be affected); and
2. Determination of Sample Sizes – The minimum number of samples needed in 'high', 'moderate', 'low', and 'reference' dust-fall concentration areas to detect statistically significant changes in soil and vegetation concentrations was determined through a power analysis. This analysis compared different effect sizes to determine minimal sample sizes in each dust-fall concentration zone for the trace metal monitoring program.

Baseline monitoring site locations and trace metal data were evaluated and compared to the Air Quality Dispersion model (24-hour average TSP). Following a review of the Air Quality monitoring program, the trace metal monitoring program developed three zones for sampling where 'high concentration zone' sites would correspond to TSP dispersion greater than $96 \mu\text{g}/\text{m}^3$ (the Adaptive Management Plan air-quality trigger), 'moderate concentration zone' sites would correspond to a TSP concentration ranging from $56.5 - 76.25 \mu\text{g}/\text{m}^3$, and 'low concentration zone' sites would correspond to a TSP concentration ranging from $17 - 36.75 \mu\text{g}/\text{m}^3$ (Figure 9-1). It has been assumed that any reference areas would be selected beyond the predicted extent of dust fall for the Project.

A simulation-based power analysis approach was taken to determine adequate sample sizes for the trace metal monitoring program. Several assumptions were made to inform the power analysis. First, it was assumed that baseline trace metals concentrations in soil and vegetation were the same across the extent of the Air Quality Dispersion model (Figure 9-1). This assumption is reasonable given that the Project has not undergone construction and is not currently in operation; therefore, concentrations of trace metals in soil and vegetation would not be the result of dust fall. Based on this assumption it was possible to simulate trace metal concentrations at the different site classes. For the power analysis, baseline trace metal concentrations were log-transformed to derive log-normal distributions with means and standard deviations (SD) for each substrate and selected trace metals; the mean of the log-normal distribution, when back-transformed to the original scale, is

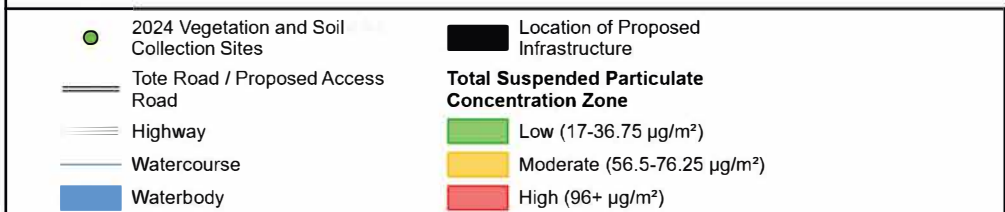
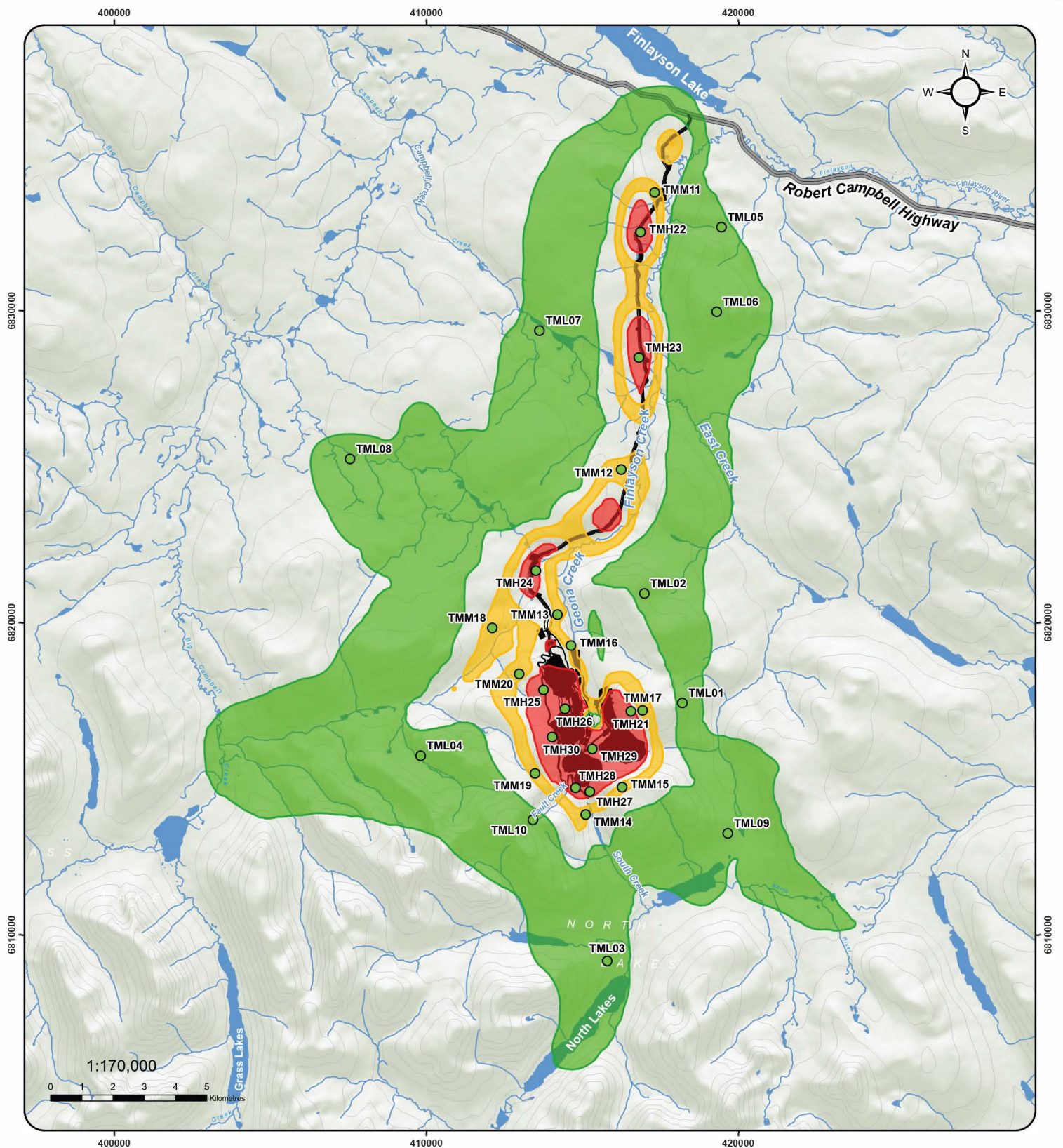
equivalent to the geometric mean. Trace metal concentration data at 'low concentration zone' sites were contrived by randomly sampling from these 'baseline' log-normal distributions. At 'high concentration zone' sites, trace metal concentrations were increased relative to 'low concentration zone' sites by randomly sampling from log-normal distributions with means 1, 1.5, and 2 SD greater than baseline means. At 'moderate concentration zone' sites, trace metal concentrations were randomly sampled from log-normal distributions with means 0.5, 0.75, and 1 SD greater than baseline means. Overall, this assumed a progressive increase in metal uptakes from 'low concentration zones' sites far from the Project, to 'high concentration zone' sites near the Project. Reference sites were not included in the power analysis because they occur beyond the predicted area of dust fall.

To detect a 2 SD change in trace metal concentrations from baseline conditions, a minimum of $n = 6$ samples is required at each site class (high, moderate, and low). The sample size requirement increases to detect smaller changes relative to baseline conditions: $n = 10$ for a 1.5 SD change and $n = 20$ for a 1 SD change. The ability to detect a 1.5 SD ($n = 10$) and 2 SD ($n = 6$) change was present for all substrate-trace metal combinations used in analyses. For most substrate types, only one or two trace metals could be detected with 0.8 power when a 1 SD ($n = 20$) change was present.

Overall, the minimum sample size required to detect a statistically significant change in trace metal concentrations among site classes (high, moderate, and low) was $n = 6$ when detecting a 2 SD change from baseline conditions.

Based on the power analysis at least six to 10 sites be sampled in 'high', 'moderate', and 'low' TSP concentration zones to collect trace metal data for soil and selected plant species. This will ensure, at a minimum, that a 2 SD change in metal concentrations from baseline conditions is detectable. A sample size closer to 10 will allow detection of smaller changes in metal concentrations. The exact site locations will be determined following a desktop and site assessment, but will generally fall within the 'high', 'moderate', and 'low' TSP concentration zones delineated in Figure 9-1. Two reference locations will also be determined. Reference sites will be located outside of the 'low' concentration zone and at least 10 km away from the Project footprint.

Metal concentrations may vary across the region and can depend on the underlying soil conditions and geomorphology. Therefore, assumptions of metal concentrations at 'high', 'moderate', and 'low' used in the power analysis may not accurately reflect metal uptake on the landscape. Field data collected in future sampling periods will be used to help refine the study design and better characterize metal uptake in soil and plant tissue across the study area. The desktop review of ecological community data and site assessments will also assist in selecting additional plant species that have dietary importance to wildlife and humans and have widespread availability across the TSP concentration zones. Based on the results of the baseline studies, only lichen and willow appear to have widespread availability.



9.3.1 Methods

9.3.1.1 Field Methods

Trace metals sampling will include soils, reindeer lichen (*Cladina* spp.), willow (*Salix* spp.) blueberry (*Vaccinium* spp) and low bush cranberry (*Vaccinium vitis-idaea*). The species will be selected for the monitoring programs as they have dietary importance to wildlife and humans and are generally available across all three TSP concentration zones. Samples will be collected using the following procedures:

- Each sample will be collected using a new pair of nitrile gloves;
- Samples will be collected using snips for vegetation and a stainless-steel spoon or trowel for soil. The snips and spoon/trowel will be cleaned with alcohol wipes before and after each site and before collection of a new sample at each site;
- Vegetation samples will be collected within a 10 m radius of plot centre at each site. For each of the focal species, the following plant parts will be collected:
 - Lichen – entire specimen
 - Willow – current year’s growth (leaves and new stems) from at least three different plants
 - Blueberry and low bush cranberry – mixture of leaves, stems and fruit
- Vegetation samples should only be taken from healthy, mature leaves; old, dead or damaged leaves will be avoided;
- Soil samples should be collected close to plot centre at each site and in undisturbed soil. Soil sample locations should be marked so the same area is not used in following years;
- During sampling, the sample amount to be collected will be:
 - Approximately 20 grams (should be confirmed by accredited laboratory doing the analysis) of each vegetation sample.
 - 100 to 200 grams (should be confirmed by accredited laboratory doing the analysis) of soil at a depth of less than or equal to 30 cm from the surface of the soil (within the rooting zone of plants to be sampled and whenever possible taken from Ae or B soil horizon unless the majority of the plant roots are found in the Ah horizon).
- Samples will be placed in new individual resealable plastic bags (i.e., Ziploc freezer bags), labelled, and frozen until being sent to an accredited laboratory for analyses. If a freezer is not available, samples will be kept in a cool place such as a cooler with ice packs;
- Replicate samples will be taken randomly at 10% of the monitoring sites; and
- Data will be collected using a standardized datasheet.

9.3.1.2 Sample Handling and Laboratory Methods

All samples will be sent to CALA accredited laboratory following up-to-date hold times. Samples should be transported to the laboratory in a cooler with ice packs including laboratory-specific chain of custody forms.

Trace metals analysis will evaluate metals uptake in plant tissues and metals accumulated on the surface of the plant from dust dispersal. These analyses have different preparation protocols in the laboratory; therefore, it is important to communicate with the laboratory prior to analysis. To evaluate both trace metals uptake in plant tissues and metals accumulated on the surface of the plant, the laboratory must divide vegetation samples including leaves and berries (excluding roots) in two. One half of each sample will be washed prior to analysis while the other half of the sample will not be washed. All samples will be analyzed using inductively coupled plasma mass spectrometry (ICP-MS). The analysis for washed samples will provide the concentration of trace metals in plant tissues (mg/kg) whereas the analysis for unwashed samples will provide both trace metals in plant tissues and trace metals deposited on plant tissues. The difference between these two results provides the actual concentration of trace metals deposited on the plant via dust deposition.

Soil samples will be prepared as usual by the laboratory prior to trace metals analysis using ICP-MS methods. Additional parameters that will be requested as part of this analysis include soil pH, texture, and cation exchange capacity. The complete list of parameters to be analysed is provided in Table 9-3.

Table 9-3: Soil and Vegetation Sample Detection Limits and Analytical Methods

Parameter	Units (dry weight)	Reporting Detection Limit	Analytical Method	Source Method
Analytical Methods used in Soil Samples				
Cation Exchange Capacity	cmol+/Kg	10	Auto Calc	AB WI-00065
Conductivity	dS/m	0.02	SM 22 2510 B m	AB SOP-00033 / AB SOP-00004
Elements by ICPMS (total)	mg/kg	Per element	EPA 6020a R1 m	BBY7SOP-00001
Nitrate-N (Available)	mg/kg	5	SM 22 4110 B m	CAL SOP-00152 / AB SOP-00023
Potassium (Available)	mg/kg	2.0	EPA 200.7 CFR 2012 m	CAL SOP-00153 / AB SOP-00042
pH @25C (1:2 Calcium Chloride Extract)	pH	N/A	BC ENV BCLM Mar2005 m	AB SOP-00033 / AB SOP-00006
pH (2:1 DI Water Extract)	pH	N/A	BC ENV BCLM Mar2005 m	BBY6SOP-00028
Soluble Paste	N/A	0.01	Carter 2 nd ed 15.2 m	AB SOP-00033
Total Carbon in Soil	mg/kg	0.02	LECO 203-821-170 m/ Lloyd Khan Method	AB SOP-00035 / CAL SOP-00243/ CAM SOP-00468
Total Organic Carbon in Soil	mg/kg	500	BC ENV Total Organic Carbon Aug 2014	CAM SOP-00468
Texture by Hydrometer	%	2	Carter 2 nd ed 55.3 m	AB SOP-00035 / AB SOP-00030

Parameter	Units (dry weight)	Reporting Detection Limit	Analytical Method	Source Method
Texture Class	NA	NA	Auto Calc	AB SOP-00030
Calcium Carbonate Equivalent	%	0.60	Carter 2 nd ed 20.2 m	AB SOP-00019
Individual Elements by ICP-MS (Total) in Soil Samples				
Aluminum	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Antimony	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Arsenic	mg/kg	0.50	ICP-MS	Method 6020 B, USEPA (2014)
Barium	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Beryllium	mg/kg	0.20	ICP-MS	Method 6020 B, USEPA (2014)
Bismuth	mg/kg	0.19	ICP-MS	Method 6020 B, USEPA (2014)
Cadmium	mg/kg	0.050	ICP-MS	Method 6020 B, USEPA (2014)
Calcium	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Chromium	mg/kg	1.0	ICP-MS	Method 6020 B, USEPA (2014)
Cobalt	mg/kg	0.30	ICP-MS	Method 6020 B, USEPA (2014)
Copper	mg/kg	0.50	ICP-MS	Method 6020 B, USEPA (2014)
Iron	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Lead	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Lithium	mg/kg	5	ICP-MS	Method 6020 B, USEPA (2014)
Magnesium	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Manganese	mg/kg	0.20	ICP-MS	Method 6020 B, USEPA (2014)
Molybdenum	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Nickel	mg/kg	0.80	ICP-MS	Method 6020 B, USEPA (2014)
Phosphorus	mg/kg	10	ICP-MS	Method 6020 B, USEPA (2014)
Potassium	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Selenium	mg/kg	0.50	ICP-MS	Method 6020 B, USEPA (2014)
Silver	mg/kg	0.050	ICP-MS	Method 6020 B, USEPA (2014)
Sodium	mg/kg	100	ICP-MS	Method 6020 B, USEPA (2014)
Strontium	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Thallium	mg/kg	0.050	ICP-MS	Method 6020 B, USEPA (2014)
Tin	mg/kg	0.10	ICP-MS	Method 6020 B, USEPA (2014)
Titanium	mg/kg	1.0	ICP-MS	Method 6020 B, USEPA (2014)
Uranium	mg/kg	0.050	ICP-MS	Method 6020 B, USEPA (2014)
Vanadium	mg/kg	2.0	ICP-MS	Method 6020 B, USEPA (2014)
Zinc	mg/kg	1.0	ICP-MS	Method 6020 B, USEPA (2014)
Zirconium	mg/kg	0.50	ICP-MS	Method 6020 B, USEPA (2014)
Analytical Methods used in Plant Tissue Samples				
Elements by ICP-MS (total)	mg/kg	Per element	EPA 6020A R1 m	BBY7SOP-00002

Parameter	Units (dry weight)	Reporting Detection Limit	Analytical Method	Source Method
Elements by ICP-MS (total)	mg/kg	Per element	EPA 6020a,200.3 R1 m	BBY7SOP-00002/21
% Moisture	%	0.3	OMOE E3139 3.1 m	BBY8SOP-00017
Individual Elements by ICP-MS (Total) in Plant Tissue Samples				
Aluminum	mg/kg	1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Antimony	mg/kg	0.05	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Arsenic	mg/kg	0.025	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Barium	mg/kg	0.1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Beryllium	mg/kg	0.01	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Bismuth	mg/kg	0.1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Boron	mg/kg	2	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Cadmium	mg/kg	0.01	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Calcium	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Chromium	mg/kg	0.2	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Cobalt	mg/kg	0.02	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Copper	mg/kg	0.05	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Iron	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Lead	mg/kg	0.01	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Magnesium	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Manganese	mg/kg	0.1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Mercury	mg/kg	0.01	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Molybdenum	mg/kg	0.05	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Nickel	mg/kg	0.05	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Phosphorus	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21

Parameter	Units (dry weight)	Reporting Detection Limit	Analytical Method	Source Method
Potassium	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Selenium	mg/kg	0.05	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Silver	mg/kg	0.02	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Sodium	mg/kg	10	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Strontium	mg/kg	0.1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Thallium	mg/kg	0.002	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Tin	mg/kg	0.1	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Titanium	mg/kg	0.25	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Uranium	mg/kg	0.002	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Vanadium	mg/kg	0.2	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Zinc	mg/kg	0.2	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21
Zirconium	mg/kg	0.2	ICP-MS	BBY7SOP-00002/ BBY7SOP-00002/21

9.3.1.3 Data Analysis and Interpretation

Data will be analysed for trace metals concentrations (mg/kg) in soil, lichen, willow and two other selected plant species for nine constituents of potential interest (COPI), as well as pH, texture, and cation exchange capacity for soil samples. Additional COPI maybe added depending on monitoring results such as increase from baseline values. Vegetation concentrations will be reported in both dry weight and wet weight. The following COPIs were selected for the Project:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Mercury;
- Lead;
- Selenium;
- Uranium; and

- Zinc

COPIs were chosen based on consideration of several factors, including the level of risk associated with each element, current baseline metal concentrations in soils and plants, and other Project baseline studies. Data management and analysis will be carried out by a qualified person with experience in ArcGIS database management and analysis. Trace metal concentrations in soil and vegetation will be interpreted in relation to AMP trigger values. Should analysis find that the trigger value for a particular COPI has been exceeded within one or more TSP concentration zones, further investigation will be undertaken, as detailed in the AMP (BMC, 2026a). This may include investigation into potential sources of the COPI, review of data from the dust monitoring program, and/or additional sampling (including sampling at reference sites if deemed appropriate).

9.3.2 Locations and Frequency

Trace metals monitoring will extend beyond the mine area footprint, covering three TSP concentration zones of dust dispersion: 'high', 'moderate', 'low', and, when needed, measurements will be taken from reference sites. Soil and selected plant species samples will be collected at six to 10 sites within each TSP concentration zone. Trace metal monitoring will be initiated pre-construction to collect baseline data at all sites including new sites.

Trace metals monitoring will be completed once during the construction phase (before operations are initiated) and every three years during operations, starting one year after the operation phase has been initiated. Leaf tissues' trace metal content varies throughout the growing season; therefore, monitoring will consistently occur around the same time during each monitoring period (Ernst, 1994). Monitoring will be completed near the end of the growing season (August). Depending on results from early analyses, monitoring frequency may change during operations as determined by changes in trace metal concentrations.

9.3.3 QA/QC

QA/QC protocols for metals concentrations in soil and vegetation will include the following:

- Two people are required to safely conduct sampling in backcountry locations. The same person sampling the soil should not sample the vegetation to prevent cross-contamination;
- Powder-free nitrile gloves are to be worn when sampling; use new gloves for each sample and when collecting different plant species at the same site;
- The shovels and trowels will be cleaned after each sampling event using distilled water;
- Samples will be stored in a cool, dry place ($\leq 10^{\circ}\text{C}$) until transport to the laboratory; and
- Ten percent of analyzed samples will be blind duplicates, as an assurance on analytical quality and consistency.

Samples will be sent to a CALA accredited laboratory, which will follow accepted QA/QC protocols.

9.3.4 Reporting

Annual reports, summarizing all data collected in the previous year and any changes to the monitoring program will be submitted to YWB and EMR. All field data will be analyzed and provided in summary tables within the annual report. Raw data will be available upon request.

The report will include the following:

- Total number of sites monitored including the number of soil and vegetation indicator species sampled at each site;
- Total number and location where replicate samples were collected;
- Laboratory results;
- Results of analysis against AMP trigger values; and
- If warranted, description of proposed changes to mitigation practices and/or the trace metals monitoring program in response to monitoring results.

10 WILDLIFE AND WILDLIFE HABITAT

The environmental monitoring for Wildlife and Wildlife habitat is presented in the Wildlife Protection plan (BMC, 2026h).

11 MINE INFRASTRUCTURE

Mine facilities and infrastructure have the potential to adversely impact the environment and to pose health and safety risks, if they do not perform as intended. Monitoring is proposed for water management, waste and overburden storage facilities, the open pit and the land treatment facility (LTF). In addition, Scope I and Scope II emissions are monitored to characterize potential Project-related impacts on climate change. The information collected in these monitoring programs will be used to evaluate the performance of mine facilities and infrastructure, and to update, if justified, their design and operation. It will also be used to support implementation of trigger action responses plans (TARPs) included in the Operations, Maintenance and Surveillance (OMS) Manuals and the Groundwater Control Management Plan (GCMP), and evaluation of AMP triggers (BMC, 2026a).

11.1 WATER MANAGEMENT FACILITIES

The main water management facilities at the Project include the Class A, B, and C Storage Facility Collection Ponds, the Overburden Stockpile Collection Pond, the Pit Rim Pond, the UWMP and the LWMP. These facilities will be regularly monitored according to the OMS Manual for water management facilities. The initial OMS Manual will be developed during Detailed Design in conformance with guidance provided in Mining Association of Canada (2019) and industry norms, and will be provided to EMR prior to Project construction. The OMS Manual is a live document that will be updated regularly throughout Project construction and operations to be appropriate for current and predicted conditions. This section provides a general description of the monitoring program that will be further detailed in the OMS Manual.

11.1.1 Methods

The water management facilities monitoring program takes a flexible, fit-for-purpose, risk-based approach to monitoring facility performance to ensure that all facilities perform as intended and do not pose unacceptable risk to the environment, human health or Project operations. These facilities include ponds, spillways, diversion channels, collection ditches and culverts. Monitoring will be performed to ensure that all potential failure modes are adequately characterized to ensure that their risk is appropriately mitigated. Monitoring requirements and methods will be defined by the Project Engineering team and the Engineer of Record (EOR), and may include some or all of:

- Regular visual inspections, at varying levels of detail, by internal and external personnel. Visual inspections will focus on: signs of deformation, instability or erosion; debris or snow/ice build up; seepage; liner tears or deformation; and riprap integrity;
- Deformation monitoring using survey monuments and/or remote sensing methods such as photogrammetry or Interferometric Synthetic Aperture Radar (InSAR), and inclinometers and extensometers if deemed necessary;
- Foundation and embankment pore pressure monitoring using vibrating wire piezometers (VWPs) and/or monitoring wells;
- Pond levels, as discussed in Chapter 4;
- Pond inflow and/or outflow rates using a calibrated flowmeter, where applicable;
- Surface water and groundwater quality monitoring, as discussed in Chapter 5 and Chapter 6;

- Sediment accumulation monitoring using depth markers painted on pond liners, manual measurement and/or staff gauges; and
- Permafrost monitoring using visual inspection, subsurface temperature monitoring using thermistors, surface water quality monitoring (Chapter 5) and climate monitoring (Chapter 2).

All monitoring data will be reviewed weekly by the Project Engineering team, and at least quarterly by the EOR, and following significant seismic or storm events or unexpected monitoring results. Data will be used to support regular updates to slope stability and water balance models, and annual updates to the OMS Manual, including TARP and linkages with the Emergency Preparedness Plan (EPP) for waste management facilities and the Project's Emergency Response and Health and Safety Plan (BMC, 2026i).

11.1.2 Locations and Frequency

A general overview of monitoring locations and frequencies is provided in Table 11-1, and further details will be included in the OMS Manual for water management facilities. Monitoring locations will evolve throughout construction and operations, and monitoring frequency may change depending on EOR and/or Independent Review recommendations, and in response to rare or unexpected events or conditions.

Table 11-1: Water Management Facilities Monitoring Program Overview

Monitoring Type	Frequency	Location
Daily inspection by trained operators/technicians	Daily	Embankment toe, crest, spillways
Monthly inspection by the responsible Engineer	Monthly	All components of all water management facilities
Annual inspection by EOR	Yearly	All components of all water management facilities
Survey monuments	Quarterly	As determined by EOR on embankment
Remote sensing	Monthly to yearly	Select water management facilities as determined by EOR
VWPs and/or monitoring wells	Daily to monthly	Embankment and foundation, as determined by EOR
Pond levels	See Chapter 4	
Pond inflows and outflows	Continuous	Inflow and outflow of select ponds
Water quality	See Chapter 5 and Chapter 6	
Sediment accumulation	Monthly	All water management facilities
Thermistors	Monthly	Foundation, as determined by EOR

11.2 OPEN PIT

The Open Pit will be monitored following the procedures described in the Ground Control Management Plan (GCMP). The initial GCMP will be developed during Detailed Design in conformance with industry standards of practice, as summarized in Read and Stacey (2009). The

GCMP will be provided to EMR prior to Project construction. The GCMP is a live document that will be updated regularly throughout Project construction and operations. This section provides a general description of the monitoring program that will be further detailed in the GCMP.

11.2.1 Methods

The Open Pit monitoring program takes a flexible, fit-for-purpose, risk-based approach to monitoring pit slope performance to ensure that all interim and final pit slopes perform as intended and do not pose unacceptable risk to the environment, human health or Project operations. Monitoring will be performed to ensure that all potential pit failure mechanisms are adequately characterized to ensure that their risk is appropriately mitigated. Monitoring requirements and methods will be defined by the Project Engineering team, including an internal or external Geotechnical Engineer, and will vary throughout operations depending on geologic conditions and slope performance. Monitoring may include some or all of:

- Regular visual inspections, at varying levels of detail, by internal and external personnel. Visual inspections will focus on signs of instability, seepage and changing geological conditions;
- Geological and geotechnical mapping;
- Deformation monitoring using theodolites and a network of survey prisms, fixed or mobile slope radar systems, and/or remote sensing methods such as InSAR. These methods may be supplemented in specific areas using inclinometers, extensometers and crack meters if deemed necessary; and
- Pore pressure monitoring using VWP's and/or monitoring wells.

All monitoring data will be reviewed weekly by the Mine Engineering team, and following significant seismic or storm events or unexpected monitoring results. Data will be used to support regular updates to slope stability models, groundwater seepage models and dewatering procedures, and annual updates to the GCMP, including TARP and EPP.

11.2.2 Locations and Frequency

A general overview of monitoring locations and frequencies is provided in Table 11-2, and further details will be included in the GCMP. Monitoring locations will evolve throughout construction and operations.

Table 11-2: Open Pit Monitoring Program Overview

Monitoring Type	Frequency	Location
Daily inspection by trained operators	Daily	Operating pit areas
Regular inspection by Engineering team	Weekly to monthly	Operating pit areas and areas of potential pit slope instability
Geological and geotechnical mapping	As appropriate	New operating areas and/or areas of potential pit slope instability
Survey Prisms	Weekly to monthly	Select pit locations as determined by Engineering team

Monitoring Type	Frequency	Location
Slope Radar	Continuous	Select pit areas as determined by Engineering team
Remote sensing	Monthly to yearly	Full pit
VWPs and/or monitoring wells	Daily to monthly	Select pit locations as determined by Engineering team

11.3 MINE WASTE AND OVERBURDEN STORAGE FACILITIES

Mine waste and overburden storage facilities at the Project include the Class A, Class B and Class C Storage Facilities and the Overburden Stockpile. These facilities will be regularly monitored according to the Operations, Maintenance and Surveillance (OMS) Manual for waste management facilities. The initial OMS Manual will be developed during Detailed Design in conformance with guidance provided in Mining Association of Canada (2019), and will be provided to EMR prior to Project construction. Key components of the OMS Manual will include:

- Governance, including roles and responsibilities, training, tracking and reporting;
- Facility descriptions;
- Operation, including performance objectives and operating procedures;
- Maintenance, including description and documentation of maintenance procedures;
- Surveillance, including discussion of risk and design considerations that determine monitoring needs, surveillance activities, analysis and reporting;
- Decision making and responses, including a TARP and linkages with the Project EPP.

This section provides a general description of the monitoring program that will be further detailed in the OMS Manual.

11.3.1 Methods

The waste management facilities monitoring program takes a flexible, fit-for-purpose, risk-based approach to monitoring facility performance to ensure that all facilities perform as intended and do not pose unacceptable risk to the environment, human health or Project operations. Monitoring will be performed to ensure that all potential failure modes are adequately characterized to ensure that their risk is appropriately mitigated. Monitoring requirements and methods will be defined by the Project Engineering team and the EOR and may include some or all of:

- Regular visual inspections, at varying levels of detail, by internal and external personnel. Visual inspections will focus on: signs of deformation, instability or erosion; debris or snow/ice build up; seepage; liner tears or deformation; and riprap integrity;
- Deformation monitoring using survey monuments and/or remote sensing methods such as photogrammetry or InSAR, and inclinometers and extensometers if deemed necessary;

- Foundation and embankment pore pressure monitoring using VVPs and/or monitoring wells;
- Surface water and groundwater quality monitoring, as discussed in Chapter 5 and Chapter 6;
- Dust monitoring, as discussed in Chapter 3; and
- Permafrost monitoring using visual inspection, subsurface temperature monitoring using thermistors, surface water quality monitoring (Chapter 5) and climate monitoring (Chapter 2).

All monitoring data will be reviewed weekly by the Project Engineering team, and at least quarterly by the EOR, and following significant seismic or storm events or unexpected monitoring results. Data will be used to support regular updates to slope stability and water balance models, and annual updates to the OMS Manual, including the TARP and linkages with the EPP.

11.3.2 Locations and Frequency

A general overview of monitoring locations and frequencies is provided in Table 11-3, and further details will be included in the OMS Manual for waste management facilities. Monitoring locations will evolve throughout construction and operations, and monitoring frequency may change depending on EOR and/or Independent Review recommendations, and in response to rare or unexpected events or conditions.

Table 11-3: Mine Waste and Overburden Storage Facilities Monitoring Program Overview

Monitoring Type	Frequency	Location
Daily inspection by trained operators/technicians	Daily	Facility toe, slope and crest
Regular inspection by the responsible Engineer	Weekly to monthly	All waste management facilities
Annual inspection by EOR	Yearly	All waste management facilities
Survey monuments	Quarterly	As determined by EOR on facility slope and crest
Remote sensing	Monthly to yearly	Select waste management facilities as determined by EOR
VVPs and/or monitoring wells	Daily to weekly	Facility and foundation locations, as determined by EOR. Likely to include multiple VWP strings in each waste management facility.
Water quality	See Chapter 5 and Chapter 6	
Dust generation	See Chapter 3	
Thermistors	Monthly	Foundation, as determined by EOR

11.4 LAND TREATMENT FACILITY

The location and design of the Land Treatment Facility (LTF) are presented in the Waste Management Plan (BMC, 2026j). The LTF will be located in the Waste Management Facility and lined with a chemically resistant synthetic membrane with a permeability of 3×10^{-13} cm/second. The LTF will be constructed with berms surrounding the facility and a backfill cushion to protect the liner while

allowing equipment to work. A sump will be installed in the LTF footprint which will collect snow melt, excess surface water and runoff prior to treatment at the Water Treatment Plant. All water will be passed through the oil/water separator before being transferred to the Water Treatment Plant and all separated oil will be stored and disposed of in the waste oil burner.

Following construction, the LTF will be visually inspected on a weekly basis to monitor for signs of wildlife, surface run-off, seeps, presence of standing water, structural damage, safety signage, appropriate labelling/signage and proper storage of contaminated material piles. Soil testing and testing of the water in the LTF sump will occur on a quarterly basis at a minimum, including testing for the presence of hydrocarbons. All sampling will be performance in accordance with Yukon Contaminated Sites Regulation Protocol 11 (Yukon, 2023), where applicable. A land treatment facility permit from YG is required to build and operate the LTF. Monitoring, sampling and reporting will be conducted in accordance with the requirements of that permit.

11.5 EMISSIONS

BMC recognizes the important role that industry plays in climate change and in allowing Yukon to meet its emissions reduction objectives. The Project has been designed to include many practices that will minimize greenhouse gas (GHG) emissions, and further efforts will be made throughout Detailed Design, construction and operations to further decrease our climate change impact.

The Project will monitor Scope I and Scope II GHG emissions. Emissions will be calculated based on monthly fuel consumption using both absolute tonnes of GHG (CO₂e) and GHG production intensity. Energy usage and intensity for fuel and electricity consumption will be monitored systematically, and GHG emissions will be calculated in accordance with GHG Protocol Standards.

11.6 REPORTING

Monitoring results from infrastructure monitoring programs will be reported as required for compliance with WUL, QML and other licence requirements. Monthly and annual reports will be submitted to YWB's Waterline including data relevant to the WUL. Annual reports will also be issued directly to EMR, including all infrastructure monitoring data collected during the previous years, and applicable analyses.

Reporting to EMR, RRDC and LFN will include third-party engineering reports and performance audit reports for mine waste storage facilities and ponds, as required for compliance with QML requirements. These performance audit reports will be sufficiently detailed to support understanding of facility performance and to identify trends that could materially impact Project operations. These audits and reports will be funded by BMC and will be:

- prepared by an independent engineer or engineering firm acceptable to EMR;
- assess whether facilities have been constructed in accordance with approved designs, permits, and specifications;
- assess the readiness of facilities to operate safely and effectively within design parameters; and
- identify any deficiencies, departures from approved designs.

12 PROGRESSIVE RECLAMATION

The Project will implement a progressive reclamation approach as detailed in the RCP (BMC, 2026b), reclaiming areas no longer required for mining activities during the operational phase, aiming to minimize adverse effects such as the establishment of invasive species or air or water quality degradation. The Project will also implement measures to minimize the area impacted by Project activities. The Project Environmental Department will be responsible for ensuring that Project activities remain within marked footprint boundaries, and that progressive reclamation is implemented in a timeline manner and monitored for effectiveness. Data will be used to revise progressive reclamation methods as appropriate to improve effectiveness.

Baseline environmental conditions have been monitored intermittently since 1995 and as recently as 2024, and conditions are well characterized, as described in the Site Characterization Plan (BMC, 2026c).

12.1 METHODS

The progressive reclamation monitoring program is intended to track the Project development footprint and the extent, distribution and quality of reclaimed areas. The extent of the development footprint and reclaimed areas will be measured by handheld GPS, aerial surveys, drone or other technology, and tracked in a database.

Vegetation and ecological communities (including the identification and extent of wetlands) were classified and mapped to support the Project's Environmental and Socio-economic Screening Assessment (BMC, 2017). The information related to classifying and characterizing wetlands that are within or adjacent to the Project footprints or that could be affected by Project Activities was updated in 2024 (EDI, 2025). Collectively the baseline information will serve as the basis for the monitoring program. Ecological community information will be collected in accordance with the Field Manual for Describing Yukon Ecosystems (Yukon, 2017) and will reference the same ecological communities identified in baseline studies.

On an annual basis the areas of impacted ecosystems and progressively reclaimed areas will be surveyed. Once confirming that an area has been successfully reclaimed, the Environmental Department will determine which ecological community is present within the reclaimed area. Successful reclamation will be determined as per information and guidelines outlined in the Reclamation and Closure Plan (BMC, 2026b). Progressive reclamation will be tracked as the area disturbed by Project activities relative to the area reclaimed for the mine area footprint on an annual and cumulative basis. This information will then be used to determine the amount of direct vegetation habitat loss resulting from the Project by evaluating changes in area and vegetation community compositions compared to baseline conditions.

Following each field survey, spatial data files will be uploaded using a mapping program such as ArcGIS to calculate the following values:

- Newly disturbed mine area;
- Newly reclaimed mine area;

- Annual and total disturbed mine area;
- Annual and total reclaimed mine area; and
- Annual mine area footprint – annual mine area footprint reclaimed.

12.1.1 QA/QC

Surveys will be conducted by qualified personnel and data will be verified by experienced vegetation ecologists with the appropriate qualifications and experience to verify plant identification. Wetland delineation and classification will be reviewed and approved by a qualified wetland professional.

12.1.2 Locations and Frequency

The progressive reclamation monitoring program will encompass the entire Project footprint including the Access Road. Each survey will focus only on areas of disturbance and/or progressive reclamation since the previous survey. During Project construction and operation, monitoring will be conducted once annually to capture the direct loss of vegetation from clearing activities and to track locations that are progressively reclaimed. To ensure comparability of the data over time, this monitoring program will be completed in early to mid-summer when most plant species are productive and growing.

12.1.3 Reporting

Monitoring results from the progressive reclamation monitoring program will be provided to EMR in an annual report including discussion of methods, results and proposed changes to the monitoring program and/or progressive reclamation methods.

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APPENDIX A: STANDARD OPERATING PROCEDURE – CAMPBELL SCIENTIFIC METEOROLOGICAL STATION



Unit 3 151 Industrial Road ■ Whitehorse, YT Y1A 2V3
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Standard Operating Procedure

SOP: Campbell Scientific Meteorological Station

Written by: Nesha Wright

Date: June 16th, 2022

Reviewed by: Nesha Wright

Date: January 15, 2024

Equipment Required	Personal Protective Equipment
Cables (mini USB)	Gloves,
First Aid Kit	Rubber Boots,
Field Logbook, Pencil	Cruise Vest
Bucket	Propper footwear
Winterization solutions	
Tools (flat head screwdriver,etc)	



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1 INTRODUCTION

Meteorological data are critical for a variety of assessment and planning purposes at prospective mine sites and other industrial developments. They are used to prepare site water balances, operations plans, loading models, and are a critical requirement for permitting. Therefore, sound and consistent data collection practices are key to ensuring meteorological data quality. This document addresses data collection methods, equipment maintenance and data validation guidelines.

2 DEFINITIONS

Parameters

Air Temperature (°C) – A measurement of ambient atmospheric temperature.

Soil Temperature (°C)- Measurement of the surface soil temperature.

Net Radiation (W/m^2) – This is the difference between all incoming and outgoing radiation. Net radiation plays a key role in determining the thermal conditions of the Earth's surface, therefore soil, vegetation etc.

Geonor Precipitation (mm) – A measurement of liquid precipitation over time.

Albedo is an expression of the ability of the Earth's surface to reflect sunlight. This value is typically represented by a percentage. Therefore, more reflective areas will have a higher albedo while darker areas (like soil) will have lower albedos.

Snow Depth (m) - Snow depth is measured by emitting an ultrasonic pulse and then measuring the elapsed time between the emission and return of the pulse. An air temperature measurement is required to correct variations of the speed of sound in air.

Wind Direction and Strength (Cardinal direction and m/s) – This indicates the direction that the wind is coming FROM or TO and the strength of the wind, represented as a speed. For example, June 15th, 2022 12.69 degrees NNE, 1.38 m/s

Battery (V) – The station will give a min and max voltage

3 METEOROLOGICAL STATION DESCRIPTION

For each meteorological station the location, date of commissioning and sensor list will be unique. This document acts as an overview for the purpose of station download and general maintenance.



4 FIELD ACTIVITIES

4.1 STATION INSTALLATION

For specifics on how to install each aspect of a station please refer to the manuals below. In general, the selected location should be representative of the area of interest (ex. Not in a heavily forested area if most of the site is open tailings ponds), not near any seasonal hazards (ex. Snow removal or slumps) and well documented. Any new installations will need to be surveyed and coordinates recorded.

4.2 FIELD INSPECTION

Solar Panels – Ensure that all solar panels are free of frost, snow and debris. A blocked solar panel will result in a station battery dying and therefore no data will be collected.

Guy lines – Ensure these are tight, seasonal changes may result in the loosening of cables or change in the ground surface.

Glycol - The propylene glycol/methanol mixture in the Geonor T-200 precipitation gauge should be replaced annually (or if level in the gauge reaches the top of the inner bucket), ideally in the fall. Before doing any work on the Geonor, be sure to tighten the set screws on the three sensors as the transducers are very sensitive. Loosen them again once work is complete. To empty the bucket, use manual pump attached to mast on site. Refill with fresh antifreeze mixture according to Table 5-1 below. The total capacity of the KZK Geonor is 1500 mm. A calibration should be performed before refilling the bucket for antifreeze (see section 8.3 of the Geonor T-200B instruction manual for details https://s.campbellsci.com/documents/ca/manuals/t-200b_man.pdf).

Battery – Ensure that the battery level is sufficient to allow for the continued collection of data.

Desiccant – Replace with new if required.

Cables – All cables should be checked for signs of wear and damage. Animals, wind and natural elements will all impact the integrity of the cables. Ensure that all wires are securely connected to the datalogger inside the enclosure.

Evaporation Pan - Automatic evaporation gauge and refill kit should be commissioned in the spring and decommissioned in the fall to avoid any risk of water freezing in the system and causing damage. To decommission, drain all water out of the system.

Solar Radiation Sensor - Ensure that the solar radiation sensor is free of frost, snow and/or debris. The sensor can be wiped free of dust using a soft cloth dampened with water or alcohol, as needed. Condensation within the dome should also be checked for.



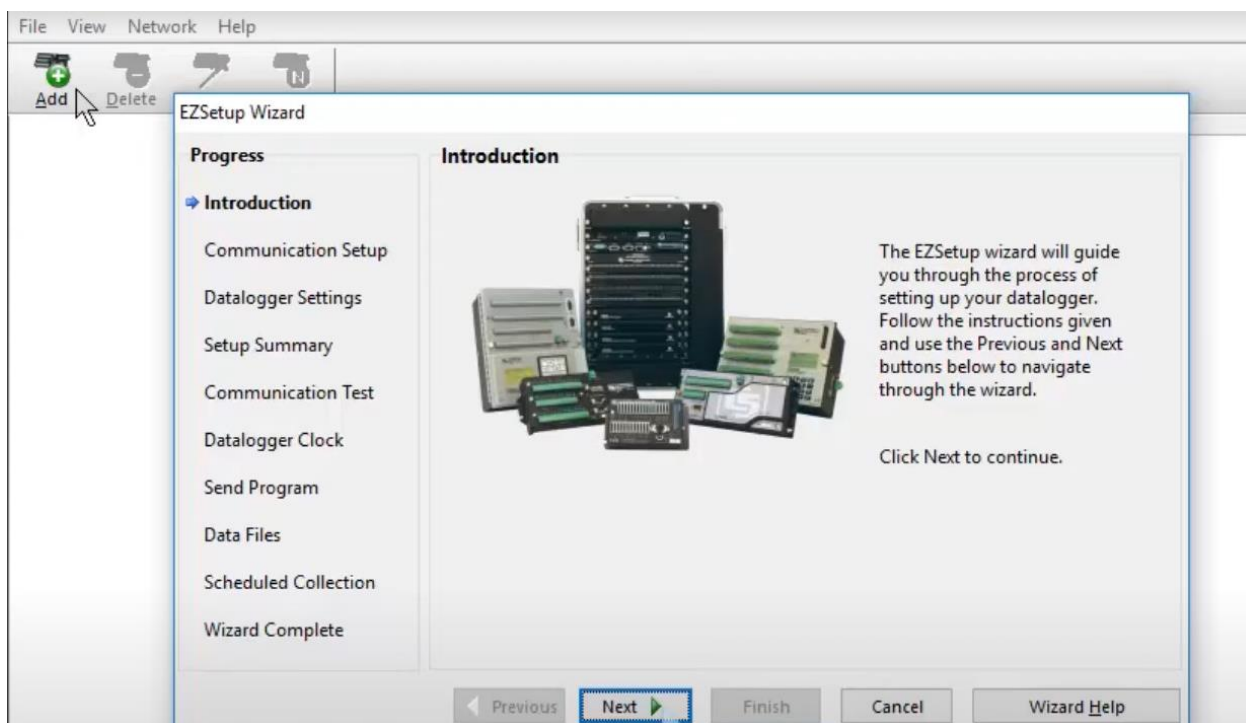
5 RETRIEVING DATA FROM STATIONS

Depending on the station the data will be retrieved differently. Stations with a remote connect system (Iridium set up) can be reached using platforms such as Drive HQ or Filezilla at any time. Stations with direct download capability only require LoggerNet and site access.

5.1 DIRECT DOWNLOAD.

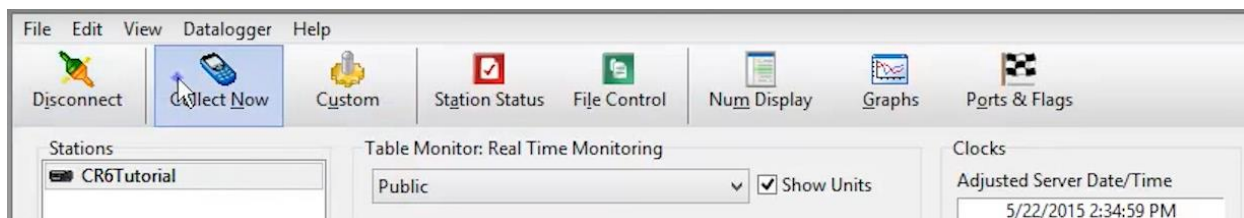
- Setup station in LoggerNet:
- LoggerNet->SetUp->Add (in EZView)->Next-> Select the Datalogger Type (add name)-> Direct Connect->Next to Communication Test -> Set Datalogger clock -> Output File Name (select appropriate location on computer)-> Finish





Once the station is setup:

LoggerNet-> Connect -> Select station -> Connect -> Collect Now



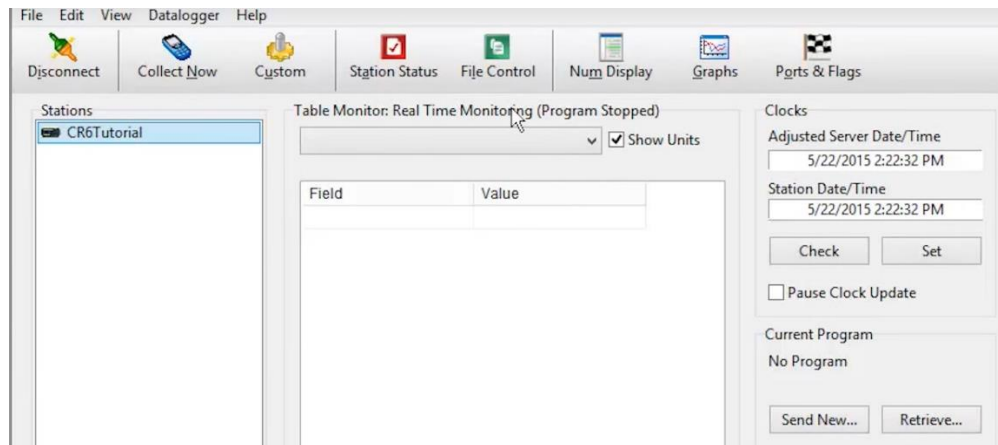
5.2 UPLOADING NEW CODES

Connect to Station using LoggerNet

- LoggerNet-> Connect-> Connect

Download the data before uploading new codes, otherwise the data will be lost

- At the bottom right: Current Program-> Send New



- Warning windows about data being lost (hence having to download it first)
- Make sure there are no errors in Compile Results window

5.3 CALIBRATION OF SENSOR IN THE FIELD

Evaporation pan – reset it and calibrate during De-winterization (see section 5.4)

Field calibration of the Evaporation gauge must be complete when the evaporation pan is filled.

- LoggerNet-> CRBasic Editor->FieldCal()->Insert->Insert

A manual field calibration can also be performed:

- Partially fill the evaporation pan and measure the depth with a ruler.
- Measure the voltage using the gauge and the BrHalf() or ExDelSE() instruction with a multiplier of 1.0 and an offset of 0.0.
- Add more water to the evaporation pan and measure the depth in the pan using the ruler.
- Measure the voltage at that depth using the gauge and the BrHalf() or ExDelSE() instruction with a multiplier of 1.0 and an offset of 0.0.
- Calculate the multiplier using the following equation:

$$m = (D2 - D1) / (V2 - V1)$$

Where,

m = multiplier

D1 = initial depth measurement (inches or cm)

D2 = second depth measurement (inches or cm)

V1 = initial voltage measurement (mV)

V2 = second voltage measurement (mV)

Calculate the offset using the following equation:



$$b = D1 - m \cdot V1$$

Where,

b = offset m = multiplier

D1 = initial depth measurement (inches or cm)

V1 = initial voltage measurement (millivolts)

5.4 WINTERIZATION & DE-WINTERIZATION

Evaporation Pan - Automatic evaporation gauge and refill kit should be commissioned in the spring and decommissioned in the fall to avoid any risk of water freezing in the system and causing damage. To decommission, drain all water out of the system. Follow calibration steps. During the winter months when the water may freeze, drain and clean the pan and then store both the pan and evaporation gauge indoors. If the evaporation pan must be left outside, turn it upside down.

Precipitation Gauge – Snowfall adapter must be installed in the fall and the tipping bucket must be lowered. Fill the snowfall adapter with antifreeze solution (Table 5-1). Note the 40/60 ratio below cannot use RV antifreeze. It is suggested that the desired amount be pre-mixed and brought into the field. Propylene Glycol can be sourced from Ajax Ltd. and Methanol from Canadian Tire. Pour mineral (or baby oil) to prevent evaporation (summer or winter), pour enough to cover the top with about $\frac{3}{4}$ of an inch. In the spring, remove snowfall adapter and collect antifreeze solution, and dispose of properly. Raise tipping bucket.



Table 5-1: Antifreeze solution table for T200-B precipitation gauge (Source: Geonor)

TABLE 6-1. Antifreeze Solution Propylene glycol (40%) / Methanol (60%)		
Antifreeze as % total capacity	Freezing Point (°F)	Freezing Point (°C)
0	32	0
10	26	-3
20	20	-7
30	10	-12
36	0	-18
40	-5	-20
43	-10	-23
48	-20	-29
52	-30	-34
55	-40	-40
58	-50	-46
60	-60	-51

6 DATA MANAGEMENT AND PERIODIC MAINTENANCE

6.1 UPLOADING DATA

Upon returning from the field in the case of a direct download station the data will be uploaded by the Climate Team, for all remote stations, data is uploaded monthly.

6.2 QA/QC AND DATA VALIDATION

A quality assurance and quality control check is completed monthly for all parameters. For all parameters, invalidate outliers. Outliers can be identified more easily when the data are plotted on a line or bar chart. When outliers are identified, investigate potential cause (e.g. sensor malfunction, human or animal interference, etc.) and take corrective measures if necessary. No data should ever be directly deleted without documenting the change. The exception to this is data which falls outside the range that the sensor reads.

Data is compared to the following tables depending on the type of station (Campbell Science or HOBO). Data found to be outside of these parameters is highlighted so to trigger further investigation. Based on data surrounding a highlighted point, the value is either kept or removed from the dataset, when possible, an explanation is provided.



Table 6-1 Campbell Science Parameter Validation

Campbell Science				
Parameter	Unit	Range	Accuracy	QAQC Range
Temperature	°C	-80 to 60 °C (-112 to 140 °F)	at -80 to 20 °C: $\pm(0.226 - 0.0028 \times \text{temperature})$ °C at 20 to 60 °C: $\pm(0.055 + 0.0057 \times \text{temperature})$ °C	-35 to 35
Relative humidity	%	0 to 100% RH	15 to 25 °C (59 to 77 °F): $\pm 1\%$ RH (0 to 90% RH) $\pm 1.7\%$ RH (90 to 100% RH)	15-100% (lowest in YT is 15, highest 99%)
Tipping Bucket TE525	mm	4.73 ml(0.16 fl. oz) volume per tip 0.01 in (0.254 mm) rainfall per tip	1.0% up to 2 in/hour (50 mm/hr)	Up to 7mm/hr
Geonor T-200B	mm	Capacity: 600 mm 1000 mm 1500 mm Collection Area: 200 cm ²	0.1% full scale	7mm/hr up to 1500 mm
Pluvio	mm			Up to 7mm/hr
Wind speed	m/s	0 to 100 m/s (0 to 224 mph)	± 0.3 m/s (± 0.6 mph) or 1% of reading	0-15 m/s then look at values up to 100m/s as flagged.
Wind Gust	m/s			Flagged above 15m/s
Wind direction	°	0° to 360° mechanical, 355° electrical (5° open)	$\pm 3^\circ$	0-360
Barometric pressure	mb	500 mb to 1100 mb	Total Accuracy3: ± 0.3 mb @ 20 °C ± 0.6 mb @ 0 to 40 °C ± 1 mb @ 20 to 45 °C ± 1.5 mb @ -40 to 60 °C	500-1100
Solar radiation (Net Rad)	W/m ²	0.2 to 100 μm , -200 to 1000 W/m ²		-200 to 1000
SnowVEU10	m	0.4 to 10 m (1.3 to 32.8 ft)	0.2% of distance to target	Negative values will be removed, seasonal values removed
SnowVEU10 Quality Numbers		0 - Unable to read measurement 1-100 Good measurement quality 100-300 Reduced echo signal strength 300-600 High measurement uncertainty		Will flag when values are 0 or greater than 300



Table 6-2 HOBO Scientific Parameter Validation

HOBO				
Parameter	Unit	Range	Accuracy	QAQC Ranges (YT)
Temperature	°C	-40 to +75°C	± 0.7°C @ 25°C	-35 to +30
Relative humidity	%	0 to 100%	± 3% over the range of 0° to 50°C	15 to 100%
Rainfall	mm	Up to 10 cm/hr	± 1% at up to 20 mm/hr	up to 7mm/hour
Wind speed	km/hr	0 to 44 m/s	± 0.5 m/s or ± 4% of reading, whichever is greater	0 to 44 m/s
Wind direction	°	0 to 358°	± 5°	0 to 358°
Barometric pressure	kPa	660 to 1070 mb	± 1.5 mbar over full pressure range at 25°C	660 to 1070 mb
Solar radiation	W/m ²	0 to 1280 W/m ²	± 10 W/m ² or ± 5% of reading, whichever is greater	0 to 1280 W/m ²

A comparison with regional stations (Faro, Watson Lake) can help determine the validity of certain records.

Snow Depth - Temperature compensation is applied to the SR50A output using the following equation. If the compensation is not applied the readings are only valid for 0 deg. C.

$$Distance = Reading_{SR50A} \sqrt{\frac{T_{Kelvin}}{273.15}}$$

6.3 SENSORS INFORMATION AND REFERENCES

Below is a list of the sensors commonly included in a weather station. For general information on any of the sensors please refer to the Campbell Sci website. For specifics, individual manuals are linked below. Calibration is done by Campbell Sci.

```
'=====
'Sensors and Serial Numbers:
'=====

'T107B_1 Temperature Probe S/N:
'T107B_2 Temperature Probe S/N:
'T107B_3 Temperature Probe S/N:
'HC-S3 Rotronic HygroClip Relative Humidity and Temperature Probe S/N: 61104901
'TE525WS Rain Gage with 8 in. Orifice S/N: 33575-903
'T-200B Geonor all-weather precipitation gauge S/N:
'SR50A Snow Depth Measurement Sensor S/N: 11264
'CMP3_1 Kipp AND Zonen Pyranometer S/N: 187584
'CMP3_2 Kipp AND Zonen Pyranometer S/N: 187490
'NR-LITE-L Net Radiometer S/N: 031401
'05103 Wind Monitor S/N:
```



The sensors:

T107 Temperature Probe – no longer available, product was retired in 1997

HC-S3 – Produce has been retired. Some replacement parts and accessories may be available. Manual (https://s.campbellsci.com/documents/ca/manuals/hc-s3_man.pdf)

TE525WS-Should not require field calibration. Manual (<https://s.campbellsci.com/documents/us/manuals/te525.pdf>)

T-200B – Manual (https://s.campbellsci.com/documents/ca/manuals/t-200b_man%20CSC.pdf)

SR50A – Note that for this sensor to be accurate the temperature sensor must be in working order so that the data can be compensated for. The transducer assembly should be replaced **every 3 years** (in the Yukon) Manual (<https://s.campbellsci.com/documents/us/manuals/sr50a-series.pdf>)

CMP3-Should be recalibrated **every 2 years** (returned to Campbell Sci). Manual (<https://s.campbellsci.com/documents/us/manuals/cmp3.pdf>)

NR-LITE2 – Should be recalibrated **every 2 years**

05103 – **Replace bearings when they become noisy** or the windspeed threshold increases above an acceptable level. Manual (<https://s.campbellsci.com/documents/us/manuals/05103.pdf>)

APPENDIX B: STANDARD OPERATING PROCEDURE – SURFACE WATER HYDROLOGY



Unit 3 151 Industrial Road ■ Whitehorse, YT Y1A 2V3
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Standard Operating Procedure

SOP: Surface Water Hydrology

Written by: Charlotte Rentmeister

Reviewed by: Robert Dekuysscher

Date: October 17, 2023

Equipment Required	Personal Protective Equipment
Wading Rod	Hip / Chest Waders / wading boots (non-felt soles)
Flow meter	Wading belt
YSI	Personal Flotation Device
Bucket (small and large),	Tag Line, throw bag
Salt	Gloves, Rubber Boots, Cruise Vest
Calibration solution, graduated cylinder	
Tape Measure	
First Aid Kit	
Field Logbook, Pencil	
Field Tablet	



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1 INTRODUCTION

Hydrometric data are critical for a variety of assessment and planning purposes. These data are required for any resource development to establish baseline data, assess contaminant loading, determine water withdrawals and discharges and used for engineering design. They are used to prepare site water balances, operation plans, loading models, baseline reports and assess flood risk. Sound and consistent data collection practices are key to ensuring hydrology data quality and thus the accuracy of various models and risk assessments. There are many steps involved in producing accurate discharge records, and rarely are all steps conducted by the same individual or even within the same firm. Therefore, **detailed documentation of conditions and observations during field activities and careful data management are critical to building strong records! Remember these records will be used for decades to come!** The following Standard Operating Protocol is tailored to the types and site typically encountered by Ensero Solutions staff in the Yukon Territory.

1.1 DEFINITIONS

Hydrology: The study of water occurrence, distribution, movement and balances in ecosystems

Surface Water Hydrology: Branch of hydrology of the land surface dealing with rainfall–runoff relationships and the general water budget on the surface of the earth.

Hydrometry: The measurement of water on or below the earth's surface.

Stage: The height or elevation of the stream's water surface above a reference elevation, read from a staff gauge. The true stage is the height of that section above the height of zero flow dictated by the section control.

Staff Gauge: A graduated scale placed in a position so that the stage of a stream may be read directly from it.

Discharge: The volume of water flow which is transported through a given cross-sectional area in each period. Discharge (Q in m^3/s) = Velocity (V in m/s) x Area (A in m^2).

Control: The condition downstream that determines the stage discharge relationship. It may be a boulder control with rapids below or an artificial structure such as a weir. It may also be more subtle such as the convergence with another channel or a narrowing of the stream (constriction). A shifting control may exist where the bed or banks change seasonally. In fact, the dynamic nature of controls makes hydrology on small streams very difficult.

Laminar Flow: When flow lines are in parallel layers with no disruption, cross currents, eddies or swirls. This occurs in reaches with fine bed sediment and straight banks.

Flowmeter: Meter used to measure streamflow velocity, used with measurements of stream width and depth to calculate discharge at a single point in time.

Central to hydrology data processing is the discharge record (below). This is the graphed relationship of how discharge (Q) varies at a location over time. Discharge is typically expressed in L/s or m^3/s . A continuously logged discharge record and actual field discharge measurements plotted together is the product of hydrometric monitoring. The hydrograph is a graphic representation of those data which are in turn used in loading models, water balances, baseline reports and flood forecasting.

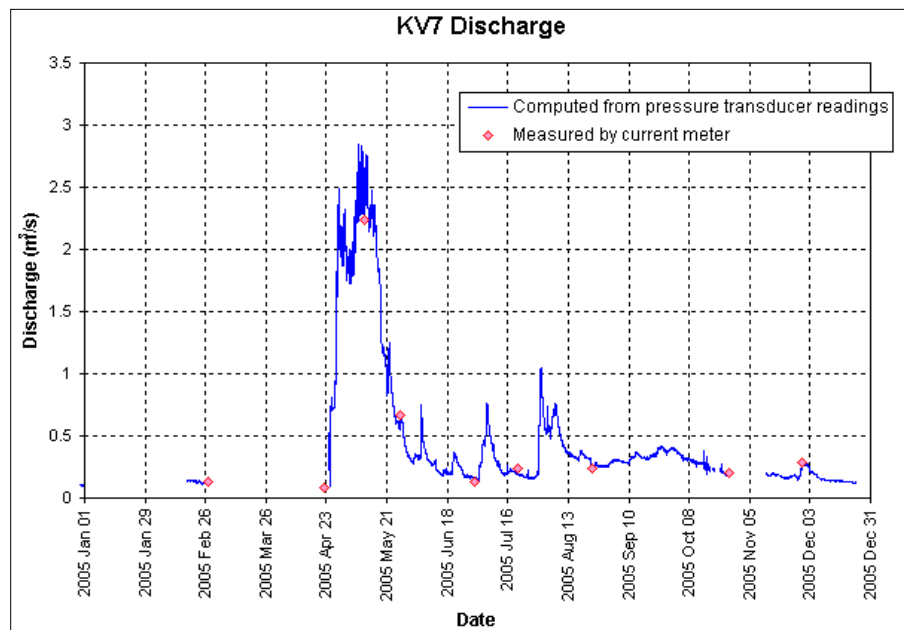


Figure 1-1 Discharge Record

In order to produce an accurate discharge record, several steps are required:

1. Field Activities:

- a. Installation of a durable hydrometric station with staff gauge and datalogging instruments;
- b. Documentation of key conditions during station visits – stage readings from staff gauge (including reading at which zero flow exists), photos of staff gauge, photos up and downstream conditions and metering section used, notes on stream conditions (e.g. ice presence anywhere in channel? High or low flow, vegetation in channel? Etc.), weather conditions (including precipitation), time of day, meter used for readings (AA – Rickly or SI, pygmy, Global, MMB, YSI (salt slug) etc.);
- c. Collection of accurate and precise field discharge (discrete) measurements with concurrent staff gauge readings, across as wide a range of stages as possible (i.e. high, medium and low flows);
- d. Periodic (minimum twice annually) surveys of elevation of staff gauge to track and account for 'drift' or vertical movement of staff gauge.

2. Data Management and Processing:

- a. Calculation of discharge values from metering data (varies with meter used);
- b. Prompt and proper management and filing of notes, photos, observations and datalogger files;
- c. Processing of data into a site rating curve(s); and
- d. Processing datalogger records into discharge records.

Activities during each of these steps need to be conducted properly and with care, as uncertainty or errors induced by improper methods are compounded in later steps. Proper protocols and practices for conducting each of these steps to ensure data integrity are the focus of this document.



2 FIELD ACTIVITIES

2.1.1 HYDROMETRIC STATION INSTALLATION

There are many factors to consider when situating and installing a permanent hydrometric station. Installation should be completed with the assistance of a senior project manager or hydrologist, but a station and its location should meet the following criteria:

- Site is accessible by field staff in a safe fashion, even at high stages and all seasons;
- Site is in an appropriate reach of the watershed – i.e. data from the station will be valid for planning/environmental baseline purposes;
- Located at a point where the stream cross-section is stable (won't shift) and where all but the highest stages will be contained in the channel (i.e. not flood over bank);
- Located in or close to a relatively straight reach with shallow slope and ideal conditions for traditional velocity-area stream gauging – i.e. the flow should be as close to laminar as possible with volume distributed as evenly across the channel as possible;
- Ideally, in a location where there is a natural control (narrowing or immobile obstacles) just downstream to 'back' water up where the logger will be, and free draining flow below the control – no obstacles like deadfall;
- The staff gauge and logger should be situated so that at the lowest flows they will still register a stage – i.e. they'll still be within the wetted width of the flow;
- Staff gauge should be installed such that it is plumb and will not move or 'drift' in any direction, either vertically or laterally – usually requiring a cribbing structure anchored to at least two points on the bank;
- Staff gauge can be read accurately and safely at all stages (i.e. careful consideration of orientation during install);
- Datalogger is installed as close to the bottom (or gauge zero) of the staff gauge as possible in a non-turbulent area – ideally in a stilling well that is perforated to flood to the same level as surrounding water level;
- Datalogger cord (if applicable) is securely anchored to protect from inadvertent movement (wildlife, personnel) and the connection end is protected from the elements.

The stilling well itself should be constructed using a length of PVC or ABS pipe. Black 2" pipe, typically ABS, is seen as advantageous for assisting in warming the pipe and thus helping melt ice in and around the pipe. The stilling well must be perforated for at least the lower 10cm, but the perforation may go higher. The pipe should not be capped on the bottom and it is also useful to wrap the perforated sections in landscaping fabric, securing it with zip-ties, to prevent sedimentation in the well. The well should be removed for de-silting annually regardless of whether fabric is used or not. Photograph 1 shows a hydrometric station installed with angle iron; one iron in the stream bed and another bolted and crossing close to 90 degrees hammered into the bank plus two guy wires anchored to more angle iron and a tree. Please refer to the Ensero Solutions *Standard Operating Protocol: Installing a Solinst based hydrometric monitoring station in small streams*.



Photograph 1: Typical Hydrometric Station

2.2 DOCUMENTATION

Datalogger records and flow readings are of limited value without key supporting information collected from the field. Upon arrival at the metering location, there are several items that *MUST* be noted along with the metering data. It is important to note anything that may affect the discharge measurement, and if the metering location has a staff gauge and/or flow recorder, this information is critical support data for the meter readings. The following is an example of field data collected upon arrival at the metering location; this list is laminated and available to field staff.



ENSERO solutions		Water Quality Monitoring Field Form			
Date:		Start Time:		End Time:	
Project:	Field Crew (circle sampler):	Weather (e.g. air temp, precip):			
Station ID:		# of Bottles:		Pictures: # _____ to # _____	
Insitu Data		Salt Dilution Calibration Details		QA/QC Samples	
Meter #:		Volume (mL)	Sp. Cond.	Please Note: Sample Bottle Label; Duplicate Collection Details; De-ionized Water Batch #'s for Blanks (once per trip) Circle to indicate collection of sample & presense of trip blank Trip Blank Field Blank Duplicate	
Temperature:	°C	Initial vol. of H ₂ O			
DO:	% saturation	+20mL sol'n			
DO:	mg/L	+20mL sol'n			
Specific Cond.:	µS/cm	+20mL sol'n			
pH:	pH units	[NaCl] in stock Sol'n:			
ORP:	mV				
Notes: Relative Flow - High / Low / Average; Water Clarity - Clear / Turbid; Logger Download Info; Erosion / Sedimentation; Sediment / Benthic Samples; Unusual Circumstances. Sketch &/or Photos (Staff Gauge, Sample Equipment, Environmental Conditions)					
Salt Dilution	Trial #1	Trial #2	Staff Gauge; Start:	m	SG Reading Error +/- mm
BL Sp. Cond.			Staff Gauge; End:	m	SG Reading Error +/- mm
Mass (g)					
Peak Sp. Cond.			SS; Start Time:	End Time:	
5 Photo Checklist: upstream, downstream, across transect, SG close up of WL, Entire SG/Hydrometric station					
Pg: of:					

Figure 2-1 Blank Surface Water Field Sheet

These requirements should be understood and memorized by staff that regularly collects field hydrology data. Anomalies in datalogger records can be corrected or adjusted and errors can be fixed later if, for example, the staff gauge reading is noted, or a photo of the staff gauge is taken, or if a different meter than normal is used, but is noted.

If in doubt, record all the details in the field!!

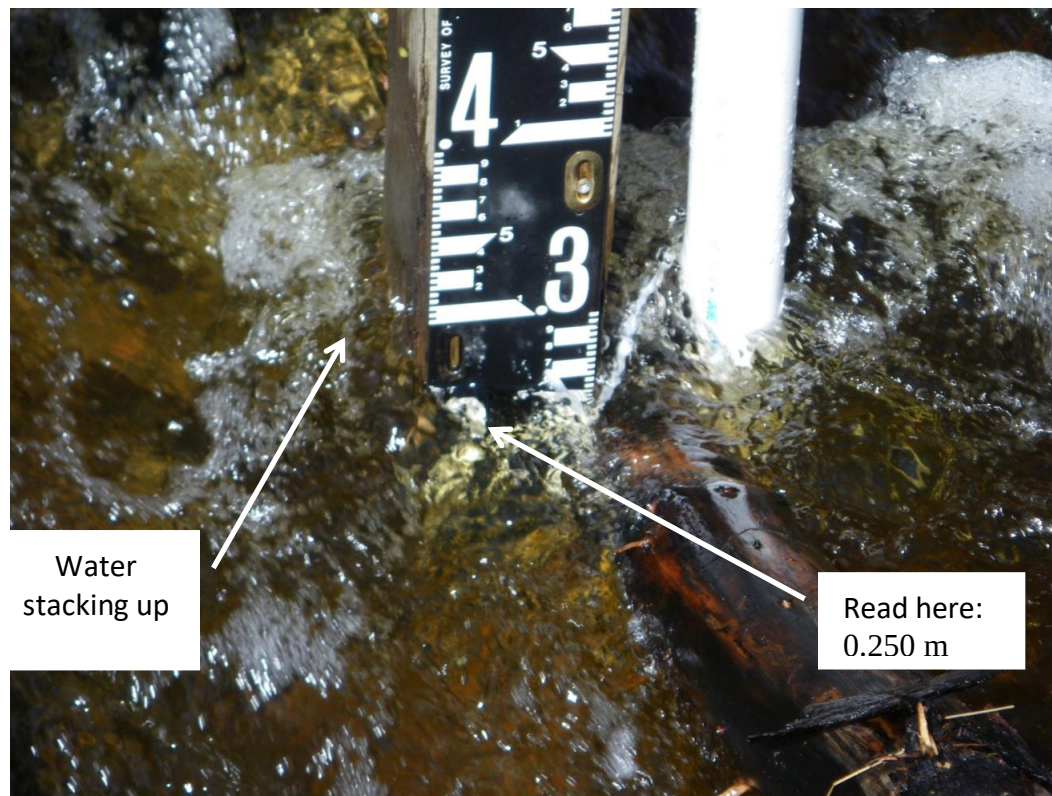
Staff gauges are used to record the **stage** (water level) of a creek, river, reservoir, etc. The staff gauge is the datum for all the measurements, meaning that all measurements and data records are relative to the staff gauge. It is therefore important to not only read staff gauges carefully, but to make note of anything that would suggest the gauge may have moved or any new debris in the channel that may affect the water level (e.g. fallen tree within the gauge reach or blow out of control feature, even the smallest amount of new ice forming on the banks will affect stage). Photos and any estimates of direction and magnitude of movement can be very valuable in planning repairs and correcting data records.

Be careful to read and record the gauge correctly in meters, to 3 decimal places (i.e. to the nearest mm). Taking a photograph of the water level on the gauge is required to cross check staff gauge readings if suspect. **Staff gauge readings should be taken both before and after metering**, as stage of a stream can change over the course of a visit to a station. ALWAYS TAKE A PHOTO! If the water is turbulent, take several photos to show the variation.

High flow conditions can result in water 'stacking up' against part of the staff gauge structure. In this case, readings should be read at the downstream side of the gauge to minimize error.



Conversely, some stations will have no surface flow when the station is visited. Although tempting to not collect any data, these conditions are critical to the process of developing accurate discharge records. **Zero is a number!** Zero flow conditions should not only be noted in field records but photographed as well. Often staff gauges will be in a pool that may still show a 'water level' when there is no discharge. This 'zero flow reading' is very important to rating curve development and should be documented. Defining the zero flow period of a system is an important requirement for the Water Use License application.



Photograph 2: Water Stacking on Staff Gauge Structure

2.3 DISCHARGE METERING

Discharge (flow) measurements are usually conducted using a current meter to measure velocity at various points along the width of the stream. Accurate metering is critical to the accuracy of the discharge record. There are many elements to consider when conducting stream discharge measurements and there are many opportunities for error. Adherence to Standard Operating Procedures is critical to data integrity.

If conditions permit, flow measurements should be conducted using a current meter. The manual of operation provided with the meter must be followed and the general current meter use and flow measurement procedure from this protocol should be followed. For more details refer to the Manual of British Columbia hydrometric standards or the Water Survey of Canada Technician manuals Current Meter Procedure

The following general methods should be followed when conducting flow measurements while using the FH-950 portable flow meter:

- The "sixth-tenths-depth" or "two tenths and eight tenths depth" measurements, in which the velocity at sixth-tenths of the stream depth is assumed to represent the average velocity through the vertical water column, and



- The midsection method, which is a standard discharge measurement technique whereby the depth, revolutions and time are measured for each of several verticals along a cross-section.

This procedure has been prepared under the assumption that a person wading across the stream will undertake the flow measurements. For detailed procedures on conducting flow measurements from a boat or bridge refer to the Section D.2.2 of the Manual of Standard Operating Procedures for Hydrometric Surveys, published by the Ministry of Environment (1998) and available online.

The flow measurement procedure should consist of the following steps:

1. Locate the monitoring station (the stations should be clearly marked).
2. Assess and mitigate safety risks. It is required that two people conduct flow measurements, you should never attempt a discharge measurement alone. Debris and slippery substrates are other common hazards. Waders (with wading belt), throw bags, handlines and PFDs are available safety items. Field technicians should own or be provided with properly fitting waders of good quality.
3. Identify an appropriate cross-section to meter. The cross section should be:
 - a. In a location where metering can be done safely and repeatedly at different stages if required;
 - b. In as straight a reach as possible (laminar flow) – excessive turbulence can impact readings;
 - c. Stable – muddy/sandy bottoms and banks make accurate metering difficult;
 - d. Free of backwater, eddies, obstacles, etc. if possible.
4. Improving the metering section. Where necessary, take the time to improve the metering section by removing boulders and debris from the metering section and the area immediately above it. Remove significant in-stream vegetation for a distance of three times the depth from the area upstream and downstream from the section. On smaller watercourses it may be possible to construct small dikes to cut off sections of shallow flows and dead water. This should be done when the station is established and a matter of minor maintenance upon each visit. This work must be documented in detail.

After the modifications are made, be certain to allow enough time for conditions to stabilize before proceeding with the measurement. Note if the modifications have an influence on the gauge reading – ideally, they should not, or should be done prior to gauge installation/reading. All improvements to the metering section should be completed before starting the measurement, i.e. do not make changes to the metering section (such as by moving rocks) during the discharge measurement.

5. Use a measuring tape (tagline) spread across the channel to mark the locations where depth and velocity measurements will be conducted. Position the tagline correctly. Take the time to ensure that the tagline is placed in a position that is perpendicular to the direction of the current and secured to either bank such that it will not touch the water or slip.
6. Record the distance along the tagline of the right bank (facing downstream). The “bank” in this case is the water/land interface (i.e. the bank will be different each time you gauge the site). There will be no depth or velocity readings associated with the two bank distance readings (i.e. they are both zero by definition).
7. Collect depth and velocity measurements at intervals (panels) along the tagline. Factors to consider:
 - a. **Number and spacing of measurements.** There should be 20-25 (21 ideal) flow measurements across the channel. However, the number of measurements can be reduced for narrow channels. If the cross section is very narrow, use a small meter and space the verticals more closely. Distance between measurements should be spaced such that approximately the same volume of water passes through



measured 'panels' per unit of time – i.e. measurement spacing can be increased in shallower areas of slower flow near the banks but should be tightened together where the channel deepens, and the flow rates increase. This will ensure that any error in the measurement is not disproportionately compounded. A minimum distance for the FH-950 or March McBirney is 10cm.

- b. **Position of the technician.** The field technician's position with respect to the current meter is very important when making a discharge measurement by wading. The technician should stand to the side and downstream from the meter so as not to influence the velocity. Studies show that the following position has the least effect on the operation of the current meter: stand in a comfortable, safe place facing either shore no less than 0.4 m downstream and to the side of the current meter.
- c. **Position of the current meter.** Hold the wading rod in a vertical position and the current meter parallel to the direction of flow while measuring velocity. Vertical axis meters - if the axis of the meter is not kept vertical, the meter will tend to under-register. Horizontal axis meters - many propellers are designed to compensate for angular flow. Consequently, any deviation from the vertical position of the rod will introduce an error in velocity.
- d. **Uneven Channel Bed.** Sounding a channel bed that is extremely soft or strewn with boulders requires a great deal of extra care and attention. Be careful not to over-sound by allowing the bottom of the wading rod to sink into soft channel bed material. If the channel bed is very rough, take time to adjust the observed depths so that they reflect both the tops of the boulders and the depths between them. Sometimes there may be a near-vertical boundary separating zones of different depth or velocity. In this case, position the adjacent measuring verticals equidistant from this boundary, so that the boundary coincides with the common boundary of the partial sections.
- e. **Precision.** The rod is graduated to 0.02 metres with the zero mark at the bottom of the rod. The depth is the point at which the level water surface intersects the rod. Observations should be made to the nearest 0.01 meter.
- f. **Depth or measurement.** Velocity is to be measured at sixth-tenths (0.6) of the depth from the water surface. Adjust the height of the current meter to sixth-tenths of the depth. Ensero Solutions utilizes top set wading rods which are calibrated to allow the user to quickly adjust the current meter position by setting the water depth position on the adjustment gauge. For water levels above 0.75m it is preferable to use the two point velocity method of measuring the velocity at two-tenths and eight-tenths of the water depth. This can easily be achieved by setting the adjustment gauge to half the water depth (two-tenths) and double the water depth (eight-tenths). If using the FH-950 or Marsh-McBirney meter you may choose to use the two-point method at depths greater than half a meter.
- g. **Taking the reading.** Measure the average velocity at each location. This is measured digitally with our instruments. Ensure that the timing is started immediately after the current meter been properly placed in the channel. Also ensure that the average velocity is measured for a minimum of fifteen (30) seconds. The measurement time interval can be adjusted on digital meters.

Distance or Station along tagline (reading in m from bank), Depth (of water at reading station, in m) and velocity are recorded as shown in an example below (Figure 2-2).

Repeat the discharge measurement. You may use the same tag line or adjust the position within the same reach if conditions permit. It is important to collect your velocity and depth readings at different distances along your tagline to ensure confidence in your measurement.



Where the reach is ideal you will experience a difference of five percent or less. If your error is over 10% it is likely that there were either too few velocity measurements or conditions are not ideal. Non-ideal conditions are created by turbulence which is the result of too much channel slope and uneven beds, usually from boulders. In some cases, this is unavoidable, and a third measurement should be taken.

		Sta. ID: KV-9		Pjct. Code:		Date: 8 July 20	
Sampler: KT		Recorder: CR					
Start Time: 10:35		End Time: 11:14					
Staff Gauge Start (m): 0.480 +/- 1 m		End Height (m): 0.480 +/- 2 m					
L.Bank: 2.00 m		R.Bank: 5.64 m		Meter type & #: FH950			
	Dist. (m)	Depth (m)	Vel. (m/s)		Dist. (m)	Depth (m)	Vel. (m/s)
1	2.10	0.32	0.117	2.15	0.32	0.160	
2	2.25	0.32	0.197	2.30	0.32	0.158	
3	2.40	0.34	0.139	2.45	0.38	0.150	
4	2.55	0.35	0.116	2.60	0.39	0.195	
5	2.70	0.39	0.239	2.75	0.39	0.260	
6	2.85	0.40	0.327	2.90	0.37	0.303	
7	3.00	0.41	0.292	3.05	0.31	0.185	
8	3.15	0.40	0.240	3.20	0.40	0.226	
9	3.30	0.36	0.282	3.35	0.36	0.244	
10	3.45	0.35	0.277	3.50	0.35	0.270	
11	3.60	0.36	0.276	3.65	0.37	0.265	
12	3.75	0.39	0.298	3.80	0.38	0.235	
13	3.90	0.39	0.209	3.95	0.39	0.251	
14	4.05	0.38	0.228	4.10	0.38	0.234	
15	4.20	0.37	0.269	4.25	0.36	0.243	
16	4.35	0.36	0.231	4.40	0.36	0.256	
17	4.50	0.36	0.241	4.55	0.37	0.227	
18	4.65	0.35	0.220	4.70	0.38	0.268	
19	4.80	0.38	0.220	4.85	0.38	0.244	
20	4.95	0.39	0.233	5.00	0.39	0.234	
21	5.10	0.40	0.221	5.15	0.40	0.204	
22	5.25	0.39	0.136	5.30	0.40	0.163	
23	5.40	0.42	0.174	5.45	0.42	0.189	
24	5.55	0.40	0.084	5.60	0.40	0.048	
Note:				Pg: of:			

Figure 2-2 Surface Water Discharge Field Sheet

2.3.1 DILUTION GAUGING PROCEDURE

Dilution gauging is a convenient and reliable method for gauging channels with irregular morphology that are not suitable for the conventional velocity-area flow metering method described above. There are two methods of dilution gauging, constant rate injection and slug injection; the following procedure will describe the field methods for salt slug injection. Additionally, dilution gauging is useful for ice covered streams.

NOTE: Flow metering by traditional velocity-area method is always preferred to dilution gauging if possible!

The slug injection method deposits a known mass of salt into the stream “instantaneously” and measures the concentration downstream overtime. The measurement period covers the time it takes for the conductivity to respond to the tracer and return to background levels.

The following preparations should be made prior to a field trip involving dilution gauging:



Equipment: Large mixing bucket, small calibration bucket, calibration solution, pre-weighed salt, 500 mL and/or 1000mL graduated cylinder, a 60mL syringes, YSI multimeter, and a pair of handheld radios. In winter, an ice chipper and/or auger will be necessary, and a smaller bucket may be useful. Note: The syringes from water sampling/filtering may be reused for this.

Salt must be pre-weighed prior to going into the field. It is also helpful to weigh out site specific salt quantities so there is one less decision to make in the field. This can be done by reviewing past flow records or measuring out approximately 15 grams for every L/s of discharge (i.e. if you expect a flow between 20-40 L/s) bring $15 \times 40 = 600$ g of salt. There is a precision scale located in the field room for this purpose. Heavy-duty Zip lock bags work well for transporting salt. Alternatively, you may pre-mix solution of known concentration and measure precise quantities to add to your bucket, but the added weight is not very field friendly. For higher background conductivities more salt may be needed. A Quantity of 4 kg is the practical upper limit of what can be dissolved in a 20L utility pail.

Stock calibration solution must be prepared prior to departing for the field. Mix the stock solution at 10,000 ppm prior to the field trip. That is ten (10) grams of salt for every litre of water. Mixing in large quantities such as 50 grams in 5 litres will reduce the error and ensure enough stock solution for several field events. Use deionized water for mixing stock solution. Volumes must be precise, use graduated cylinders, syringes and pipettes. Be sure to add your salt to your graduated cylinder prior to filling it with water.

The following general steps should be followed when conducting salt dilution type stream gauging:

1. Locate the monitoring station (the stations should be clearly marked).
2. **Assess and mitigate safety risks!** It is strongly recommended that two people conduct flow measurements, particularly when streams with high flows are encountered. One team member should operate the YSI multimeter while the other “injects” the salt slug.
3. The YSI multimeter should be set to log at one second intervals making sure to include the station ID.
4. Mix your salt solution with stream water in the large bucket so that it is completely dissolved. The salt should be poured into the pail slowly while mixing; this is the quickest way to dissolve the salt! The ice chisel works well for stirring. Check to see that your team member has started logging with the YSI and dump the salt into the stream (radios work well here). In winter, the small bucket may be critical in order to fill your mixing bucket, ice is often thick and making a hole large enough for a 20L bucket can take a long time. Be sure, however, to make the hole large enough to dump the salt mixture quickly without hitting the sides (ice). Use at least 1L for every 200 g. For small salt quantities you can use more water. For example, 200g could be mixed in 5L of water for easier dissolving.
5. When collecting water quality samples be sure to obtain them either prior to the dilution or upstream of the injections site. Doing the injection first will save time as you wait for the salt wave to pass, but only do so if you can collect the sample above the injection site.
6. Once the conductivity has returned to base level inject your second slug or stop logging if your second slug has passed, you are finished. Make sure you have recorded the time and quantity of salt used in your field notes in addition to the staff gauge reading at the site. Be sure to photograph the staff gauge, collection site, injection site upstream and downstream photos plus record the time to the minute of the reading.
7. You may perform your calibration before or after your dilution gauging so long as you obtain your background water above your measurement reach following the experiment or dump your calibration solution below your reach if done prior to your measurement. Obtain your calibration by following the steps below:



- a. Take a 1,940 mL sample of water from the creek and measure the specific conductivity. Use a graduated cylinder and syringes to measure your water and place it in a small bucket. Make sure the conductivity is the same as that recorded as the baseline for the salt test. You can use more water but be precise and be sure to record the amount used;
- b. Add 20 mL of stock solution from a syringe. Stir and re-measure the specific conductivity. Record values and repeat at least two more times.

2.4 SURVEYING AND TRACKING STAFF GAUGE DRAFT

Despite attempts to stabilize staff gauges, natural freeze-thaw cycles and ice movement have enormous force that can move staff gauges. Vertical movement of a gauge changes the standard or datum that all other measurements and records at that site are compared to. Stage records can be corrected for this movement or 'drift' is measured regularly.

Periodic surveys are the best way to measure this drift. Completed in the spring and fall, drift can be measured, and change can be connected to a specific date and time.

Hydrometric levelling is an integral part of station establishment and its maintenance. The methods described must be strictly adhered to so that data can be properly adjusted later. It is strongly recommended that a levelling test be carried out prior to any level checks, and after any accidental rough usage. The instrument should never be adjusted unless the test indicates the same magnitude of error at least two times. A common procedure known as the 'Two-Peg Test' is usually carried out to test the levelling instrument and determine whether any adjustment is required. If you are unsure whether this test has been conducted recently you should complete the test.

2.4.1 PROCEDURE FOR CONDUCTING THE TWO PEG TEST

The Two-Peg Test ensures that the level (instrument) is accurately calibrated.

Establish two firm points, A and B, about 60 meters apart. Each part can be marked with a peg or a stake.

1. Set up the instrument midway between points A and B.
2. Stand rod on point A and take reading (a).
3. Stand rod on point B and take reading (b).
4. Record the difference between these two readings (a-b). The correct difference in elevation between points A and B is a-b; this is true even if the level is not sighting a true horizontal line, because the instrument is set up exactly midway.
5. Move and set up the instrument at a point that is 3 – 4 meters away from point A, at a 90° angle from the line created between point A and point B.
6. Take second readings on a rod set on points A (c) and points B (d).
7. The difference in readings found between points A and B in step 4 should be unchanged (ie. $a-b=c-d$) for the instrument to be in proper adjustment.
8. Should these second readings give a greater or lesser difference of 0.004m than in step 4, the instrument is out of adjustment and must be adjusted until the horizontal cross-hair is equal to the reading of (d)

NOTE: ADJUSTMENT FOR EACH TYPE OF INSTRUMENT VARIES AND THE OPERATOR SHOULD REFER TO THE INSTRUCTION MANUAL FOR THE PROPER PROCEDURE TO ADJUST THE INSTRUMENT.



2.4.2 LEVELLING PROCEDURES

1. Tripod should be set on firm ground
2. The placement should ensure secure footing for the person using it
3. Accuracy of levelling can be increased by ensuring that all backsights (BS) and all foresights (FS) are equidistant, this will eliminate any instrument or physical errors
4. The level must first be adjusted so that the cross hairs are in focus for the operator
5. The levelling rod must be placed firmly on a repeatable point of a stable object. Note: Levelling rod should be placed directly on top of the nail head at Ensero Solutions hydrometric station Benchmarks to ensure this placement repeatability.
6. The telescope can be pointed roughly at the levelling rod and focused.
7. Levelling rod must be held plumb, both side to side and front to back. Tip: use a corner level that will allow the holder of the rod to keep the rod plumb, wave the rod slightly back and forth, the lowest number is the correct reading.
8. To verify accuracy of the reading: the surveyor should call out the recorded level height, the rod holder should point to the level height on the rod, and the surveyor should then re-survey verifying the level height that has been recorded.
9. Rod readings to 0.001 m are enough.

Always place the rod directly on top of the nail head of the benchmarks and directly on top of the staff gauge. The rod must be held plumb. (Side to side - Rod will be parallel to vertical cross hairs; Forward to backward - tip the rod towards the levelling instrument and away from it. At the point of the lowest reading is where the rod will be completely plumb. The corner level will also ensure that the rod remains plumb.

2.4.3 PROCEDURE – LEVEL CIRCUIT TO STAFF GAUGE

The procedure for determining the elevation of a staff gauge in relation to the elevation of a benchmark involves several steps. Ensero uses three benchmarks in order to accurately determine the elevation of the staff gauge.

1. Set up levelling instrument in a convenient location midway between staff gauge and benchmark #1 (BM#1). No attempt to stay on the line directly between the two is necessary;
2. Record a backsight (BS) on BM#1. BM should be assumed to be 100.000m;
3. Move the rod to the next benchmark or staff gauge and record the foresight (FS) reading;
4. Repeat step three for the remaining BMs and the staff gauge, also the control if apparent;
5. Set-up the instrument in a new location;
6. Take a BS reading to the staff gauge;
7. Take a FS reading to each BM;
8. Calculate elevations. By adding the recorded backsight value to the known elevation of the benchmark, the height of the instrument is determined. The foresight is then subtracted from the height of the instrument to obtain an elevation of the other BMs and staff gauge. There should be no more than 4mm difference between the two elevations calculated for each benchmark, if there is repeat the survey. Also note that the difference



between the backsight taken on a given point and the foresight taken on the following point is equal to the difference in elevation between the points.

Note: it does not matter which benchmark you begin and end with as you are just performing a check to see that there are no errors in your measurements and any difference in elevation between the bench marks and the staff gauge is consistent through all three however it is prudent to take previous survey results in the field to compare and most stations are established with BM#1 as 100.000m.

Level Notes

*Recording accurate and complete field notes is the most important part of the levelling operation. Notes and sketches constitute a permanent record of the survey, and it should be possible for them to be interpreted with ease by anyone having knowledge of levelling. Survey specific field sheets are available.

When recording notes:

1. Enter the known elevation of the benchmark or staff gauge (or reference mark) on the line in the column headed 'Elevations as Given';
2. The benchmark identification number is entered in the column headed 'Station';
3. On the top line, in the column headed 'BS (backsight)', the reading obtained with the levelling rod on the benchmark or point of known elevation is entered as the backsight;
4. The value for the column 'Ht.Inst.' (height of instrument) is computed by adding the backsight value to the known benchmark elevation;
5. In the column headed 'foresight (FS)', the foresight reading for the point for which an elevation is to be determined is observed and recorded;
6. The elevation of the benchmark is calculated by subtracting the FS value from the Ht.Inst. This value is entered in the 'elevation column' and on the same line as the foresight just observed;
7. When the instrument is moved, the new height of the instrument is determined by a backsight on the turning point (i.e. the last benchmark for which you just determined the elevation). The observation and notes are continued in this manner until the circuit is closed by levelling back to the original starting station;
8. Following this fill out the mean elevation for each benchmark (Figure 2-3). You will have calculated the height of two of your benchmarks twice and once for one (e.g. in Figure 2-3 BM1 is calculated once and that elevation is used twice).
9. The difference should be the same or very close to the same in all cases and is indicative of the gauge correction. Print your name and date. Have someone else check your calculations. If you are aware of an event that may have cause a change in the staff gauge, please record \the datethe date and provide a brief explanation.



KV 41 Survey June 8 1005 → 1622					
Station	BS	HT	FS	EL	GN
BM1	0.546	100.546			100.000
SL			1.458	99.088	
BM3			1.425	99.121	
BM~			0.230	100.316	
BM~	0.233	100.549			100.316
BM2			1.430	99.119	Δ2
SL			1.462	99.087	Δ1
BM1			0.549	100.000	Δ0
SL 0.312 @ 1624 ±5 stacking also					

Figure 2-3 Staff Gauge Survey Field Sheet



2.5 MAINTENANCE OF METERS AND RATING TABLES

Current meters should be re-calibrated every year and be tested periodically.

3 DATA MANAGEMENT AND PROCESSING

3.1 MANAGEMENT AND FILING OF NOTES, OBSERVATIONS AND DATALOGGER FILES

Standardized management of data collected in the field is important in hydrological monitoring programs. Standard protocols and systems make data processing easier and less prone to error. Processing of data may involve referring to the original field notes in order to cross check suspicious values. This involves cross checking for transcription errors as well as looking for notes on conditions which may support anomalous values. The following steps should be taken upon return from hydrology field work:

1. Field notes scanned and filed digitally in the project files as appropriate; follow established folder and file naming protocols.
2. Photos should be saved and labeled (e.g. US, DS, Across, SG), specifically those of gauging stations or flow conditions;
3. Any datalogger files downloaded should be transferred immediately from the field laptop or Levellogger to the server into the appropriate folder. Details on the download should have been recorded in the field notes – date and time of download, filename, real time values etc.
4. Manual stream gauging data should be processed into a discharge value (see below) and reported in the field report, entered the projects discharge master file and entered into the in-situ spreadsheet for the project for input into EQWin water quality data management software. Data managers should be alerted when this has been completed.

Note: Field memos should be prepared after every field trip. Templates are available from managers and other field staff. Observations and calculations related to hydrology should be included in the detailed reports. These are valuable documents for Quality Control purposes and future investigations into site conditions and observations.

3.2 CALCULATION OF DISCHARGE

3.2.1 CALCULATING DISCHARGE FROM CURRENT METER

The midsection method is most often used to calculate stream discharges. In this method the stream is divided into several panels. Each panel extends from half the distance from the previous depth and velocity measurement to halfway to the next depth and velocity measurement (see below for reference).

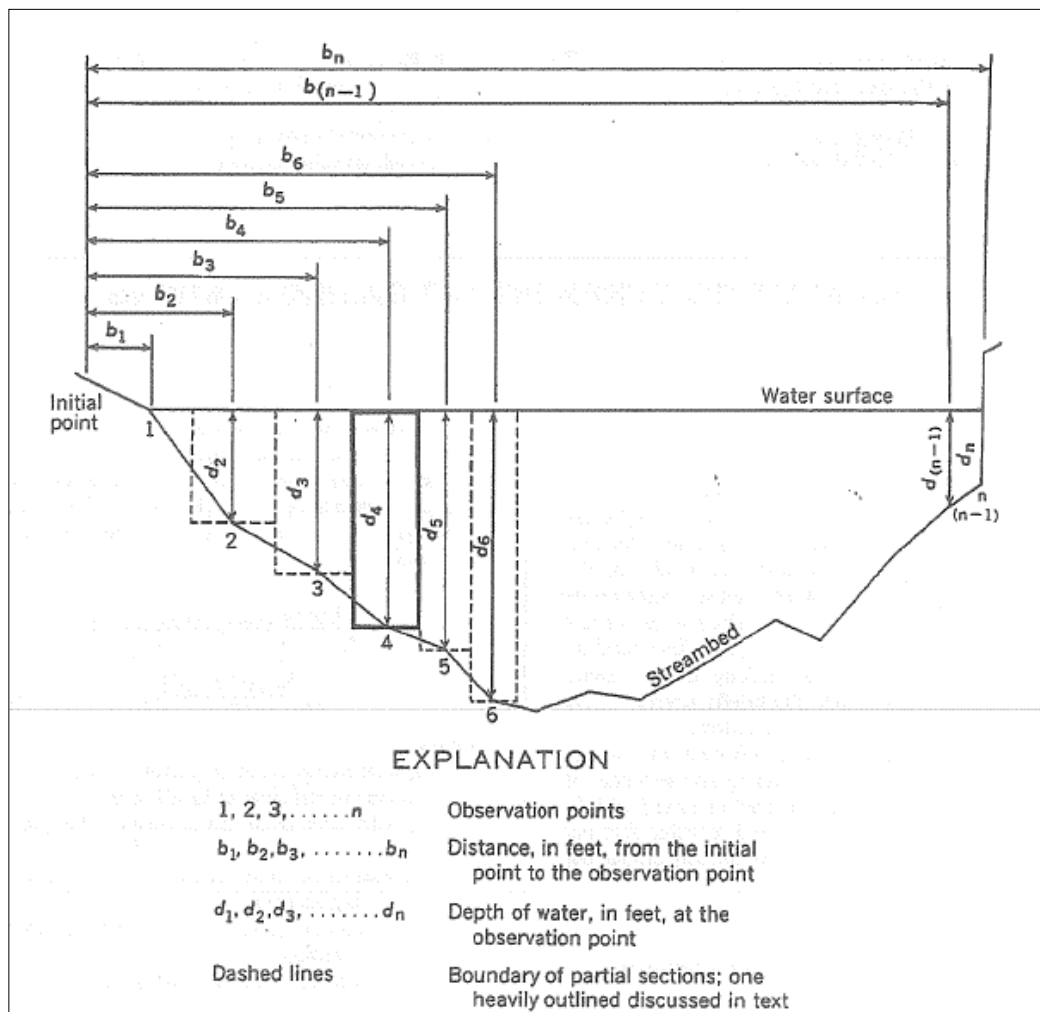


Figure 3-1 Mid-Section Method

The flow (discharge) in each panel is computed by multiplying the mean velocity at the centre of the panel by the corresponding width measured along the surface tape or cord. This width should be taken to be the sum of half the distance to adjacent verticals. The velocity in the two half widths next to the banks can be estimated.

$$Q = d_1 V_1 (b_1 / 2 + (b_2 - b_1) / 2) + d_2 V_2 ((b_2 - b_1) / 2 + (b_3 - b_2) / 2) + \dots$$

Where b_1, b_2 , etc. are distances from the initial point (m).

d_1, d_2 , etc. are the water depth at the measurement (m).

V_1, V_2 , etc. are the velocity of the water column at the measurement (m/s) at 0.6 of depth.

Q is the total stream discharge (m³/s).

Ensero Solutions has spreadsheet templates set up for converting field observations into discharge (Q) values. Project files should have these spreadsheets and templates pre-established. Care should be taken to use the template specific to the meter used; meters have specific formulae, which can also vary from year to year with instrument calibration. If velocity values were generated in the field, this is not a concern. Templates for this can be found on SharePoint.



3.2.2 CALCULATING DISCHARGE FROM DILUTION GAUGING

The specific conductivity data from the YSI plots a curve like a hydrograph. Like a stormflow calculation we can calculate the volume of water passing the measurement point by integrating the area under the curve. By calculating the difference in conductivity over the period of the salt wave and taking the sum we can calculate the discharge with the following equation:

$$Q = \frac{M_s C_s}{\Delta t \sum (EC_t - EC_b)}$$

Where: Q = discharge

M_s = Mass of salt used

C_s = Conductivity Coefficient (conductivity change ($\mu\text{S cm}^{-1}$) per g of NaCl in 1m^3 of solution at 25°C)

Δt = Time (s) of sampling interval

EC_t = Electrical conductivity at time t

EC_b = Background electrical conductivity

Like those for the current meter, Ensero Solutions has spreadsheet templates for imputing data and calculating discharge. This should be done by field staff upon return from or during field excursions.

3.3 PROCESSING OF DATA INTO A SITE RATING CURVE

Note: This section is for informative purposes only. This task should not be attempted based on this limited introduction. Ensero Solutions processes all hydrometric data in Aquatic Informatics' Aquarius Time-Series software.

As discharge readings and corresponding water level readings from staff gauges are collected at a station, they can be plotted as X, Y points. The relationship between these variables is the formula of the line of best fit and can be used to translate continuous water level records from data loggers into a discharge record, or hydrograph. A minimum of three points are required for a relationship to be developed, but more points across the range of stages are highly desirable. In general, rating curves should be developed by or under the guidance of a hydrologist. However, below is a general outline of how a rating curve is developed, rating curves can also be done directly in Aquarius.

Steps for developing a rating curve:

- Plot a single series, with stage on the X-axis and corresponding discharge on the Y-axis.
- Chart as a scatter graph
- Add a Power trend line to the data set. A power trend line assumes that zero flow occurs at zero on the staff gauge. Since this is unlikely the staff gauge must be adjusted for the "height of zero flow". This means that if the height of zero flow is at 0.02 m then 0.02 must be subtracted from all staff gauge readings.

An example of a two stage rating curve is shown below. This results from a change in the dominant control such as overtopping the bank.

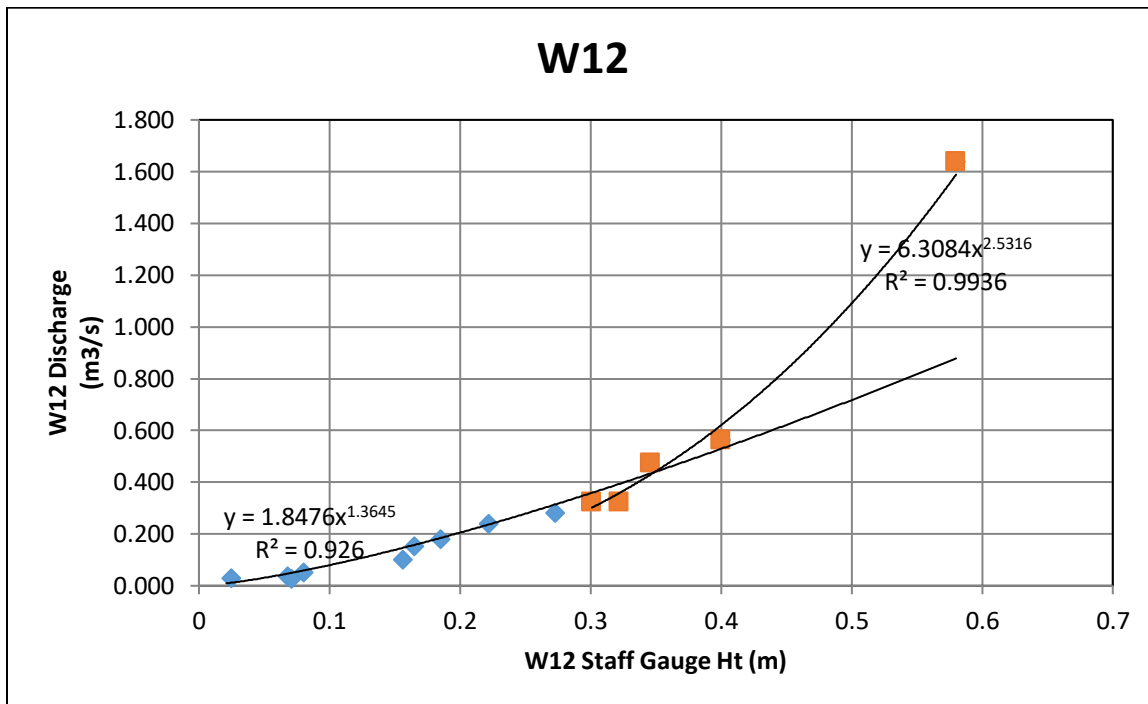


Figure 3-2 Completed Rating Curve

3.4 PROCESSING DATALOGGER RECORDS

Note: This section is for introduction only. While record can be processed in excel the process is cumbersome and there are many potential pits falls not covered below. Ensero Solutions utilizes Aquatic Informatics' Aquarius Time-Series software for correction of stage record and processing into discharge hydrographs, these tasks should be completed by a qualified hydrologist or water resources engineer.

Compensated depth of water records from downloaded files are combined into a single 'master' spreadsheet. The following steps are required to convert to an accurate discharge record:

- **Offset:** The water depth from the datalogger at any given point in time will not usually be the same as the staff gauge reading from the same time – the membrane on the datalogger is rarely positioned at exactly 0.000 m on the staff gauge. Therefore, the stage record from the logger will need to be 'adjusted' or 'offset' to line them up. This requires accurate staff gauge readings and time of observation (during the logger collection period). The difference between the logger water depth and staff gauge reading for each point in time can be calculated and the average of all these differences can be applied to the entire data record as a single offset adjustment (this could be a negative or positive difference, care needs to be taken to apply the correction in the proper direction). An example of this is shown below:



Table 3-1 Stage Record Adjustment

Date	Time	Metered Q	Staff Gauge	Logger Reading	Offset		
3-May-07	1343	0.395	0.400	0.452	0.052		
9-May-07	1400	0.231	0.330	0.431	0.101		
10-May-07	1140	0.27	0.340	0.364	0.024		
14-May-07	1400	0.137	0.261	0.298	0.037		
16-May-07	1330	0.10	0.242	0.286	0.044		
30-May-07	1130	0.02	0.185	0.223	0.038		
31-May-07	1600	0.027	0.13	0.239	0.109		
28-Jun-07	1500	0.013	0.16	0.193	0.033	Average:	0.055

Note: The offset can be determined and programmed into the instrument upon installation, such that the data record is 'adjusted' upon download and export. Notes should indicate if this is conducted or not at installation.

In addition to the offset from the staff gauge, a second offset must be applied to adjust the record relative to the height of zero flow. The height of zero flow may be obtained directly by surveying the height of the section control downstream of the stilling well or indirectly by adjusting the offset until the "best-fit" is found for the observations to a power function with an exponent base (usually 1.5-2.5). This process should only be completed by a qualified professional.

- **Apply Rating Formula to Stage Record:** The rating curve formula developed for the station is used to convert the stage record to a discharge record. The adjusted stage record values are mapped into the formula as the X variable to determine the discharge for that stage. The formula can then be 'dragged' down the entire data record. See below for example using above rating formula:

Clipboard		Font		Alignment	
MONTH				=1.6783*(AE12)^2+(0.2671*(AE12))-0.0621	
AD	AE	AF	AG	AH	AI
11 Compensated Stage	Corrected Stage	DISCHARGE	Temp. °C		
12	0.452	0.400	AE12))-0.0621	22.94	
13	0.441	0.389	0.295	20.88	
14	0.436	0.384	0.288		
15	0.431	0.379	0.280		
16	0.446	0.394	0.304	18.56	
17	0.446	0.394	0.304		

Figure 3-3 Rating Formula Example

- **Plot Hydrograph:** the discharge values can then be plotted as Y-axis values against data/time on the X-axis as a discharge record or hydrograph. An example is shown below. Loggers are often launched prior to being placed in the stream, so the data record may need to be 'cropped'. Temperature readings can help to determine if the instrument was in water or air, if field notes are not available or need to be refined for exact time. Erroneous data may be logged due to ice formation, and the temperature record can also help with this determination. This exemplifies the critical importance of taking detailed physical observations when in the field so that data may be qualified.

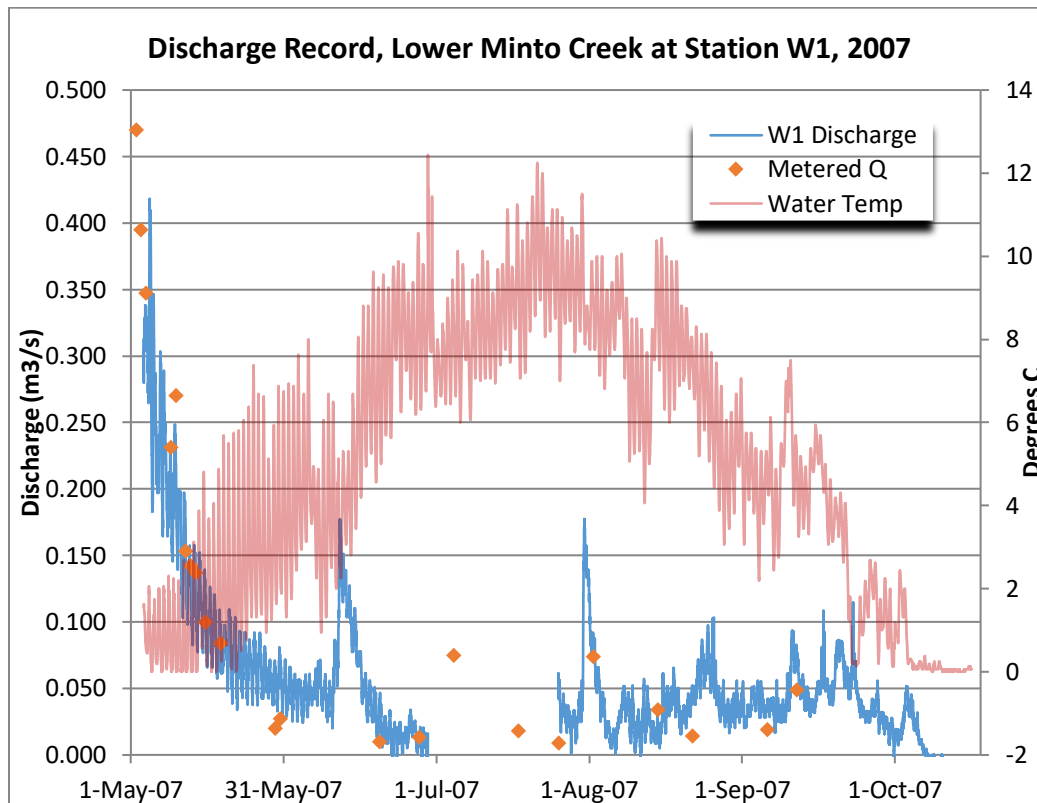


Figure 3-4 Hydrograph Example, Minto Creek 2007

- Dataloggers have shown a tendency to output data with date/time values that do not plot properly in Excel. This problem has consumed excessive time in the data management stage in the past, so the issues and potential resolutions are presented here:
- .csv files are less functional than .xls files. Try saving original data files in .xls format.
- Regional settings – US and Canadian regional settings on computers read dates differently. Dataloggers often output dates in the US data format (DD/MM/YY), and if the laptop/PC used to download the files is set to the Canadian regional setting, issues arise that are difficult to correct. All computers should be set to US: Control Panel>Regional Settings and Languages
- Dates need to be in Date/Time format to chart properly. Often outputs are in TEXT format and need to be converted using the DATEVALUE function.
- Date and Time fields are often separated into separate columns, and data is charted in 'blocks' where all data from one day is charted at the same point on the x-axis. In order to create a true 'continuous' record, Date and Time fields will need to be combined. If the original fields are formatted properly (DATEVALUE and TIMEVALUE) then it can be as simple as combining using a formula like: =A1+B1.
- The worst case scenario is that you must deconstruct a date into its parts and recombine/reformat using functions like: =LEFT(A2,3,1).
- Dataloggers do not automatically adjust for daylight savings time. Typically, the area 'synched' with the time of the computer launching it. When data records are being compared with metering for offsets, differences should be accounted for by adjusting the metering time to match the data record – if required. This must be



taken into consideration when combining discrete discharge measurements as well. Typically, daylight time is used since the open water season occurs during this time standard.

4 REFERENCES

Resources Information Standards Committee (RISC), 2009. Manual of British Columbia Hydrometric Standards. Province of British Columbia, Ministry of Environment, Science and Information Branch.

APPENDIX C: STANDARD OPERATING PROCEDURE - SURFACE WATER QUALITY SAMPLING



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Standard Operating Procedure

SOP: Surface Water Quality Sampling

Written by: Nesha Wright

Reviewed by: Andrew Gault

Date: August 2022

Updated November 2023

1 SURFACE WATER QUALITY SAMPLING

Ensero's field procedures for surface water sampling are based on generally accepted engineering principles, *Standard Methods for the Examination of Water and Wastewater* (Baird et al., 2017), which was co-produced by the American Public Health Association, the American Water Works Association, and the Water Environment Federations, *British Columbia Ministry of Environment and Climate Change's British Columbia Field Sampling Manual* (BC ENV, 2020) and *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment by Canadian Council of Ministers of the Environment* (CCME 2016).

1.1 APPLICABLE LEGISLATION

Surface water sampling methods are governed provincially within Canada. Therefore, the applicable legislations for each province or territory should be reviewed prior to initiating a program (see Table 1-1, below).

Table 1-1. Applicable legislation for surface sampling methods in Western Canada

Province/ Territory	Guidance
British Columbia	Field Sampling Manual

1.2 SURFACE WATER QUALITY COLLECTION

1.3 PREPARATION

A checklist should be developed prior to the sampling trip. The generic checklist should identify the following:

- Type and number of laboratory-supplied bottles and preservatives
- Field equipment such as meters (e.g., YSI multiparameter), sampling tools (e.g., multiple samplers, through ice samplers, Van Dorns, automatic composite samplers), and filtration apparatus (e.g., membrane filters and disposable luer-lok syringes)
- Nitril gloves
- Ice packs and coolers
- Field logbooks
- Personal protective equipment
- First aid kit
- Camera or video equipment as required
- GPS, maps, and communication devices as required
- Laboratory requisition forms

1.4 WATER QUALITY PARAMETERS

The following parameters should be collected for each sampling event:

- In-situ data from a calibrated multiparameter probe (e.g., YSI):
 - Temperature;
 - pH;
 - Specific conductance (SPC);
 - Dissolved oxygen (DO); and
 - Oxidation-reduction potential (ORP)
- Laboratory analyses:
 - pH, SPC, total dissolved solids (TDS), total suspended solids (TSS), hardness
 - Anion scan (chloride, fluoride, sulphate, nitrate, nitrite);
 - Alkalinity and acidity;
 - Ammonia;
 - Dissolved organic carbon (DOC);
 - Total and Weak Acid Dissociable (WAD) cyanide;
 - Total metals (including hardness and mercury); and
 - Dissolved metals (including hardness and mercury).

1.5 SAMPLING PROCEDURE

A multiparameter probe (e.g., YSI) should be calibrated according to the manufacturer's instructions daily before commencing sample collection. To avoid cross-contamination, new nitrile gloves should be worn at each sampling location and all sampling equipment should be cleaned using de-ionized water after collecting each sample.

Water quality data and relevant information collection comprise the following approaches:

- When field personnel must enter a stream to collect surface water samples in a water body with current, they should always start downstream and work upstream to avoid contaminating unsampled areas with river sediment disturbed by working in the river.
- Fieldnote should be taken for each sampling location, GPS coordinates, date and time, personnel, weather (e.g., sky cover, rain, overflow ice or heavy fog), and overall sampling condition. Any potential contamination sources should also be recorded (e.g., unusual winds, strange odours, murky water, and human error). A minimum of three photographs should be taken (upstream, across, and downstream) of the sampling location.
- Each sample should be collected from a section of the water way that is un-disturbed (human or natural influence), considered representative of the area (e. g., in the flow of the stream) and upstream from the sampler. When possible, samples will be taken upstream of infrastructure such as culverts and bridges.
- Obtaining a surface water sample comprises the following steps:
 1. Place the multiparameter probe in the water and turn it on. Take the in-situ measurements when the readings stabilize.
 2. Surface water should be collected manually by dipping a clean collection bottle without preservative into the water without disturbing sediments or vegetation. Ensure that while filling bottles from the body of water, the field personnel's hand should be downstream of the bottle opening.
 3. Surface water will then be placed into clean laboratory-supplied bottles according to their requirements (pre-labelled on the bottles):
 - a. Water for dissolved metal analysis will be extracted by a disposable syringe, injecting water through a 0.45 µm single use filter into a laboratory-supplied bottle, preserved with laboratory-supplied nitric acid.
 - b. Water for total metal analysis will be extracted by a disposable syringe, injecting water into a laboratory-supplied bottle, preserved with laboratory-supplied nitric acid.
 - c. Water for anion analysis will be extracted by a disposable syringe, injecting water through a 0.45 µm filter into a laboratory-supplied bottle. No preservative is needed.
 - d. Water for dissolved mercury analysis will be extracted by a disposable syringe, injecting water through a 0.45 µm single use filter into a laboratory-supplied bottle, preserved with laboratory-supplied hydrochloric acid. Samples collected for total mercury requires preservation but no filtration.
 4. Note that the filtration and preservation should be done immediately after collecting samples when possible. In cases where the immediate filtration and preservation are not achievable, these processes should be completed no more than 12 hours after collection.

5. All samples should be stored in a cooler with sufficient ice packs (twice the volume of ice packs to sample in the summer, one to one in the winter) to remain cold (~4°C) during sampling and during transport to the laboratory. Samples should be kept refrigerated when required.

A Chain of Custody form (COC) should be filled up prior to the shipment to the laboratory. All *insitu* and field notes must be uploaded to the online data base and a memo created within two weeks of completing the field work.

2 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Three types of additional samples should be collected for quality assurance and quality control (QA/QC):

- **Duplicate samples** are used to assess the precision of the sampling and analytical process. Duplicate samples should be collected at the same sampling point using the same sampling procedure as the original samples.
- **Trip blanks** are designed to detect widespread contamination from the containers, caps and preservative during transport and storage. A trip blank is provided by the analytical lab and is kept with the samples.
- **Field blanks** are designed inform on contamination resulting from the handling technique and through exposure to the atmosphere. Field blanks should be exposed to the sampling environment without contacting with ambient water. These samples are processed in the same manner as a field sample with the deionized water provided by the analytical laboratory. The site where the field blank is processed and the batch number of the deionized water should be documented.

3 PACKAGING AND SHIPPING

All samples should be packed in coolers with sufficient ice packs (twice the volume of ice packs to sample in the summer, one to one in the winter) to keep cold (~4°C) during sampling and during transport to the laboratory. Samples should be kept refrigerated when required. The bottle packages contain glass vials and may contain preservative; it is advisable to use the packaging provided by the laboratory to prevent bottles from breaking. Due to time sensitive analysis, it is advisable to contact the analytical laboratory and transportation services to arrange how samples are getting shipped out prior to starting field work.

REFERENCES

- Baird, R.B., Eaton, A.D. and Rice, E.W., Eds. (2017). *Standard Methods for the Examination of Water and Wastewater*. 23rd Edition, American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.
- British Columbia Ministry of Environment and Climate Change Strategy (BC ENV). 2020. Field Sampling Manual. British Columbia Ministry of Environment and Climate Change. <https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual>
- Canadian Council of Ministers of the Environment. (2016). Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment.

APPENDIX D: STANDARD OPERATING PROCEDURE – GROUNDWATER MONITORING



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Standard Operating Procedure

SOP: Groundwater Monitoring

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Reviewed by: Fred Marinelli

Date: April 15, 2021

Updated October 20, 2023

1 WELL PURGING PRIOR TO SAMPLING

This Standard Operating Procedure (SOP) discusses methods for purging a groundwater monitoring well prior to water sampling for chemical analysis. Procedures for taking and processing the water sample (filtering, bottle preparation, chain-of-custody, etc.) are discussed in a separate SOP.

1.1 APPLICABLE LEGISLATION

Groundwater purging and sampling methods are governed provincially within Canada. Therefore, the applicable legislations for each province or territory should be reviewed prior to initiating a program (see Table 1-1, below).

Table 1-1. Applicable legislation for groundwater sampling methods in Western Canada

Province/ Territory	Guidance
Yukon	Protocol No. 7: Groundwater Monitoring Well Installation, Sampling, and Decommissioning
British Columbia	Field Sampling Manual, Part E, Groundwater Pollution Monitoring

1.2 GROUNDWATER MONITORING WELLS

Groundwater monitoring wells are constructed by drilling and installing PVC pipe down a borehole. The bottom portion of the PVC is “slotted” or “screened” and this is where groundwater enters the well (referred to as the *screened section*, *slotted section*, or *screened interval*); the rest of the PVC is solid pipe (see Figure 1-1). Screened PVC is conventionally manufactured in 1.5 or 3 m lengths (5 ft or 10 ft), and the most common screened interval length is 1.5 or 3 m (5 ft or 10 ft). A filter (sand) pack is commonly placed in the annulus between the screen and borehole wall. In the annulus above the sand pack is a seal consisting of bentonite, cement grout, or both. A drilling completion log should show the well dimensions and depth ranges for blank PVC, slotted PVC, sand packs, and seals. Installation of groundwater monitoring wells is to occur as part of a drilling program, and it is typical for drilling contractors to perform the manual installations; a Qualified Professional (QP; i.e. professional hydrogeologist)

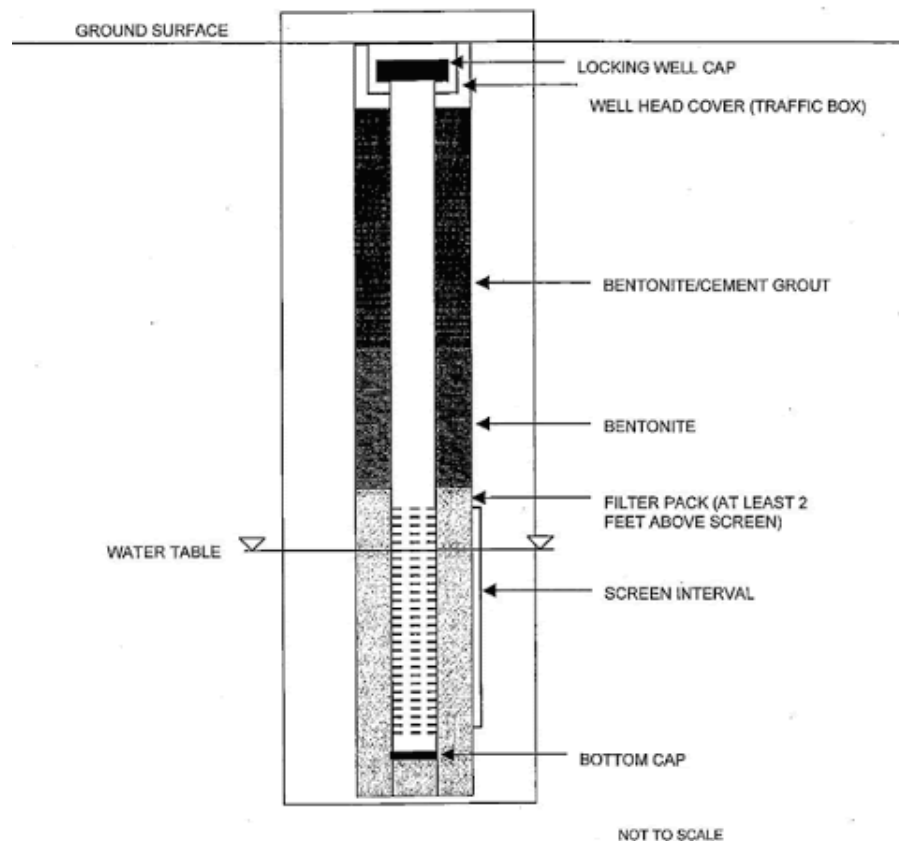


Figure 1-1: Typical groundwater monitoring well (Source: Hawaii State Dept of Health)

1.3 GROUNDWATER SAMPLING METHODS

This Standard Operating Procedure (SOP) discusses three approaches for preparing a groundwater well for water sampling: (1) Purge Sampling, (2) Low-Flow Sampling, and (3) Discrete Sampling. There are a variety of pumps that can be used depending on the well geometry and hydrologic conditions. Ensero prefers the use of Low-Flow sampling methods so as not to disturb the water column and bias the samples by remobilizing colloidal metals which are not dissolved. The Low-Flow Sampling method is also recommended when targeting hydrocarbon parameters (i.e., EPA, LEPH/HEPH, BTEX, VOC, PAH). When Low-Flow sampling is not possible due to water table depth or extreme winter conditions, Purge Sampling is an acceptable alternative. When neither Low-Flow nor Purge Sampling are possible, it is permissible to utilize Discrete Sampling methods to obtain a groundwater sample. Appropriate measures must be taken to prevent cross-contamination between groundwater monitoring wells and associated samples, such as: use of dedicated tubing, clean storage of well tubing, and decontamination of sampling and measurement equipment between monitoring wells.

The key objective is to collect a water sample that is representative of native groundwater and not consisting of previously stagnant water that was sitting in the well or well water otherwise affected by previous drilling and well completion activities. Parameters to be monitored and recorded during sampling to ensure stabilization is achieved include pH, specific conductance (SPC), dissolved oxygen (DO), oxidation-reduction potential (ORP), and total suspended solids (TSS). When key physical parameters stabilize, it is assumed that previously stagnant groundwater that has had time for gaseous exchange with the atmosphere has been removed and formation water is being drawn. Generally, three consecutive in-situ readings of pH within 0.1 standard unit, and SPC within $\pm 3\%$, DO within $\pm 10\%$, and ORP within $\pm 10\text{mV}$ are acceptably stable conditions, at which point sampling is permissible. In-situ readings are taken at regular intervals that are either time (i.e. every 5 minutes) or volume dependent (i.e. every half well holding volume).

1.3.1 LOW-FLOW SAMPLING METHOD

This groundwater sampling method is not typically used at Ensero project sites because our sampling programs seldom involve hydrocarbon analysis. This method may also be used for sampling organic compounds in low-producing monitoring wells.

For Low-Flow Sampling, a stiff suction tube (typically ¼-inch diameter plastic) is lowered into the screened interval and the pumping rate is sufficiently small to not create significant water-level drawdown (less than 30 cm) in the well. In-situ parameters are typically taken at a set frequency (e.g., every five minutes). When measuring in situ parameters, the depth to water should be measured at each reading interval. Purging should be continued until physical parameters stabilize as discussed in Section 1.2. Once stabilization of parameters is achieved, the low discharge from the peristaltic pump can be used to fill the sample bottles.

Pumps capable of supporting low-flow sample methods include submersible pumps, bladder pumps, and peristaltic pumps. See section 2, Equipment Considerations, below.

1.3.2 PURGE SAMPLING METHOD

Purging is the process of removing previously stagnant water from the well and replacing it with formation groundwater prior to sampling. The first step is to calculate the well volume (sometimes referred to as “holding volume”), which represents the volume of water inside the PVC pipe and in the adjacent sand pack or open annulus. A common rule of thumb is to remove a *minimum* of three well volumes prior to sampling, though purging may continue past three well volumes if in-situ parameters do not stabilize. If parameters do not stabilize after four well volumes, samples can be taken; however, further purging may be carried out at the discretion of the field technician.

It is good practice to measure in-situ parameters after each half well volume has been pumped. Once stable values for in-situ parameters are achieved for three consecutive readings, water samples can be collected from the pump discharge. If the well is low producing, the pump intake may be set within the screened section or near the bottom of the well, and pumping should lower the water level in the well to near the pump. If the well is high producing, the pump intake can be placed closer to the static water level to ensure that previously stagnant water above the screen is replaced with formation groundwater.

In some situations, a well may be pumped dry despite low pumping rates. If an adequately low pumping rate cannot be maintained without the well going dry, it is acceptable to purge the well dry and return within 24 hours to collect the sample. In-situ parameters of the recharge water should be measured at the time of sampling. In this situation, it is a good idea to prioritize the filling the sample bottles over taking the in-situ readings. In some cases, the sampling field crew may have to return to a well more than once if after purging dry there is not enough recharge water for a full sample suite. In this situation, the field technician should consult with the Project Manager to determine a sample priority list and fill bottles in the order of priority. Sometimes it might be necessary to fill each sample bottle to the minimum volume required as specified by the laboratory; see Table 1-1 for the most common hierarchy of groundwater sample collection, however consultation with the Project Management is always advised to confirm this hierarchy. Poor access may make returning to a well more than once time-consuming and therefore unreasonable.

Pumps capable of supporting purge sample methods include submersible pumps, inertial pumps, peristaltic pumps, and bailers. See section 2, Equipment Considerations, below.

1.3.2.1 WELL VOLUME CALCULATION

One well volume is calculated using the Water Level (DTW) and Well Depth (DTB) measurements. Subtracting the Water Level from the Well Depth gives the height of the water column in the well. The diameter of the well will determine the multiplier to apply to the height of the water column (Table 1-2). Information provided in Table 1-2 can also be found on the back side of the groundwater field data sheet (Figure 5-2).

Table 1-2: Well volume calculation parameters

Well Inner Diameter (mm)	25	32	51	78	100	150
Well Inner Diameter (in)	1	1.25	2	3	4	6
Volume (L/m of casing)	1	0.8	2	4.5	7.9	17.7

Example: A 2-inch well with a DTW of 12 m and DTB of 30 m has a estimated holding volume of 36 L calculated as follows:

- Height of water column is $30\text{ m} - 12\text{ m} = 18\text{ m}$
- Volume per meter of casing for a 2-inch well is **2 L/m**
- $18\text{ m} \times 2\text{ L/m} = 36\text{ L}$
- One well volume is 36 L, therefore three well volumes is **108 L**, the purge volume to aim for.

- In-situ parameters should be taken every half well volume (18 L) until a minimum of three well volumes has been purged AND parameters have stabilized. If parameters do not stabilize after 108 L of water was purged, the purge should continue up to four well volumes, or 144 L.
- A suitable equipment choice for this well would be the Waterra Power Pack or Waterra Hydro Lift pump. The Grundfos could also be used, but may be a less convenient option.

1.3.3 DISCRETE SAMPLING

Discrete Sampling refers to the collection of a groundwater sample directly from the screened interval of the water column; little or no purging nor the stabilization of in situ parameters is possible when utilizing this method. Discrete sampling methods are not widely accepted by the regulators in the Yukon and therefore should not be used unless there is an unusual field situation and the method is approved by the Project Manager and/or Technical Lead. There are rare instances where this method is permissible due to access/equipment issues, time constraints, or specification by the client. Examples of discrete samplers include Snap Samplers, Geoprobe Samplers, and HydraSleeve™.

1.4 SAMPLE PRESERVATION

Sample Preservation is necessary to maintain the natural chemistry of the groundwater samples, and to prevent further chemical reactions, sorption, or biological action from altering the sample post well extraction. Sample Preservation instructions and materials will be provided by the accredited laboratory and must be adhered to in the interest of maintenance of sample integrity.

2 EQUIPMENT CONSIDERATIONS

2.1 PUMPS

There are various pumps that can be used for well purging. The depth of the well, depth to water, and well yield usually determine the appropriate pump. Table 2 summarizes the pump types typically used for groundwater sampling.

Waterra plastic tubing deserves more detailed description as it is frequently used for Ensero groundwater monitoring programs. It can be ordered in 100, 200, and 500-foot rolls. The most commonly used size of Waterra tubing is 5/8-inch OD (“standard flow” tubing), but other sizes are commercially available. A Waterra footvalve (essentially a check valve) is required at the bottom end of the tubing in order for water to be pumped from the well. The D16 and D25 footvalves will fit the standard flow tubing. D16 footvalves are suitable for drivepoints or one-inch wells, and D25 footvalves are suitable for 2-inch wells. The basic idea is to rapidly lift and lower the tubing, so inertia moves the water column upward and the footvalve prevents water from draining out the tube. Lifting and lowering the tubing can be done by hand or with powered mechanical machines specifically designed for this purpose.

Table 2-1: Equipment details

Equipment	Operating Conditions	Notes
Waterra Power Pack (gasoline engine) Inertial pump	Uses Waterra tubing and footvalve (5/8" in OD or 1/2" in OD). Depth to water is less than 60 m.	Gas-powered engine. Max flow rate is dependent on DTB, DTW, etc.; flow rate decreases as depth to water increases. Flow rate goes to zero when depth to water exceeds 60 m. Applicable for Purge Sampling method.
Waterra Hydrolift (electric powered) Inertial pump	Uses Waterra tubing and footvalve (5/8" in OD or 1/2" in OD). Depth to water is less than 60 m	Requires 120 volt generator. Max flow rate is dependent on DTB, DTW, etc.; flow rate decreases as depth to water increases. Flow rate goes to zero when depth to water exceeds 60 m. Applicable for Purge Sampling method.
Grundfos Redi Flo 2 Electric submersible pump	Has built-in tubing on a reel. Depth to water is less than 80 m (when controller is at 400 Hz; this requires the 4000W generator).	Requires 120 volt generator and controller box. Known to be "finicky" and unreliable at low flow rates. Avoid pumping wells with high sediment/silt content as this can damage the pump (grit can damage the impeller). Max flow rate is 0.5 L/s; flow rate decreases as depth to water increases. Flow rate goes to zero when depth to water reaches 83 m. Applicable for Low-Flow and Purge sampling methods.
Geosub Electric submersible pump	Must connect tubing. Depth to water is less than 60m.	Requires 120 volt generator and controller box. Avoid pumping wells with high sediment/silt content as this can damage the pump (grit can damage the impeller). Max flow rate is 0.22 L/s; flow rate decreases as depth to water increases. Flow rate goes to zero when depth to water exceeds 60 m. Applicable for Low-Flow sampling method.
Waterra tubing Manual hand operated pump	Dependent upon the individual. Can use 5/8" in OD or 1/2" in OD tubing, but usually 5/8" tubing is preferred.	Suitable for purge volume less than 60 L and when depth to water is less than 30 m (but ultimately up to the field technician's discretion). Applicable for Purge and Sample method
Peristaltic Pump	Depth to water less than about 7 m. Maximum depth to water decreases at higher altitude.	120 volt AC and 12 volt DC models are available. Applicable for Low-Flow Sampling method.

Bailer Teflon, Stainless Steel, or PVC	Equivalent flow rate and volume dependent upon the individual and depth to water.	Use of a bailer is not preferred but is sometimes necessary when Waterra tubing cannot be used. Typically, bailers are used for shallow wells and purges under 30 L. Applicable for Purge Sample Method.
--	---	---

3 WINTER GROUNDWATER SAMPLING POINTERS

Cold winter conditions can complicate groundwater sampling. Some winter-related considerations are summarized below:

- Drain all pumping equipment as soon as possible after use.
- Drain Waterra tubing by feeding it upside down back into the well. Water left to freeze in Waterra tubing will render the tubing unusable for pumping.
- It may be necessary to fill a large bottle with pumped well water and process the sample at the hotel/camp before it freezes.
- During transport between sites on a snowmobile, one can wrap the pump and other equipment in an insulated tarp or in an electric blanket with the generator running.
- Consider setting up a double sized ice fishing tent with a space heater to prevent equipment from freezing.

4 USEFUL TERMS

Drivepoint: A small diameter well, usually steel but sometimes PVC. Drivepoints do not have an outer casing like traditional monitoring wells, and they are driven into the ground by hand.

Frost Jacking: Impact of permafrost causing either the steel casing around the PVC to settle, or the PVC to jack up higher than the cap of the steel well casing. This could sometimes make it difficult or impossible to open/close the steel casing of the well.

Head: Can be synonymous with Water Column, but usually refers more to pressure created by the height of the water column.

Hydraulic lift: The distance from the top of the water column to the pump or ground level.

Geodetic groundwater level: The groundwater level in meters above mean sea level (m amsl). Calculated by subtracting the measured DTW from top of casing (TOC) from the surveyed elevation in m amsl of the TOC.

Water Column: The height of water in the well, i.e. DTW minus DTB.

5 DOCUMENTATION

Depth to water measurements should be referenced to a permanent measuring point as shown on Figure 2. This is typically a black mark at the top of the PVC pipe. The field notes should indicate that this is depth to water below top of casing (TOC).



Figure 5-1: Top of Casing

The Ensero Groundwater field data sheet is shown on Figure 5-2. Please ensure all fields data are filled out. Some considerations are summarized below:

- Depth to water and well depth are to be measured as vertical distance below TOC. Do not cut or otherwise change the top of casing measuring point. If for some reason, some of the PVC needs to be cut, accurately document the length of pipe removed and establish a new measuring point with a black mark.
- Well stick-up height is the measured vertical distance from the base of the well at ground level to the TOC.
- Record the temperature and precipitation (if any) as rain or snow can affect the quality of the sample.
- The seal refers the ground around the well casing.

Figure 5-2: Front Page of Ensero Groundwater Field Data Sheet

Figure 5-3: Back Page of Ensero GW Field Data Sheet

6 GROUNDWATER PACKING LIST

6.1 BASICS

- Knife or tube cutters
- Multitool
- Tape (electrical, tuck tape)
- Field data sheets, field book
- Pencils
- Sharpies
- PPE (nitrile gloves, vest, steel-toe boots, hard hat)

6.2 DATA COLLECTION

- Water level meter (30 m, 100 m, skinny tape)
- Tag line
- 20L graduated bucket
- Vice grips (optional, to hold tubing to the bucket)
- Sample bottles
- Spare 500 mL wide mouth bottles (winter)
- Measuring tape (to measure stick-up)
- Waterra tubing (5/8" or 1/2")
- Waterra footvalves (D25 for 2-inch wells, D16 for 1-inch wells)
- High turbidity filters (Waterra FHT-45)
- Syringes and 0.45 µm filters
- YSI multimeter and probes
 - Calibration solution for longer trips, storage solution for probes

6.3 PUMP

6.3.1 POWER PACK

- Waterra tubing
- Jerry can and extra gasoline
- Ratchet straps
- Hearing protection

6.3.2 HYDROLIFT

- Waterra tubing
- Jerry can and extra gasoline
- Ratchet straps

6.3.3 GRUNDFOS

- Generator (4000W preferred)
- Jerry can and extra gasoline
- Controller box
- Happy Hose

6.3.4 GEOSUB

- Generator (4000W preferred)
- Jerry can and extra gasoline
- Controller box
- ½" tubing (until we put Geosub on a reel you will need to bring your own tubing)

6.3.5 PERISTALTIC

- ¼" tubing
- 12V battery

6.3.6 OTHER

- Turbidity meter
- Sulfide test kit

REFERENCES

- British Columbia Ministry of the Environment (BC MOE). 2013. *B.C. Field Sampling Manual, Part E, Groundwater Pollution Monitoring*. https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/bc_field_sampling_manual_part_e.pdf.
- Yukon Environment. 2017. *Protocol No. 7: Groundwater Monitoring Well Installation, Sampling, and Decommissioning*. <https://yukon.ca/sites/yukon.ca/files/env/env-protocol-7.pdf>.

APPENDIX E:

INVASIVE SPECIES MANAGEMENT PLAN



KUDZ ZE KAYAH PROJECT

INVASIVE SPECIES MANAGEMENT PLAN

Rev 01

February 2024

BMC MINERALS LTD.

DISCLAIMER

This Management Plan has been developed to meet the appropriate subject objectives based on current regulatory requirements, current or planned site activities, existing and expected site conditions, and designed outcomes. Operational processes/practices for achievement of licence terms and conditions may be updated from time to time as appropriate due to changes to site activities or conditions, differences from expected objective achievement, or improvement of management practices. All rates, capacities, dimensions, weights, volumes and durations in text or figures are based on current feasibility level designs and are subject to change based on final design, licence conditions or site conditions encountered. Updates will be resubmitted to government authorities and/or stakeholders as required.

LIST OF REVISIONS

Issue Date	Revision Number	Description of Revision
October, 2015	Rev 00	Prepared by Access Consulting Group and issued to BMC
February, 2024	Rev 01	Updated by BMC for incorporation into the Environmental Monitoring, Surveillance and Reporting Plan

LIST OF ACRONYMS AND ABBREVIATIONS

cm	centimetre
ISMP	Invasive Species Management Plan
KZK	Kudz Ze Kayah
mm	millimetre
YISC	Yukon Invasive Species Council

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APPENDIX C: AQUATIC INVASIVE SPECIES OBSERVATION FORM

1 INTRODUCTION

The Invasive Species Management Plan (ISMP) has been developed to define a protocol for identifying, preventing and/or controlling the spread of invasive species, and monitoring and evaluating the success of control methods during the undertaking of the Kudz Ze Kayah (KZK) Project. The Project is located approximately 260 km northwest of Watson Lake, 115 km southeast of Ross River, and 24 km south of the Robert Campbell Highway near Finlayson Lake, Yukon (Figure 1-1).

The Yukon Invasive Species Council (YISC) defines an invasive species as, “a species of plant, animal, aquatic life or micro-organism that is not native (to Yukon/an ecosystem) and whose introduction or spread is likely to have net negative effects on our society, our economy, our environment, or our health” (YISC, 2023).

The primary goal of this plan is to provide management techniques to prevent invasive species infestations at disturbed sites in the Project area.

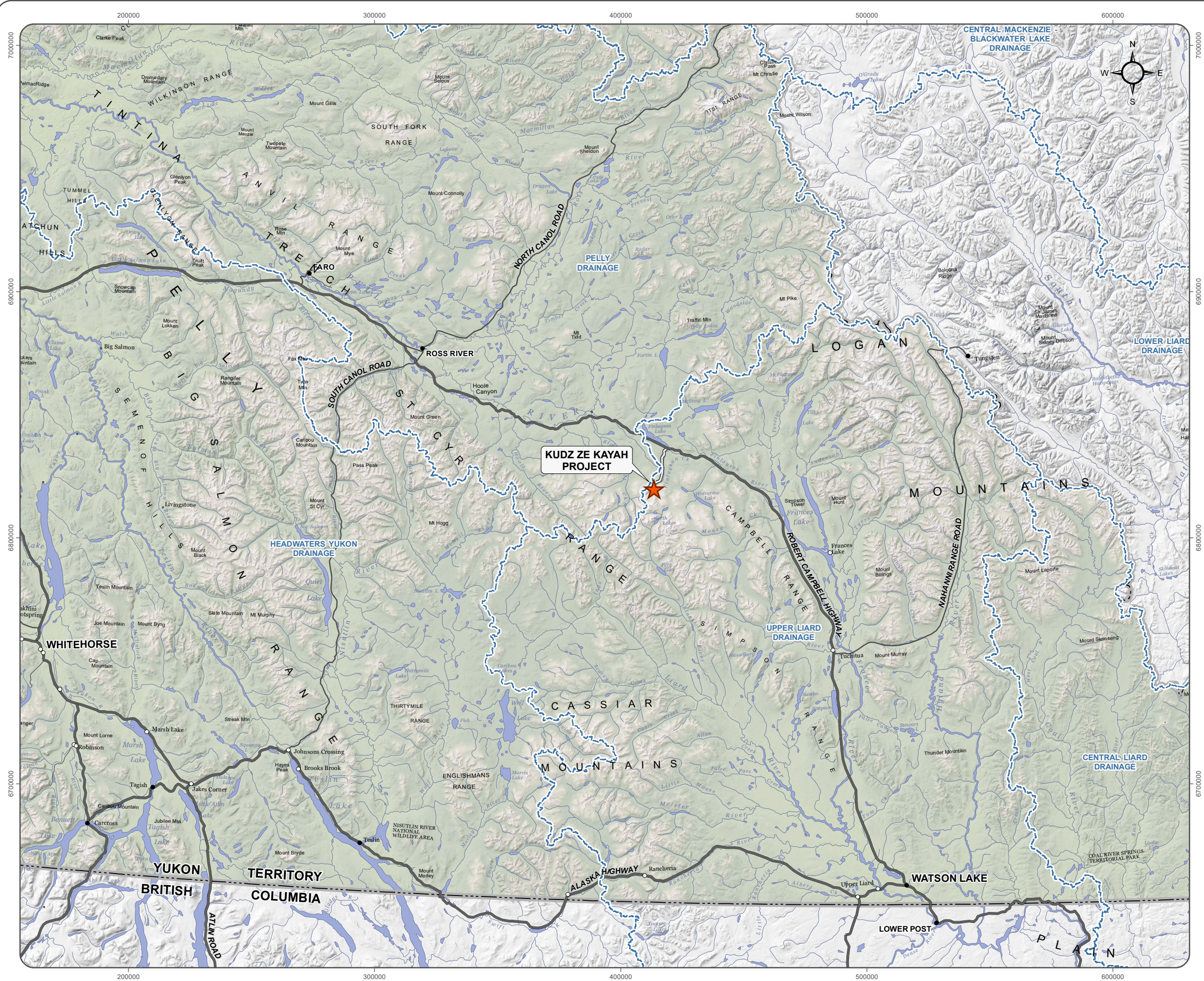
1.1 OBJECTIVES

The objectives of the ISMP are:

- Provide information on the invasive species that have been documented within the Project area, as a basis for management activities;
- Provide information on invasive species present in Yukon that have the potential to be transported to site;
- Provide management practices for preventing and/or minimizing the colonization and spread of invasive species;
- Outline monitoring strategies for evaluating prevention and control success in the future; and,
- Be adaptable to the different phases of the Project.

1.2 RELEVANT LEGISLATION

Currently, Yukon does not have specific legislation regarding invasive species management; however, re-vegetation requirements do exist for sites disturbed during natural resource extraction under the *Quartz Mining Act* (2003), the *Placer Mining Act* (2003) and under the Land Use Regulations (C. 17) of the *Territorial Lands (Yukon) Act* (2003). These regulations require vegetated areas disturbed by operational activities to be returned to a state that either allows re-vegetation by native plants or the site should be left in a state that closely resembles the pre-disturbance conditions. Therefore, invasive plants should be managed in order that appropriate revegetation can take place during site closure.

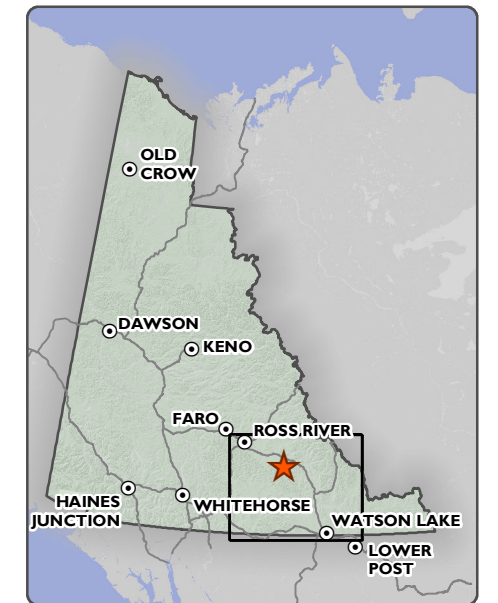


KUDZ ZE KAYAH PROJECT

FIGURE 1-1

PROJECT LOCATION

MAY 2023



 KUDZ ZE KAYAH PROJECT



Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 1:50,000. Reproduced under license from Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada. All rights reserved. Drainage areas obtained from National Hydrology Network 2011

Datum: NAD 83; Projection UTM Zone 9N

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1:1,500,000 when printed on 11 x 17 inch paper



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(Last edited by: bprince, 4/13/2022/12:14 PM)

2 SPECIES IDENTIFIED

There have been nine invasive plant species and six plant species that can easily be mistaken for invasive species identified within the Project area. The following sections provide descriptions of these species.

No invasive animals, aquatic species or micro-organisms have been identified within the Project area.

2.1 INVASIVE PLANT SPECIES

2.1.1 Smooth Brome (*Bromus inermis*)

Yukon Invasive Species Council invasiveness rank: 1 (may displace or replace native ecosystems) (Bennett, 2011).

Smooth brome (Figure 2-1) was introduced to Canada from Eastern Europe and has been used extensively in pastures, and hayfields and seeded in roadside ditches in the last hundred years. It is a vigorous plant producing abundant forage and out-competes native species by growing earlier in the spring, growing tall stems that shade native plants, and by spreading via dense mats of rhizomes. Smooth brome is a perennial grass, 20–150 cm tall, and usually appears in loose clumps. It has green to purplish flowers and blooms June to September (Reaume, 2011).

Smooth brome may alter resource conditions and competitive interactions in plant communities where it invades and this may then have potential cascading effects. Smooth brome could facilitate invasion by other species, and more importantly, it could enhance their competitive ability under field conditions, creating higher threats to biodiversity (Bennett et al., 2014).



Smooth brome (*Bromus inermis*) growing in the field, and an individual sample for identification purposes.

Figure 2-1: Smooth Brome

2.1.2 Oxeye Daisy (*Leucanthemum vulgare*)

Yukon Invasive Species Council invasiveness rank: 1 (Bennett, 2011)

Often cultivated in gardens as a “wildflower”, this non-native is an aggressive invader. Oxeye daisy (Figure 2-2) is a perennial that spreads primarily by seed, but also by shallow, creeping roots (rhizomes). Individual plants can produce over 500 seeds that are viable in the soil for two to three years or more. The greatest impact of oxeye daisy is on forage production in pastures and meadows. Dense stands of oxeye daisy can decrease plant diversity and increase the amount of bare soil in an area.



Figure 2-2: Oxeye Daisy

2.1.3 Narrowleaf Hawksbeard (*Crepis tectorum*)

Yukon Invasive Species Council invasiveness rank: 1 (Bennett, 2011).

Narrowleaf hawksbeard (Figure 2-3) occurs throughout Yukon along all the major highways (YISC, 2010). Hawksbeard only reproduces by seed, but each plant is capable of producing up to 50,000 seeds. The plant will therefore displace native colonizers and competes with hay crops and, once established, is hard to remove.

The yellow flower heads are numerous with green bracts arranged in two distinctive rows. Stems are single, sometimes branched, rising from a small taproot, growing to 20 – 60 cm or taller. Lower leaves are lanceolate, stem leaves decrease in size and mostly linear on the upper portion of the stem (YISC, 2010).



Figure 2-3: Narrowleaf Hawksbeard

2.1.4 White sweetclover (*Melilotus officinalis*)

Yukon Invasive Species Council invasiveness rank: 1 (Bennett, 2011)

A member of the pea family, white or yellow sweetclover is a well known invasive plant in the Yukon. It has become a serious problem along roadsides where it attracts animals and hides them from view. The cost of mowing and treating roadsides infested with this plant is mounting yearly. Sweetclover may also invade natural riverside gravel bars throughout Alaska and Yukon and displace native vegetation and wildlife habitats, as well as cause problems for river recreation.

Once established, the plants are tricky to control as one plant is capable of producing over 300,000 seeds per year and these may remain viable in the soil for many years (80% viable after 30 years).



Figure 2-4: White Sweetclover

2.1.5 Perennial ryegrass (*Lolium perenne*)

Yukon Invasive Species Council invasiveness rank: 2 (aggressive, widespread, persistent, but may not replace native species or change ecosystem function) (Bennett, 2011).

Perennial ryegrass (Figure 2-5) has been a common forage grass for hundreds of years and has recently become a widely-planted turfgrass in the Pacific Northwest (USDA NRCS, 2002).

It grows erect to about 0.9 m tall. Stems grow singly or in clumps and are rounded to slightly flatten in cross-section. Leaf blades are flat, glossy and generally hairless, leaves are usually folded in the bud. Flowering takes place from May through September. The flower head is 8–30 cm long. It consists of small, spikelets that are spaced apart along the main flowering stem and are alternate to one another. Occasionally spikelets branch off the main axis (USDA NRCS, 2002).



Figure 2-5: Perennial Ryegrass

2.1.6 Alsike clover (*Trifolium hybridum*)

Yukon Invasive Species Council invasiveness rank: 2 (Bennett, 2011).

Alsike clover (Figure 2-6) was introduced from Europe and is used agriculturally as a pasture, hay or silage crop, and is also planted to prevent erosion (NatureServe, 2015; USDA NRCS, 2008). It grows in wet or acidic conditions, is well adapted to a range of soil types and grows well in northern latitudes at high elevations (NatureServe, 2015). The plant spreads by seed and under ideal conditions, seeds last up to six years in the soil (NatureServe, 2015).

Alsike clover is not native to the Yukon and as with timothy, it was found at 10% of sites surveyed in a 2007 roadside invasive plant survey (Line et al., 2008). Because it is a nitrogen fixing species, the presence of alsike clover will alter the plant community composition, as well as provide early spring forage for herbivorous wildlife (NatureServe, 2015; USDA NRCS, 2008). It will also form dominant stands and exclude native vegetation (UAA, 2011a).

It is a perennial plant growing 15 to 20 cm tall with stems that are ascending to erect. The leaves are typical of clover: trifoliate, smooth and each leaflet is oval or elliptical. Flower heads have 30 to 50 white to pink flowers about 6 to 11 mm long that bend down after pollination and turn brown with maturity (UAA, 2011a; USDA NRCS, 2008).

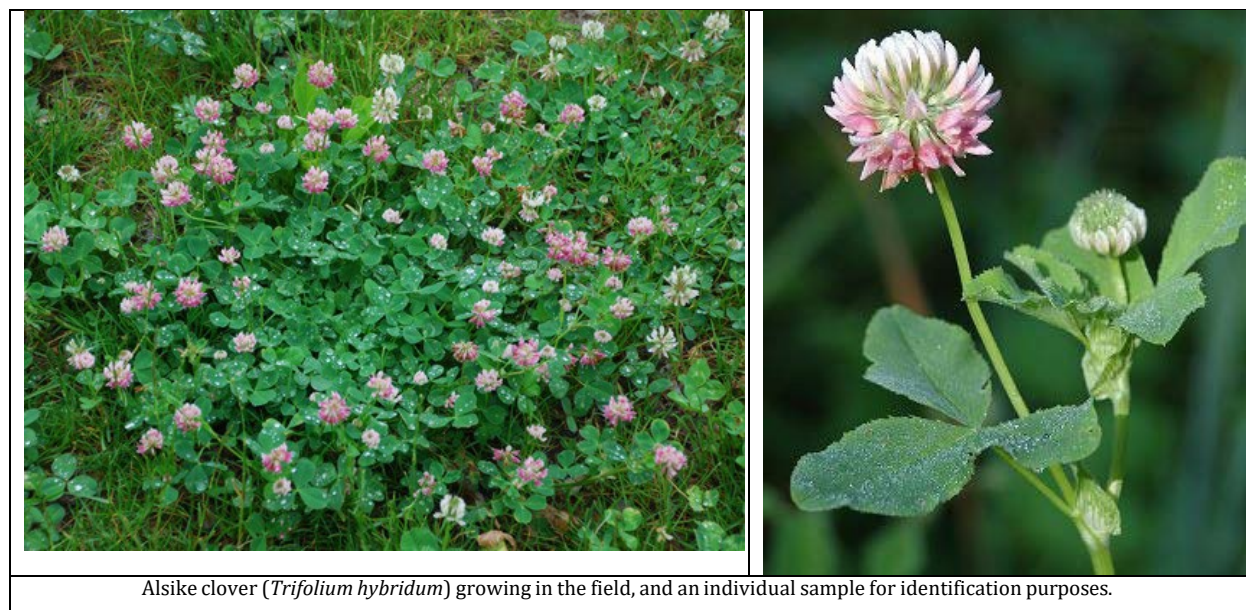


Figure 2-6: Alsike Clover

2.1.7 Pineapple-weed (*Matricaria discoidea*)

Yukon Invasive Species Council invasiveness rank: 3 (taxa present in Yukon, not known to be invasive here, but have been found to be invasive in other jurisdictions) (Bennett, 2011).

This weed (Figure 2-7) is native to the Pacific coast and is now widely distributed in North America. Pineapple-weed is a summer or winter annual that reproduces by seed and seeds germinate from early spring to early fall. This species tolerates compact soil and mowing (Berry and Coop, 2000).

The plants are 5 to 40 cm tall, bushy with finely divided leaves. Mature plants have elongated branching stems with alternate leaves. Flowers are present from May to September and are yellow-green, rounded or conical shaped. The crushed leaves have a pineapple scent.



Figure 2-7: Pineapple-weed

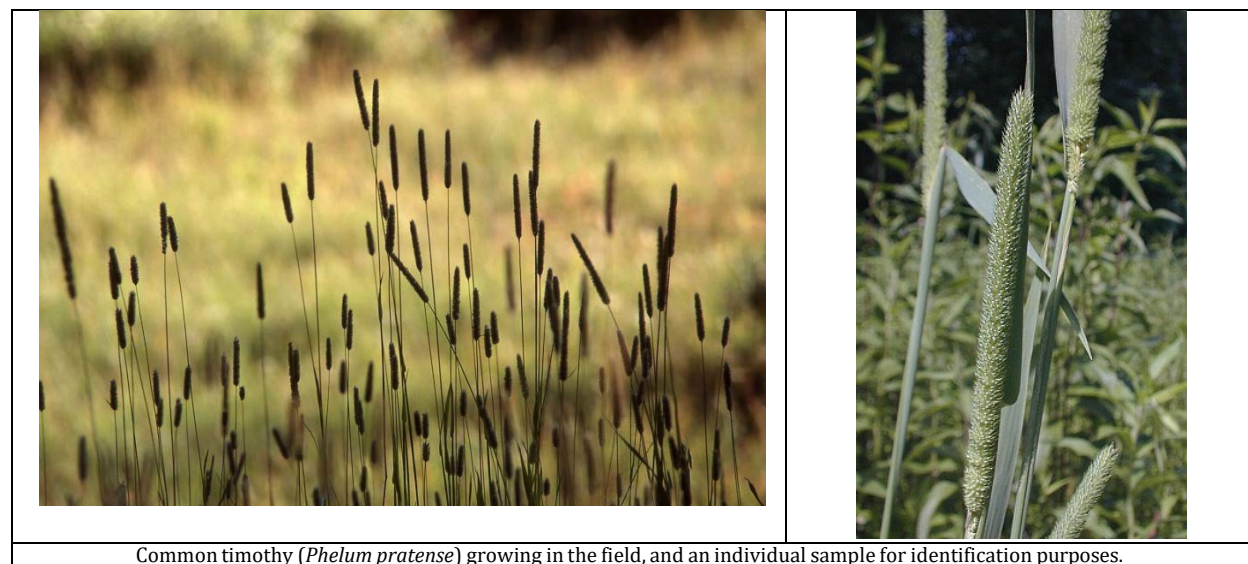
2.1.8 Common timothy (*Phelum pratense*)

Yukon Invasive Species Council invasiveness rank: 4 (has been reported in the territory, has not been shown to be problematic, may not persist) (Bennett, 2011).

Common timothy (Figure 2-8) is an agricultural species of perennial bunchgrass introduced from Eurasia and inhabits mesic fields, roadsides, waste areas and disturbed sites (Klinkenberg, 2015b). It is well adapted to cool areas and high elevations (USDA NRCS, 2011). Timothy spreads via seed distribution and seeds can remain viable in the soil for up to five years (USDA NRCS, 2011).

Timothy is considered a non-native, or exotic, plant by YISC and was found at 10% of sites surveyed in a 2007 roadside invasive plant survey (Line et al., 2008). Because timothy was historically used as a reclamation species in the Yukon, it is not considered invasive in the territory. However, it can spread into native vegetation communities under ideal conditions and exist as a monoculture (USDA NRCS, 2011). Seedlings can prevent the establishment of conifer seedlings and increase fire hazards (UAA, 2011c).

Timothy has erect, tufted stems, purple or brown at the base, and growing up to 100 cm tall in clumps from fibrous roots (Klinkenberg, 2015b; UAA, 2011c). Leaves are short with smooth sheaths, flat blades 4-8 mm wide with rough margins. Flowers are yellow on a slender cylindrical inflorescence 4-11 cm long and less than 1 cm wide resembling a small cat-tail and giving rise to one of its common names, meadow cat's-tail (UAA, 2011c; USDA NRCS, 2011).



Common timothy (*Phelum pratense*) growing in the field, and an individual sample for identification purposes.

Figure 2-8: Common Timothy

2.2 NATIVE PLANTS COMMONLY MISTAKEN AS INVASIVE

2.2.1 Foxtail barley (*Hordeum jubatum*)

Considered noxious native species as its upward pointing barbs on the bristles can cause injury to grazing animals, particularly their mouth, throat and eyes. Best to manage as it can colonize disturbed areas quickly.

Foxtail barley (Figure 2-9) is an annual or perennial grass that is considered a native species in Yukon. It is, however, opportunistic and spreading rapidly across Yukon landscape, both along roads and in agricultural situations. The Yukon public has voiced concern about this plant due to its socio-economic impacts: it is harmful to livestock and horses due to its sharp awns, it reduces crop yields and it forms monocultures in once-diverse native ecosystems. Each plant can produce over 150 seeds, which may remain viable in the soil for over a year (UAA, 2011b). A strategy for managing this species is in demand in Yukon and thus it should be part of an invasive species monitoring program (Line et al., 2008).

The plant grows 30 to 60 cm tall and has gray-green, rough leaves, 2 to 3 mm wide. The spikes are nodding, pale green to purple, and bushy. At maturity, spikes fade to a tawny color and become very brittle. Each seed has 4 to 8 awns and sharp, backward-pointing barbs (UAA, 2011b).



Figure 2-9: Foxtail Barley

2.2.2 Bitter fleabane (*Erigeron acris*)

Bitter fleabane (Figure 2-10) is a native pioneer species that often colonizes disturbed areas such as pastures, abandoned fields, vacant lots, roadsides, railways, and waste areas. In these habitats it competes, often successfully, with introduced invasive weeds.

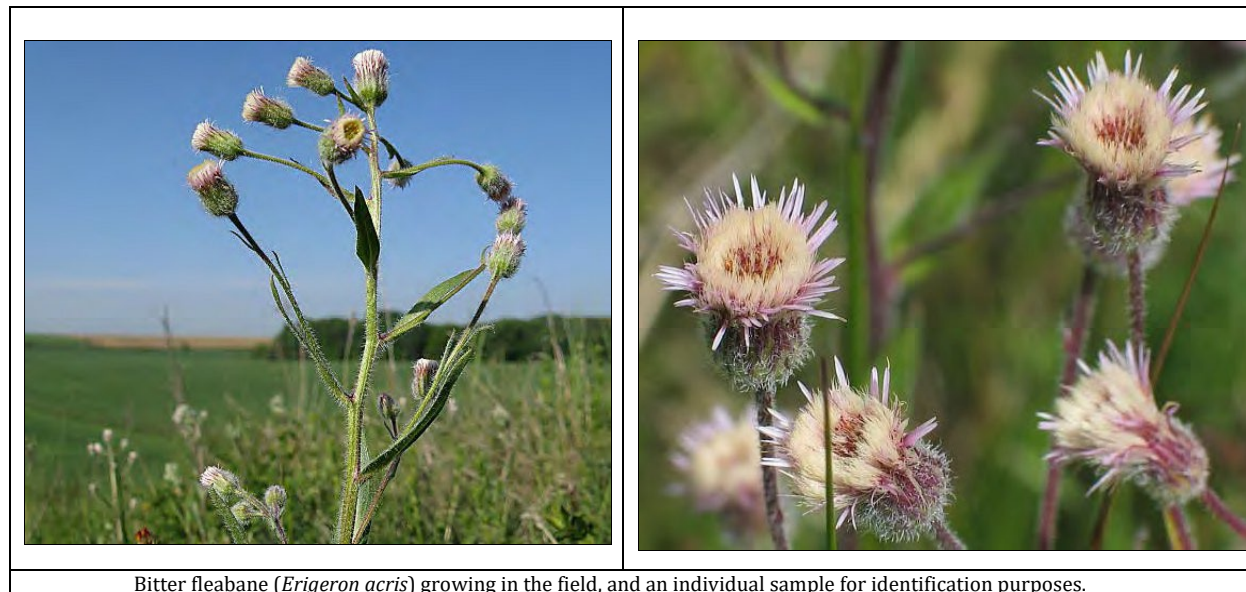


Figure 2-10: Bitter Fleabane

2.2.3 Horned Dandelion (*Taraxacum ceratophorum*)

The horned dandelion (Figure 2-11) is native to North America and often found in alpine environments. It is a perennial herb and grows from a simple or branched stem-base and a thick, often black, taproot; stems ascending to erect, solitary to several, simple, hollow, glabrous or sparsely long-hairy, exuding milky juice when broken, 3-60 cm tall. Basal leaves lanceolate to oblanceolate, 1-35 cm long, 0.3-6 cm wide, tapering basally to a more or less winged stalk, nearly entire to toothed or more often pinnately lobed to pinnately cut, the terminal lobe often wider than the others, Heads with yellow strap-shaped flowers, solitary; involucre 7-22 mm tall; involucre bracts in 2 series, the outer ones egg-shaped to lanceolate, appressed to ascending, glabrous or long-hairy, the inner ones lance-oblong, long-pointed, usually horned at the tips, rarely only slightly so; ray flowers yellow, sometimes purple-veined; disk flowers lacking (Klinkenberg, 2015c). Best to manage as it can colonize disturbed areas quickly.

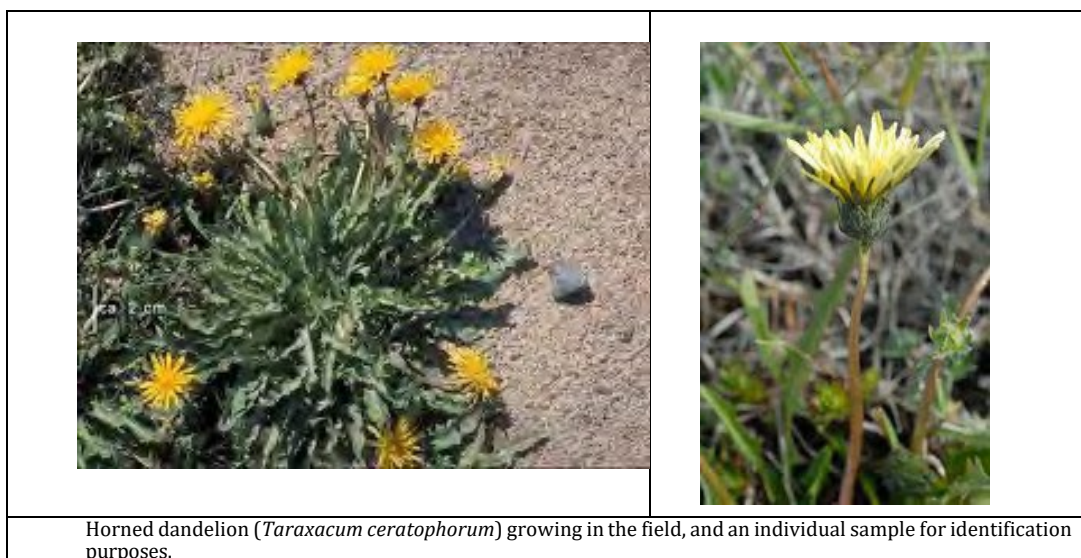


Figure 2-11: Horned Dandelion

3 INVASIVE SPECIES MANAGEMENT AND CONTROL METHODS

This section describes the invasive species management methods BMC will undertake for Project. The methods presented have been developed for the Project activities and known environmental conditions. These are broad management techniques that can be adapted to the various areas within the project area and activities taking place.

The approach integrates various methods of invasive plant control across the life cycle of the project and consists of the following components:

- Identification and understanding of invasive species;
- Prevention of invasive infestations;
- Control methods and implementation; and,
- Monitoring and evaluation of control strategies.

3.1 IDENTIFICATION AND UNDERSTANDING OF INVASIVE SPECIES

3.1.1 Invasive Plant Species

Invasive plants species are plants that spread extensively and rapidly and, by virtue of some unique attribute, are undesirable (e.g., noxious to wildlife) and very difficult to control. Invasive species are a concern for land and resource managers throughout Canada, including the Yukon. During development, native plant communities are often removed and soils are often exposed resulting in competition between native species and invasive plants, which are adept at exploiting disturbed areas to flourish. The vehicular traffic usually associated with resource development also serves to transport invasive plant material and seeds from other areas.

Invasive plants and animals are the second greatest threat to biodiversity after habitat loss (IUCN, 2011). In other North American jurisdictions many invasive plants are responsible for habitat damage, loss of subsistence resources, and economic growth. However, not all introduced plant species are invasive.

The advancement of invasive plants onto the Project site and Tote Road is dependent on many factors, including distance from seed sources, frequency and type of transport vectors, extent of soil disturbance, solar exposure, and climate variability. An understanding of these factors and how they affect invasive plant advancement is as important as being able to identify invasive species. Additionally, some invasive plants can be confused with native plants and vice versa, so identification training for on-site Environmental Monitors and appropriate staff will be conducted.

The Yukon Invasive Species Council (YISC) has created a series of educational posters featuring 21 of the more aggressive invasive plants found in the Yukon. These can be downloaded from the YISC website: <https://www.yukoninvasives.com/invasive-species/plants> (YISC, 2024a) and are included in Appendix A. The plant species are ranked in order of invasiveness as provided by the YISC and

provide a brief description, range, comparison to similar plants, ecological impact and control methods for each invasive plant. These 20 aggressive invasive species are of the greatest concern and will be considered a management priority. The plants listed in Table 3-1 below are key species of note for the Project area. Another source of information is a pamphlet called “Why Should I Care About Invasive Species?” (<https://www.yukoninvasives.com/~documents/resources/brochures/why-should-i-care-about-invasive-species/?layout=default>). This pamphlet was developed by the YISC to explain the challenges that invasive species pose in the Yukon.

Table 3-1: Most Aggressive Invasive Plant Species Known in the Yukon

Most Aggressive Invasive Plant Species Known in the Yukon	
Altai Wild Rye: <i>Leymus angustus</i>	Narrowleaf Hawksbeard <i>Crepis tectorum</i> *
Bird Vetch <i>Vicia cracca</i>	Oxeye Daisy <i>Leucanthemum vulgare</i> *
Common Tansy <i>Tanacetum vulgare</i>	Orange Hawkweed <i>Hieracium aurantiacum</i>
Creeping Thistle <i>Cirsium arvense</i>	Perennial Sow Thistle <i>Sonchus arvensis</i>
Crested Wheat Grass <i>Agropyron pectiniforme</i>	Quackgrass <i>Elymus repens</i>
Dalmatian Toadflax <i>Linaria dalmatica</i>	Reed Canary Grass <i>Phalaris arundinacea</i>
Greater Butter and Eggs : <i>Linaria vulgaris</i>	Scentless Chamomile <i>Tripleurospermum inodorum</i>
Leavy Spurge <i>Euphorbia esula</i>	Smooth Brome <i>Bromus inermis</i> *
Lucerne <i>Medicago falcata</i>	Spotted Knapweed <i>Centaurea stoebe</i>
Tall Hawkweed <i>Hieracium piloselloides</i>	White* and Yellow Sweet clover <i>Melilotus albus</i> (white) <i>Melilotus officinalis</i> (yellow)

* Smooth brome, narrow-leaf hawksbeard, oxeye daisy and white sweetclover have been identified in the Project area.

Education and understanding of invasive plants are key to preventing the colonization and spread of these plants in any area. KZK personnel tasked with invasive plants management will be trained in recognizing and controlling invasive plants. It will be required that these individuals have a clear understanding of what plants to look for, how to control the invasive plant, and which species are native or beneficial.

BMC will ensure employees are briefed on invasive plants during orientation. A resource binder will be maintained by the BMC Environmental Site Manager which will contain educational resources to be reviewed annually by staff. It will also include current information on invasive species at the Project and their management status.

Additionally, posters will be posted in the camp area of the invasive plants identified in the Project area and of other species that could be present. This will aid in quick identification of invasive plants.

3.1.2 Aquatic Invasive Species

Most Yukon lakes and waterways appear to be free of invasive species (Yukon Government, 2024) and no aquatic invasive species have been identified within Project area. However, aquatic invasive species can cling to boats, fishing gear, footwear and unknowingly be transported from one area to another. The following resources will be used to assist with training, monitoring and management of invasive aquatic species:

- Yukon Government (2024) has created a web site that contains information about aquatic species and how to identify them and manage them (<https://yukon.ca/en/aquatic-invasive-species/>);
- Yukon Government has also published a document entitled: Development of a Framework for Management of Aquatic Invasive Species of Concern for Yukon (Lueng and Von Finster, 2016);
- YISC has also created a series of educational documents related to aquatics species (<https://www.yukoninvasives.com/invasive-species/aquatic-invasive-species/>) (YISC 2024b); and
- The resource binder (described above) will contain educational resources on aquatic invasive species.

3.2 PREVENTION

Prevention is the most cost-effective form of invasive species management. Key prevention measures that will help prevent or minimize the introduction of invasives into the Project area are:

- Cleaning equipment (at its point of shipment) before transport to site;
- Environmental staff will inspect all equipment to ensure that it is free of soil and vegetation during unloading;
- Inspection results will be documented on an equipment inspection form;
- Contaminated equipment will either be rejected or cleaned, and any material that may contain invasive species will be properly disposed;
- Progressive reclamation to re-establish native vegetation over cleared areas.
- Unloading equipment away from watercourses;
- BMC has a dedicated clean boat on-site that is planned to be used for the duration of the Project; and
- Cleaning all fish and aquatics monitoring equipment between monitoring stations.

Key measures are discussed in the following subsections while monitoring considerations are addressed in Section 3.4.

3.2.1 Vehicle and Equipment Inspection Station

Some Project activities (e.g., clearing) will increase exposure in new areas to the introduction of invasive plants. Vehicles and equipment brought onto the site may carry seeds or plant material of undesirable plant species that could become established, creating local invasive plant seed sources.

To manage the transport of invasive plants and seeds to the Project area, BMC will ensure that equipment and personnel clothing/boots are free of plants and seeds prior to entering the BMC property. Seeds carried by vehicles and on boots or clothing can inadvertently be deposited and germinate. Disturbed, cleared areas, such as roadsides and around the camp, are particularly vulnerable as invasive plants do not have to compete with native plants for growth factors (nutrients, moisture and sunlight). Such areas are generally where people and vehicles first stop upon arriving at site.

To avoid the inadvertent deposition of foreign soils or plant materials from other locations and reduce the risk of introducing invasive plants to vulnerable disturbed areas, BMC will establish a vehicle check station at the gate house entrance to the Access Road. Vehicle and equipment inspections for invasive plant materials will include a visual check of tires, wheel wells, mud flaps and undercarriage where plant and soils may have collected. Personnel arriving at site will be instructed to perform a visual check of their clothing and footwear for plant materials and large clumps of soil that may contain seeds.

Information on invasive species (including aquatic species) will be posted at the vehicle check station, as well as instructions on how to conduct a visual inspection, and instructions for proper disposal of any invasive plant contaminated material found. A disposal bin will be provided as part of the station for disposal of invasive plant materials. Any equipment with signs of aquatic invasive species will not be permitted on site nor disposed of at the disposal station.

3.2.2 Progressive Revegetation

Revegetation of disturbed areas with appropriate species stabilizes soils that have been exposed, serving to reduce both erosion and sedimentation potential, and to lessen the risk of invasive plant colonization. Areas disturbed during road development, exploration and mine development will be revegetated as soon as possible using native grass seed mix to provide cover that will compete with invasive plants.

To date two types of seed mixtures have been used at the Project (Table 3-2): a dry area mix and a wet area mix. This list will be expanded and/or updated to include additional site-specific native plants in consultation with Kaska and as more information becomes available from the ongoing revegetation research programs at site.

Table 3-2: Seed Mixture used for Reclamation

Dry Area Seed Mix (2015)	Dry Area Mix (2016)	Dry Area Mix (2017 onwards)	Wet Area Seed Mix (2015 onwards)
37% Violet Wheatgrass (<i>Elymus violaceus</i>)	37 % Slender Wheatgrass (<i>Elymus trachycaulus</i>)	37% Slender Wheatgrass	40% Violet Wheatgrass
25% Rough Fescue (<i>Festuca altaica</i>)	25% Rough Fescue	15% Ticklegrass (<i>Agrostis scabra</i>)	33% Fowl Bluegrass (<i>Poa palustris</i>)
25% Rocky Mountain Fescue (<i>Festuca saximontana</i>)	25% Rocky Mountain Fescue	35% Rocky Mountain Fescue	27% Tufted Hairgrass
13% Glaucous Bluegrass (<i>Poa glauca</i>)	13% Tufted Hairgrass (<i>Deschampsia cespitosa</i>)	13% Tufted Hairgrass	

Grass species substitutions can be made based on specific growth conditions, availability and cost. If used, these substitutions will be checked prior to purchase to ensure appropriate grass species are chosen. All grass seeds ordered will be certified weed free.

Normally, seeding is done in spring or early summer. Alternatively, frost seeding may be done when the ground is beginning to freeze (approximately late September or early October for the Project area).

3.3 INVASIVE SPECIES CONTROL METHODS AND IMPLEMENTATION

BMC will take immediate action in the event that preventative measures are not effective, and/or invasive species have already established themselves in the Project area.

Once sites with invasive plant infestations are identified and mapped, control measures can be implemented. BMC will attempt to eradicate the invasive plants before they seed. Some plants mature faster than others so control efforts may need to be staggered throughout the summer. In the Yukon, particular at the elevation of the Project area, most plants are setting seed by early to mid-August.

Another factor to consider is whether other resources will be impacted by utilizing some control methods. For example, larger scale hand pulling or mowing need to be precisely targeted so native plants are not removed nor damaged.

Based on the site-specific characterization of where the infestation occurs, BMC will control invasive plants through one main approach: non-chemical control.

3.3.1 Non-chemical Control

In general, non-chemical methods are best if the invasive plant infestations are small and root systems are not regenerative. The best treatment for all invasive plants found thus far within the Project area is hand pulling and digging out of root systems, followed by revegetation. Hand-pulling or digging before seed production in late summer is effective, but it is important to remove as much of the roots systems as possible. However, ground disturbance while digging should be kept to a

minimum. Hand removal will likely have to continue for a few years as seeds may remain viable in the soil for five or more years, depending on the species and site conditions. Mechanical control is the most common non-chemical method. Other non-chemical control methods include:

- Botanical control uses other vegetation or vegetation products to produce a competitive environment to reduce weed growth.
- Physical control involves placement of surface control materials on (e.g. mats) or burning areas with weed infestations to control growth. This method is effective in small areas when used with caution; and,
- Biological control involves the use of living organisms to control weeds. This control can be used in areas of heavy infestations, areas near water bodies, areas with aesthetic concerns or areas where chemical control is not approved (Enbridge, 2010). This method will not be used at Project area.

During non-chemical control it is important to avoid damage or removal of native plants. These plants will compete with invasive plants for growth factors, particularly sunlight, thereby slowing the intrusion and colonization by invasive plants. As part of an integrative approach, areas that are identified as prone to invasive plants infestations can be revegetated if the area is not likely to be disturbed again in the future. The fastest means of revegetation is to use a native grass seed mix as describe in Table 3-2. These seeds can be spread with a thin layer of stockpiled topsoil. A native grass mix could also be used to quickly bolster vegetation cover, especially on steep slopes where this has the added benefit of assisting with erosion control.

After non-chemical (particularly mechanical) controls are completed, all removed invasive plant material should be placed in clear plastic bags. These bags should be left in the sun for several days to heat kill flower heads and seeds prior to disposal, as many plants continue to produce seed even after being pulled or cut. The bags can then be incinerated. Incineration is a good means of destroying invasive plant material, and some plant seeds (e.g. spotted knapweed) can only be killed by an incinerator. Table 3-3 presents the control methods for the invasive plant species that have been identified and actively managed in the Project area between 2016 and 2023.

Table 3-3: Recommended Control Methods for Invasive Plants

Species	Recommended Control Methods
Smooth brome	Cutting while in the boot stage (flowering heads still enclosed within the sheath) and hand pulling or remove with trowel.
Oxeye daisy	Hand removal with a trowel, likely for several years because seeds may remain viable in the soil for some time.
Narrowleaf hawksbeard	Unlike the other invasive plants on site, narrowleaf hawksbeard is an annual or winter annual plant. Removal of roots is not necessary for management, only the prevention of seeding. It is important to note that the flower heads can go to seed after the plant is picked, so containment of plant parts after removal is critical. Infestations of hawksbeard can be managed with hand pulling.
White sweetclover	Pulled or cut before or during flowering. First-year plants may re-grow and can be cut again. Pulling or cutting will have to be repeated over a number of years.
Perennial ryegrass	Small patches can be controlled through hand pulling as this grass is has shallow roots.
Alsike clover	The only form of dispersal is by seed, which require a long (by northern standards) season to fully mature. Small infestations have been removed by digging up root systems with a trowel, but the larger infestations will require mechanical control.
Pineapple-weed	Hand removal with a trowel.
Common timothy	Hand-pulling before the grass sets seed (July).
Foxtail barley	Sporadic to moderate infestations can be hand pulled or dug out with a trowel. Mechanical control will be needed for large infestations.
Horned and Common dandelion	Dandelions are deeply rooted perennial herbs that flower early season in the Yukon and spread predominantly via seed. They do not spread rhizomatously (by underground stems) but can resprout from fragments of taproot if disturbed. For small infestations, individuals have been removed by carefully digging up the taproot with a trowel. Buds and flowers were hand-picked in large infestations to prevent further dispersal, but alternative methods of control will be needed for these areas. Hand pulling is not feasible. Larger infestations will require mechanical control.

3.4 MONITORING AND EVALUATION OF CONTROL STRATEGIES

BMC understands that control efforts are not a permanent solution to invasive species issues and that prevention, control treatments and continued monitoring will be required for the life cycle of the Project. For example, areas that have been treated will be inspected several times after the eradication effort to determine the efficiency of the treatment, condition of site and revegetation success. BMC will deliver follow-up inspections if invasive plant infestation persists. At the same time, BMC will remain responsive and if one method or attempt is not successful, another will be selected. For example, if hand-pulling and digging are not effective, other non-chemical methods can be applied, such as controlled burns (in consultation with Yukon Environment), matting or mowing.

The treatment inspections will form part of BMC's general ISMP monitoring for areas known to host invasive species, as well as in locations that are at risk of becoming infested. Treatment inspections

will occur along with routine checks for invasive plants throughout the summer and fall (at a minimum, once a month).

Areas currently noted to be at high risk for invasive plant establishment are sites where natural vegetation has been cleared and soils disturbed. These locations are:

- Along the site tote road;
- Borrow areas;
- Vehicle pull outs;
- Camp area and parking lot;
- Old/new service roads and trails;
- Fueling station;
- Drill sites; and,
- In the vicinity of existing infrastructure.

Other sites within the Project area that may also need higher surveillance include:

- Archaeological/heritage sites (where documented);
- Important wildlife habitat, e.g., ground burrows, movement corridors, herbaceous meadows and areas where there are signs of concentrated wildlife usage;
- Research sites; and,
- Sensitive sites, such as wetlands and riparian corridors.

Neighbouring areas and transportation routes to the study area will also be considered, as these are invasive plant sources that will continue to disburse seeds and plants into the Project property if not also managed. The Territorial Highways and Public Works Department will be engaged in discussions regarding maintenance and weed control on the Robert Campbell Highway right-of-way (if required).

3.4.1 Invasive Plant Species Monitoring

Details of the Invasive Plant Species Monitoring methods are included in the Project's Environmental Monitoring, Surveillance and Reporting Plan (BMC, 2024). An invasive species observation form (Appendix B) will be used each time an invasive species is found during the monitoring and for incidental observations. If plants of an unknown status are found (e.g., plants with which Environmental Monitoring personnel are unfamiliar and could potentially be new invasive plants), the form may also be used to note the location, description and photo of the plant. This will enable EM personnel to identify the plant at a later time, away from the field location, and then return to the precise location recorded to remove the plant if necessary. The form can also be used to communicate information to local agencies or professionals involved in Yukon invasive plant management to assist with plant identification. An invasive plant log will also contain copies of the invasive plant

observation forms, photographs, diagrams and any notes about the plant and a brief description of site conditions where the plant was found.

Finally, control methods used to treat an infestation and the date and location of the control effort will be recorded in the invasive plant log. Tracking the level of success in the application of different control methods used in battling invasive plant infestations will assist in developing an effective control program.

3.4.2 Invasive Aquatic Species Monitoring

No specific monitoring programs are currently planned for aquatic invasive species. However, if invasive aquatic species are identified at site during the implementation of the Environmental Project's Environmental Monitoring, Surveillance and Reporting Plan (BMC, 2024), this will be reported to the Environmental Site Manager within 24 hrs of the observation being made. An aquatic invasive species observation form is included in Appendix C.

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APPENDIX A: YUKON INVASIVE PLANTS

Altai Wild Rye

Leymus angustus

Common name: Altai Wild Rye

Scientific name: *Leymus angustus*

Family: Poaceae

Description

Altai Wild Rye is an Asian dune grass found throughout Mongolia, Siberia and China. In Canada, it is cultivated in many places but was previously only known to occur in the wild in Saskatchewan. This is a tall (100 cm) coarse grass that reproduces mainly by seed and forms dense tussocks from short rhizomes.

Range in Yukon

Known from Carcross where it was first reported in 1998. Small patches have been eradicated from the south Klondike Highway. It may have spread to the Alaska Highway and is also known from the BC portion of the Klondike Highway and along the Chilkoot Trail.



Photo: Bruce Bennett

Similar Species

Sea Lyme Grass (*Leymus mollis*) and Hairy Lyme Grass (*Leymus innovatus*) are also large perennial grasses. Sea Lyme Grass is only native to the Yukon coast and has anthers 4-9 mm. Hairy Lyme Grass can be distinguished by having hairy glumes and anthers 3.5-10 mm whereas Altai Wild Rye has anthers 3-5 mm long; glumes glabrous, sometimes scabrous. Quack Grass (*Elymus repens*) is widely spread along roadsides and at reclamation projects; often found as a weed in commercial seed.

Ecological Impact

It is a dune stabilizing grass that could be a threat to the Carcross Dunes and the animals and plants that depend on the dune ecosystem. If it spreads along rivers, it could form dense mats that hinder succession and decrease biodiversity.

Control

All known Yukon infestations have been small and have been controlled by pulling prior to the seed maturing. Larger plants must be dug up; most of the roots are less than 30 cm deep. The seeds of wild rye continue to mature after pulling. You may put plants into clear garbage bags and then leave them in the sun to kill off the plants and roast the seeds. Herbicide control may be required in large populations.

Bird Vetch

Vicia cracca

Common Name: Bird or Tufted Vetch

Scientific Name: *Vicia cracca*

Family: Fabaceae

Description

Multiple weak stems and compound leaves with tendrils (that allow the plant to attach to other plants or objects) characterize this perennial plant. The distinct purplish/blue flowers are arranged in a one-sided spike and turn into brown or black seed pods once matured. Vetch seeds disperse by the ballistic action of drying seedpods.

Because Bird Vetch is spreading effectively via seeds and by underground horizontal rootstocks, infestations grow rapidly.



Photo: Michael Rasy Bugwood.org

Range in Yukon

It is found in most Yukon communities including Whitehorse, Dawson, Watson Lake and Haines Junction.

Similar Species

Like the garden pea, Bird Vetch has tendrils to help it climb other vegetation. In Yukon only four plant species, all vetches, have tendrils. Three of these are introduced including Bird Vetch. Spring Vetch (*V. sativa*) and Shaggy Vetch (*V. villosa*) are only known from historic collections in Dawson City. Purple Vetch (*V. americana*) is the only native Yukon vetch and is found in southeast Yukon, but has been introduced to Mayo and Rancheria. Purple Vetch has fewer flowers (3-9) per bunch than Bird Vetch (10-30).

Ecological Impact

This plant can overgrow herbaceous vegetation and climb over shrubs like alder and willow. It is known to invade undisturbed sites including spruce forests and south-facing slopes. Due to the fixation of nitrogen it may change the soil composition.

Control

Bird Vetch is difficult to eradicate once established. Hand-pulling can be effective for small infestations, but the area has to be monitored and retreated for several years. Mowing and herbicide control can also be used effectively, especially for larger areas.

Common Tansy

Tanacetum vulgare



Common Name: Common Tansy
Scientific Name: *Tanacetum vulgare*
Family: Asteraceae

Description

Common Tansy is an attractive robust perennial plant that grows up to 150 cm tall and forms flat-topped heads of bright yellow, button-like flowers. The plant emits a strong pungent smell when crushed. It is mildly toxic. It grows well in full sun and usually in disturbed sites such as roadsides, riverbanks and beaches. It is considered a noxious weed in some areas of BC, Alberta, and Washington.

Range in Yukon

Presently known from Whitehorse, Marsh Lake, Kathleen Lake and the Alaska, Klondike, and Robert Campbell highways. It is becoming popular as a hardy garden plant.

Similar Species

Lake Huron Tansy (*Tanacetum bipinnatum*) is a native species mainly known from the Porcupine and Yukon rivers (down river of Dawson City). It grows 60 cm tall and has 2-4 heads.

Ecological Impact

Common Tansy can grow along ditches and streams and restrict water flow. The plant is somewhat poisonous to humans and livestock.

Control

All known Yukon infestations have been small and have been controlled by pulling; larger plants may have to be dug up. The seeds of Common Tansy continue to mature after pulling. You may put plants into clear garbage bags and then leave them in the sun to kill off the plants and roast the seeds. Herbicide control may be required in large populations. When dealing with this plant, protective clothing should be worn to keep the plants toxins off the skin.



Photo: Andrea Altherr

Creeping Thistle

Cirsium arvense



Common Name: Creeping Thistle
or Canada Thistle

Scientific Name: *Cirsium arvense*
Family: Asteraceae

Description

Creeping Thistle is native to Europe, Asia and Africa. This perennial plant can form new shoots from deep and extensive horizontal roots. It is one of the most invasive species in North America and is a noxious weed in most jurisdictions throughout Canada and the USA, including Alaska. Male and female flowers occur on separate plants

Range in Yukon

Known from the Haines Highway just south of Haines Junction, the Takhini Hotsprings and the La Biche River. It has occasionally been found in potted garden plants in Whitehorse.

Similar Species

Elk Thistle (*Cirsium foliosum*) is a rare native species found throughout southern Yukon. It is often persecuted because it is mistaken for an introduced thistle. Elk Thistle is a biennial (flowers in the second year then dies) with a large flower head, and a stout carrot-like taproot. Elk Thistle grows in wet areas, usually near rivers.



Photo: Irina Lapina

Ecological Impact

Creeping Thistle competes directly with native plants for nutrients and water; it also produces chemicals that help displace native vegetation. It is an aggressive agricultural weed that has the potential to reduce crop yields by 100%. Due to its abundant and flammable leaf litter it can increase fire frequency and severity.

Control

Because the root system is usually well developed, it is almost impossible to dig out. Therefore perennial plants require depletion of nutrient reserves in the root system, prevention of seed production, and prevention of dispersal. If roots are cut or broken off new plants may sprout. Mowing or cutting to reduce root reserves and seed production should be done a few times a season for several years. When hand-pulling use a shovel and remove as much of the root as possible. When cut, flowering plants will continue to produce seeds. Plant material should be put in a clear plastic bag and placed in the sun until the roots and seeds are cooked.

Crested Wheat Grass

Agropyron pectiniforme

Common name: Crested Wheat Grass

Scientific name: *Agropyron pectiniforme*

Family: Poaceae

Description

Crested Wheat Grass is long lived (15 to 20 years), drought and fire tolerant and has an extensive root system. It spreads primarily via seed but may also spread via rhizomes. The flower spikes are flattened.

Range in Yukon

Widespread agronomic species commonly used in seeding projects. Found throughout Yukon. It may become invasive in native habitats.

Similar Species

Crested Wheat Grass resembles the native wild rye (*Elymus* spp.) but their seeds are arranged like a comb (pectinate) along the stem.



Photo: Stefan Gottermann, YG

Ecological Impact

It may form monospecific stands and inhibit growth of native species.

Control

Crested Wheat Grass is highly competitive and therefore needs to be controlled quickly to prevent negative impact on native species. Control is a long-term process. As a perennial, when clumps of plants are removed, even small pieces of the root system are capable of regenerating into new plants. Put plants into clear garbage bags and then leave them in the sun to kill off the plants and roast the seeds.

Greater Butter-and-Eggs

Linaria vulgaris

Common Name: Greater Butter-and-Eggs

Scientific Name: *Linaria vulgaris*

Family: Scrophulariaceae

Description

This very attractive plant resembles a yellow perennial snapdragon. It is widely found in gardens and invading roadsides in most Yukon communities. It is usually less than 50 cm tall, persistent and mildly toxic. These plants are restricted noxious weeds in Alaska.

Range in Yukon

Greater Butter-and-eggs has been found in most communities, primarily from intentional garden plantings. It is widespread in the Whitehorse and Dawson areas, and along the South Canol Road in the Quiet Lake area, Watson Lake and Haines Junction. It is mainly spread through yard waste.

Similar Species

Dalmatian Toadflax (*Linaria dalmatica*) is much more invasive. It is larger with oval clasping leaves and in Yukon is known only from the Alaska Highway on the banks of the Rancheria River where it was apparently eradicated.

Ecological Impact

Both species are persistent and aggressive invader and may form dense colonies and suppress native grasses and other perennials. They contain a poisonous glucoside that is moderately poisonous to livestock. They are known to alter local pollination ecology and reduce yields in croplands.

Control

Perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal. Greater Butter-and-eggs reproduces both by seed and roots in Yukon.



Greater Butter-and-Eggs
Photo: Andrea Altherr



Dalmatian Toadflax
Photo: B. Steward

Leafy Spurge

Euphorbia esula



Common name: Leafy Spurge
Scientific name: *Euphorbia esula*
Family: Euphorbiaceae

Description

Leafy Spurge is a deep-rooted perennial with tiny greenish-yellow flowers. When the plant is injured, a milky white sap will flow out that may cause severe irritation to human skin. The plant mainly multiplies by growing shoots from the extensive root system. It may also grow from seed. Leafy Spurge is considered noxious throughout most of its range including BC and Alaska.

Range in Yukon

Known only from the vicinity of Dawson City.

Similar Species

Cypress Spurge (*Euphorbia cyparissias*), which is a non-invasive garden plant in Haines, Alaska.



Photo: Matt Ball, YG

Ecological Impact

This invasive plant can form large monospecific stands. Most grazing animals avoid it.

Control

Leafy Spurge is extremely difficult to remove once established due to its extensive root system, making it one of the top 10 invasive plants in North America. Plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal. Burning and mowing are ineffective. Annual herbicide application and hand-pulling may deplete the root system. Rhizomes and flowering plants must be disposed of through burning.

Lucerne

Medicago falcata

Common Name: Lucerne

Scientific Name: *Medicago falcata*

Family: Fabaceae

Description

Lucerne, or yellow alfalfa, is a perennial plant in the pea family. The flowers are yellow and the seed pods curved or half-moon shaped. It is a hardy forage crop for grazing animals. It is closely related to, and often hybridizes with, alfalfa (*Medicago sativa*) so these are often considered subspecies.

Range in Yukon

Lucerne is known from the communities of Whitehorse, Mayo, Faro, Carmacks, Stewart Crossing and Haines Junction, but in recent years has spread rapidly, especially along the Alaska and Haines highways. Alfalfa is also widespread throughout the southern Yukon.

Similar Species

Alfalfa (*Medicago sativa*) is not as invasive, but is persistent and slowly spreads in disturbed areas. It can be separated from Lucerne by having pods that are spirally coiled. It comes in colours from white to dark purple including blue, red and yellow. Black Medick (*Medicago lupulina*) is an annual plant that creeps along the ground. It has shown up occasionally at some mine reclamation sites and the Dempster corner.

Ecological Impact

Lucerne may facilitate the invasion of other exotic or native species by increasing the nitrogen contents in the soil. It may invade undisturbed grasslands, reducing biodiversity and changing community structure.

Control

Perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal.



Photo: Stephan Gottermann, YG

Narrowleaf Hawksbeard

Crepis tectorum

Common name: Narrowleaf Hawksbeard

Scientific name: *Crepis tectorum*

Family: Asteraceae

Description

With dandelion-like yellow flowers, this annual plant grows a single, sometimes branched stem from a small taproot that is easily pulled. The normally 20 to 60 cm high plant has alternate leaves that get smaller toward the top. Basal leaves are stalked and toothed; stem leaves are stalkless and mostly linear.

Range in Yukon

Narrowleaf Hawksbeard occurs throughout Yukon along all the major highways. This species has been found over 1 km from roadways and along rivers. This plant does not compete well in undisturbed sites, but readily colonizes frequently disturbed sites such as roadsides and rivers.

Similar Species

Spiny Sow Thistle (*Sonchus asper*) is known only from Haines Junction and the La Biche River. This is also an annual plant with a short taproot.

Ecological Impact

Each plant produces more than 49,000 seeds; open areas and disturbed sites are readily colonized.

Control

Annual plants require prevention of seed production and prevention of dispersal. Narrowleaf Hawksbeard is easily pulled up by hand. The plants will continue to mature after being pulled. Therefore plants should be placed in plastic bags to roast the seeds. Mechanical and chemical methods can also be used to control this plant. It is a prolific seed producer that once established is hard to remove.



Photo: Bruce Bennett

Orange Hawkweed

Hieracium aurantiacum



Common name: Orange Hawkweed

Scientific name: *Hieracium aurantiacum*

Family: Asteraceae

Description:

Orange Hawkweed is a perennial herb with fibrous roots. It grows up 20-90 cm tall. Leaves form a basal rosette, occasionally with one or two small leaves on the stem. Leaves and stems are covered in soft bristly hairs that stand erect. The flowers are bright orange-red, with heads 1 cm in diameter. Petals have notched tips.

This non-native plant is known from across Canada, from Labrador to British Columbia; no records are listed from NWT or Nunavut. Widespread in the USA.

Range in Yukon

Currently known only from a roadside location along the Haines Highway.

Similar Species

The intensely orange flowers make this species readily identifiable. When not flowering, however, the leaves and stems might be mistaken for other species of hawkweeds (e.g. Tall Hawkweed, *H. piloselloides*).

Ecological Impact

Orange hawkweed spreads by stolons, rhizomes, and seed. Forming dense mats in forb meadows & wetlands to the exclusion of native species, it lowers species diversity and reduces the forage value of grasslands for grazing animals. Unlike many invasive species, it can invade undisturbed sites and is therefore considered one of the worst nuisance species in agricultural and natural areas in other jurisdictions.



*Photo: Michael Shephard, USDA
Forest Service, Bugwood.org*

Oxeye Daisy

Leucanthemum vulgare



Common Name: Oxeye Daisy

Scientific Name: *Leucanthemum vulgare*

Family: Asteraceae

Description

Oxeye Daisy is a shallow-rooted perennial daisy. It has large white flowers with yellow centers. Although it is listed as an invasive weed in 8 states and 4 provinces, it is still sold as a garden plant, including here in Yukon, and is commonly included in “wild flower mixes”. It is particularly problematic in BC and SE Alaska.



Photo: Andrea Altherr

Range in Yukon

Oxeye Daisy has been found along roadsides and in the communities of Dawson, Watson Lake, Whitehorse, Haines Junction, along the Alaska Highway at Johnson's Crossing, Morley and Rancheria rivers, and along the Haines road and Mount Lorne community.

Similar Species

Shasta Daisy (*Leucanthemum maximum*) is a cousin to the Oxeye Daisy that grows 15-30 cm taller and has larger flowers. The invasiveness of Shasta Daisy is subject to more research. The two daisy species are suspected to hybridize. Scentless Chamomile (*Tripleurospermum inodorum*) is an invasive annual or biennial large daisy-like plant which can be separated by its thin dill-like leaves and fibrous roots. It has been reported from scattered locations throughout southern Yukon where it is known to persist.

Ecological Impact

Oxeye Daisy can form dense colonies and replace up to 50% of grass species in a pasture. Grazing animals avoid it. Dense infestations increase the potential for soil erosion.

Control

Perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal. Put plants into clear garbage bags and then leave them in the sun to kill off the roots and roast the seeds.

Perennial Sow Thistle

Sonchus arvensis



Common Name: Perennial Sow Thistle

Scientific name: *Sonchus arvensis*

Family: Asteraceae

Description

Despite the name, sow thistles more closely resemble giant dandelions than they do the true thistles. Perennial Sow Thistle is considered a noxious weed throughout most of its range including BC, Alberta and Alaska. This is an invasive species able to spread long distances by wind-blown seed. It is perennial with rhizomes that can grow to 10 feet and are very difficult, if not impossible, to remove by hand unless caught at a very early stage of development. It can grow up to 2 m. It is particularly a problem for agricultural producers. In natural areas it has been known to invade beaches and lake shores.



Photo: Irina Lapina

Range in Yukon

Primarily in the Whitehorse area as far north as Carmacks but has been reported from Destruction Bay, Johnson's Crossing and the Kotaneelee gas plant. In recent years it has begun to spread rapidly along highway corridors.

Similar Species

Prickly sow thistle (*Sonchus asper*) is known only from Haines Junction, Whitehorse and the La Biche River. This is an annual plant with a short taproot. Narrow-leaved Hawksbeard (*Crepis tectorum*) is another annual plant with short taproots. It occurs throughout Yukon

Ecological Impact

Perennial Sow Thistle may modify or retard the successional establishment of native species. At high densities it can dramatically reduce water resources and possibly decrease native plant diversity.

Control

Because the root system is usually well developed, it is almost impossible to dig out. Therefore perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal. If roots are cut or broken off new plants may sprout. Mowing or cutting to reduce root reserves and seed production should be done a few times a season for several years. When hand pulling use a shovel and remove as much of the root as possible. When cut, flowering plants will continue to produce seeds. Plant material should be put in a clear plastic bag and placed in the sun until the roots and seeds are cooked.

Quack Grass

Elymus repens

Common name: Quack Grass

Scientific name: *Elymus repens*

Family: Poaceae

Description

Quack Grass is a perennial weed that reproduces through seed and its excessive whitish or yellowish rhizomes that end in sharp points. Leaves are flat and pointed.

Range in Yukon

Scattered along roadsides in Southern Yukon.

Similar Species

Quack Grass has spreading roots. The only other wild rye with spreading roots is Sand-dune Wild Rye (*Elymus lanceolatus* ssp. *psammophilus*) which has hairy seeds and flower bracts.

Ecological Impact

It forms extensive rhizomes that compete strongly for water and nutrients with cultivated crops and native grasses. It can also hinder the regeneration of native woody species when it forms dense mats.

Control

Perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal. Small fragments of rhizomes can regenerate, making Quack Grass extremely difficult to control mechanically. Quack Grass should not be planted in seeding projects.



Photo: Steve Dewey, Bugwood.org

Reed Canary Grass

Phalaris arundinacea

Common Name: Reed Canary Grass

Scientific Name: *Phalaris arundinacea*

Family: Poaceae

Description

Reed canary grass is a robust, sod-forming perennial grass that grows from 50-150 cm tall or more. It is usually associated with moist soils where it forms dense monotypic, persistent stands. This is a highly variable species that has two genotypes, a non-invasive genotype found around hot springs in southeast Yukon and an aggressive invasive genotype which was derived from European stock. It has been used in highway seeding projects and for agriculture in the territory. It is considered noxious in Washington State and is listed as an invasive species in BC and Alaska.

Range in Yukon

Presently the largest known populations are along the Alaska highway from Dän Zhür Chu (Donjek) River to the White River. It is also common on the Haines highway.

Similar Species

Canary grass (*Phalaris canariensis*) is an annual species that has reported from the Pelly River area, but it is not expected to be persistent. Bluejoint (*Calamagrostis canadensis*) is a native perennial grass of wet soils, but is not as coarse and has large soft plumes of flowers.

Ecological Impact

The dense, monotypic and persistent stands may exclude and displace other plants, particularly in wetlands. It may also slow stream flow, eliminating the scouring action needed to maintain the gravel river bottoms essential for salmon production. It may cause hay fever when in flower.

Control

Once established, reed canary grass is extremely difficult to eradicate. Perennial plants require depletion of nutrient reserves in the root system, prevention of seed production and prevention of dispersal.



Photo: Bruce Bennett

Scentless Chamomile

Tripleurospermum inodorum



Common Name: Scentless Chamomile
Scientific Name: *Tripleurospermum inodorum*
Family: Asteraceae

Description

This plant can grow annual or biennial and sometimes even a short-lived perennial. It has numerous small and daisy-like flowers. Lower leaves disappear by flowering time. Stem leaves are dill-like, finely divided into short, thread-like segments. They don't smell when crushed.

Range in Yukon:

Scentless Chamomile has been found throughout the southern Yukon including Haines Junction, Whitehorse, Ross River, Teslin, Nisutlin, and Watson Lake. It has also been found along highways and other road system far away from communities. It is considered a noxious weed in all regions of BC.



Photo: Richard Old, xidservices.com

Similar Species

Seaside Chamomile (*T. maritimum*) is a rare plant on the Yukon arctic coast. Pineapple Weed (*M. discoidea*) is another introduced plant that lacks petals and has a strong odor when crushed.

Ecological Impact

Scentless Chamomile is unpalatable to livestock and can form dense stands in pastures. It is likely to alter soil moisture and nutrient availability for other plants.

Control

Hand-pulling can be effective in small infestations. Seed production can be lowered if plants are mowed before they flower. Seeds do not produce pappus (fluff – like dandelions) and so does not spread as easily as many other species in the daisy family. Since the plants do not compete well with vigorous plants, encouraging competitive plant growth may also be used to control infested areas. To date all Yukon known infestations have been small and easily eradicated.

Smooth Brome

Bromus inermis

Common Name: Smooth Brome

Scientific Name: *Bromus inermis*

Family: Poaceae

Description

Smooth brome is an important agricultural plant. It is a primary component of most hay productions. It is a persistent, nutritious hardy species that spreads through creeping rhizomes and by seed. It is known to invade undisturbed sites. Its hardiness and ability to suppress all other species by forming a thick mat of rhizomes has made it desirable for highway reconstruction projects in the past. Though not considered noxious, this species limits habitat for native species.

Range in Yukon

Reported from every community except Old Crow; it is found along most Yukon highways and around old settlements far from roads or rivers.

Similar Species

Pumpelly's brome (*Bromus pumpellianus*) is the native cousin of smooth brome, sometimes considered a subspecies. It has hairy flower bracts or seed casings (lemmas), unlike the hairless casings that give smooth brome its name. It is widespread throughout Yukon.

Ecological Impact

Smooth brome forms a dense sod that smothers and excludes native species decreasing natural biodiversity. Smooth brome inhibits natural succession.

Control

Once planted is difficult to remove. Mechanical treatment or herbicides may be required.



Photo: Ohio State Weed Lab Archive,
bugwood.org

Spotted Knapweed

Centaurea stoebe



Common name: Spotted Knapweed
Scientific name: *Centaurea stoebe*
Family: Asteraceae

Description

Knapweeds resemble thistles but lack spiny leaves and stems. They are biennial or short-lived perennials. This species reproduces entirely by seed. Large plants can produce over 20,000 seeds. It has not been known to be a problem in Yukon, but to date it has not had a chance to get established here. British Columbia and Alaska have active programs of eradication. Spotted Knapweed is a restricted noxious weed in BC.

Range in Yukon

Spotted Knapweed has been reported from the Alaska Highway near Hays Creek, the Carcross Desert.

Similar Species

Corn Flower (*Centaurea cyanus*) is an annual garden plant that is sometimes found in commercial “wildflower” mixes. It is occasionally found on roadsides but is not known to persist.



Photo: Michael Rasy, bugwood.org

Ecological Impact

Knapweeds may invade undisturbed grasslands and produce chemicals that hinder growth and germination of other plants, reducing biodiversity and changing community structure. Also, grazing animals dislike the bitter taste of knapweed so it reduces the productivity of forage lands.

Control

The seeds of thistle and knapweed continue to mature after pulling. You may put plants into clear garbage bags and then leave them in the sun to kill off the plants and roast the seeds.

White Sweetclover Yellow Sweetclover

Melilotus albus,
Melilotus officinalis

Common name: Sweetclover

Scientific name: *Melilotus albus* (white) *Melilotus officinalis* (yellow)

Family: Fabaceae

Description

Sweetclover is an annual or biennial plant in the pea family that can grow 2 m tall but is usually less than 1 m. It rapidly colonizes gravelly well-drained soils such as roadsides, waste areas and river banks and bars. A single plant can produce 300,000 seeds and the seeds remain viable in the soil or under water for many years (80% survival after 30 years). This is likely Yukon's most invasive and problematic species. It is planted in agricultural areas to increase soil nitrogen.

Range in Yukon

White Sweetclover is widespread throughout southern Yukon. It is known along much of the Alaska, North Klondike, Robert Campbell, and Top-of-the-World highways and 30 km up the Dempster Highway. It has proven to be highly invasive along the La Biche River in southeast Yukon. The only sites known on the Yukon River in Yukon are Whitehorse, Carmacks and Dawson; although it is a serious problem on Alaskan waterways including tributaries of the Yukon River.

Similar Species

Yellow Sweetclover (*Melilotus officinalis*), the yellow coloured relative, is widespread throughout southern Yukon, though not as abundant as its cousin.

Ecological Impact

White Sweetclover readily invades open areas and forest clearings as well as on river banks. It can form large monospecific stands, overgrow and shade native species. It will degrade natural grasslands.

Control

Plants should be pulled or cut before or during flowering. First-year plants may re-grow and can be cut again. Pulling or cutting will have to be repeated over a number of years to deplete the seed bank. If mature seed is not present, plants can be left where they are pulled. The plants quickly die once removed from the soil.



Photos: Andrea Altherr

Tall Hawkweed

Hieracium piloselloides



Common name: Tall Hawkweed (King Devil)

Scientific name: *Hieracium piloselloides*

Family: Asteraceae

Description:

Tall Hawkweed is a perennial plant with erect stems up to 1 m tall. Stems exude a white milky sap when broken. Leaves have long hairs on the margins and midveins only; leaves are concentrated in a basal rosette (occasionally with one or two smaller leaves on the stems). The yellow dandelion-like flower heads are clustered, each head approximately 1 cm in width. Tall Hawkweed is considered a noxious weed in the United States. It is found through much of British Columbia; also reported in Alberta and Alaska.



Photo: Marc Schuffert

Range in Yukon

Tall Hawkweed is currently known from the Morley and Rancheria areas.

Similar Species

Flowers can look similar to Narrowleaf Hawksbeard (*Crepis tectorum*), Umbellate Hawkweed (*Hieracium umbellatum*), Perennial Sow Thistle (*Sonchus arvensis*). When not flowering, the basal rosettes of leaves can look similar to Orange Hawkweed (*Hieracium aurantiacum*).

Ecological impact

A very adaptable species, Tall Hawkweed can grow in a wide range of habitats. It spreads using rhizomes, adventitious roots and seed. Though usually found on disturbed sites, it has been documented in undisturbed natural ecosystems. Its impacts on native plant communities are not well understood at this time.

Control

Control of tall hawkweed is complicated by the presence of rhizomes and adventitious root (i.e. vegetative regeneration) that may sprout following control treatments. Mowing will not prevent vegetative spread of plants. When populations are small, hand digging is best to prevent spread. Research on the effectiveness of chemical and biological control are lacking, though treatments used on other species of hawkweeds may prove useful. Elimination or management of hawkweeds requires a multi-year program that integrates control methods with restoration techniques. Efforts should be made to increase the competitive ability of desired native species.

APPENDIX B: INVASIVE SPECIES OBSERVATION FORM

Invasive Plant Species Observation Form	
Plant Description:	Observer's Name(s):
Observation site # (format: IP (invasive plant)-chronological number of current year's site observation-year (e.g., IP-01-24, next observation IP-01-24)):	Observation Date:
Common name:	Photos taken: yes / no
Scientific name:	Attach photos with description (detailed photos of the plant, overview photos of location with a reference point so the location can be found in future surveys)
Yukon Invasive Rank # (from rank 1 (high invasiveness) to rank 7 (low to insignificant invasiveness) (Yukon Invasive Species Council, 2023):	Control Action Taken (whether any treatment is applied and if so, the treatment method, e.g., hand pulled, removed with shovel): Reported Plants Pulled.....Disposal.....Other.....
GPS Location (UTM):	Area treated/control action taken (m ²):
Site description (i.e., laydown, stockpile, roadside, clearing, nearby infrastructure, etc. including a description of the surrounding plant community):	Other relevant notes:
# of plants in 20 m x 20 m area:	Density distribution class of invasive plant population:
# of plants in 100 m x 100 m area:	Approximate % coverage:
Other invasive plant species at site (names)?	Phenology (i.e., flowering, seed set, etc.):
Habitat type (describe, more than one maybe applicable)	Site Description (laydown, stockpile, roadside, clearing, nearby infrastructure, etc. including a description of the surrounding plant community:
Riparian/wetland:	
Forested upland:	
Field:	
Roadside/borrows/culverts:	
Mine/Exploration site:	
Other:	

APPENDIX C: AQUATIC INVASIVE SPECIES OBSERVATION FORM

APPENDIX F:

TABLE OF CONCORDANCE

Reference No.	Proponent Commitment ¹	Where addressed
YESAB R120	Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured daily or weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter. During freshet and significant rain events, discharge within the creeks will be monitored more frequently than weekly using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct daily spot checks to verify flow rates when week to week changes are suspected.	EMSRP Chapter 4.
YESAB R128	Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous week's discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter. During freshet and significant rain events, discharge within the creeks will be monitored more frequently than weekly using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct daily spot checks to verify flow rates when week to week changes are suspected.	EMSRP Chapter 4.
YESAB R133	The groundwater program includes continued sampling of 32 groundwater wells at quarterly intervals. Sampling parameters include collecting in situ field parameters, (pH, temperature, ORP, specific conductance, and dissolved oxygen) static water levels, and groundwater samples, as well as a thorough QA/QC program. Additionally, the eight continuous level loggers currently deployed will be maintained and monitored throughout the year, building on the existing dataset.	EMSRP Chapter 6.
YESAB R141	Existing wells that are not incorporated into the monitoring network will be decommissioned as per Protocol No. 7 Groundwater Monitoring Well Installation, Sampling and Decommissioning from the Contaminated Sites Regulation under the Environment Act, once it is determined that those wells will not be required for future monitoring.	EMSRP Chapter 6.
YESAB R144	BMC has developed an Aquatic Resource Monitoring Plan (ARMP) (Chapter 19 – Section 19-8 of the Project Proposal) as a component of its submission for assessment under YESAA. This will be further developed in consultation with DFO and others, as the project moves forward.	EMSRP Chapter 8.
YESAB R150	The sediment monitoring data for the project will be compared to the CCME sediment quality guidelines for the protection of aquatic life.	EMSRP Chapter 8.
YESAB R152	The preliminary water quality objectives report indicates the water quality parameters that will be evaluated at sites KZ-13, KZ-37, KZ-15, and KZ-26. These will be incorporated into a monitoring, surveillance, and Adaptive Management Plan to ensure environmental protection.	EMSRP Chapter 5.
YESAB R152	The final point of compliance, parameters and standards will be determined by the Yukon Water Board in the Water Use Licensing process.	EMSRP Chapter 5.
YESAB R153	The flow and water quality programs will continue up to and including the licensing stage of the Project.	EMSRP Chapter 4 and Chapter 5.

Reference No.	Proponent Commitment ¹	Where addressed
YESAB R155	Discharge rate from the Lower Water Management Pond (KZ-8) will be monitored continuously using a totalizer flow meter with a datalogger.	EMSRP Chapter 4.
YESAB R155	In Geona Creek (KZ-37) and Finlayson Creek (KZ-15) where discharge from the mine will first enter the receiving environment, stilling wells with staff gauges will be used to collect continuous data where rating curves will be established and used to determine instantaneous discharge measurements. Weekly discharge and water quality samples will be collected at these locations when the Lower Water Management Pond is discharging. The water quality results for KZ-37 and KZ-15 will be compared to the Water Quality Objectives and their associated adaptive management thresholds.	EMSRP Chapter 4 and Chapter 5.
YESAB R156	Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous week's discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter.	EMSRP Chapter 4.
YESAB R156	During freshet and significant rain events, discharge within the creeks will be monitored more frequently increasing from weekly to daily, using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct spot checks to verify flow rates when week to week changes are suspected.	EMSRP Chapter 4.
YESAB R156	Daily onsite measurements of key parameters for KZ-8 such as pH, conductivity, and targeted metals, will be completed to ensure compliance in addition to the weekly external samples. Weekly water quality samples in Geona Creek (KZ-37) and Finlayson Creek (KZ-15) will be collected when the Lower Water Management Pond is discharging. The water quality results for KZ-37 and KZ-15 will be compared to the Water Quality Objectives and their associated adaptive management thresholds.	EMSRP Chapter 5.
YESAB R156	An additional control point will be the discharge from the water treatment plant (KZ-12). The parameters for effluent quality will primarily be related to those COPI for which treatment is required to maintain concentrations in the receiving environment that are compatible with the Water Quality Objectives and will include but not limited to pH, TSS, ammonia, cyanide, arsenic, cadmium, copper, nickel, lead, selenium and zinc. The water treatment plant discharge quality will be monitored internally daily for key performance parameters and externally weekly for the full suite of parameters.	EMSRP Chapter 5.
YESAB R160	Permafrost investigations have been and will continue to be focused on areas of infrastructure development. Additional site investigations and monitoring of existing and future instrumentation will continue to provide input to the understanding of the character and distribution of permafrost on site, which will be utilized to inform detailed design prior to any construction.	EMSRP Chapter 11.
YESAB R3-24	If during the Project lifetime, concentrations in soils reach the adaptive management thresholds (that will be defined during permitting) the PQRA will be updated and additional management measures to reduce dust will be implemented as per the adaptive management plan (i.e. road watering and/or installing misters at certain key locations). In addition, based on comments received from YESAB and RRDC, during the Adequacy stage, BMC will be installing 5 air quality monitoring stations at the site in 2018. These stations will monitor TSP, PM10, PM2.5 and metals. The results of the 2018/2019 monitoring program will be used to confirm the assumed baseline concentrations of TSP, PM10 and	EMSRP Chapter 3 and Chapter 9.

Reference No.	Proponent Commitment ¹	Where addressed
	PM2.5 that were presented in the Project Proposal. The stations will also be used in the monitoring program during construction, operations, and active closure.	
YESAB R3-26	A vegetation and soil monitoring plan will be implemented to track the effects of dust deposition relating to the mine area and Access Road. The monitoring plan is scheduled to be conducted every three years starting in the construction phase and will track change in soil metal concentrations from baseline conditions. The company has committed to developing adaptive management thresholds during permitting. If soil metals in soil exceed guidelines or are consistently higher than baseline concentrations, then additional mitigations measures will be taken to reduce emissions (as per the adaptive management plan – to be developed during permitting). In addition, the PQRA would be updated.	EMSRP Chapter 9.
YESAB R4-2	Vegetation at the site will be managed through all Project phases in order to ensure that it does not have the potential to prevent the traditional land users from using the area for harvesting vegetation in the post closure period.	EMSRP Chapter 9.
YESAB R4-4	A rigorous monitoring plan will be in place that will detect any increases in fish tissues concentrations well in advance of any opportunity for persons to collect and consume fish from the creeks.	EMSRP Section 8.2.
YESAB R4-4	RRDC's Elders Oversight Committee requested that BMC and RRDC develop a co-management program for fish and wildlife. In response to this request, BMC sent RRDC Chief and Council (in May 2017) a proposal for a BMC-Kaska Environmental, Cultural & Heritage Management Program for the Project. Through this co-management program it is anticipated that RRDC will collaboratively design, collect, report, manage and communicate the results of the fish monitoring program to RRDC citizens (including the RRDC Elders Oversight Committee). This program would be active through all Project phases and it is anticipated that it will provide a forum to incorporate culturally relevant mitigation measures to the fish and aquatic resources monitoring and adaptive management programs.	EMSRP Section 1.3.
YESAB R4-4	A monitoring program will initially collect soil samples at exposure and control sites. The sampling program will be conducted prior to construction, after development, and once every three years through to closure with data tracked over time to determine if there are any changes in metal concentrations resulting from the Project. An adaptive management plan will be developed during permitting, which will identify threshold values for additional mitigation or monitoring. If the soil concentrations trigger the threshold values (the lowest of which will be set as 'early warning' indicators, at levels below expected effects concentrations), additional mitigation measures would be implemented and a more intrusive monitoring program would be implemented (i.e., vegetation monitoring program).	EMSRP Chapter 9.
YESAB R4-4	Based on comments received from YESAB and RRDC, during the Adequacy stage, BMC has installed 5 air quality monitoring stations at the site. These stations monitor TSP, PM10, PM2.5 and metals. The results of the 2018/2019 monitoring program will be used to confirm the assumed baseline concentrations of TSP, PM10 and PM2.5 that were presented in the Project Proposal. The stations will also be used in the monitoring program during construction, operations.	EMSRP Chapter 3.
YESAB R4-4	BMC has proposed a BMC-Kaska Environmental, Cultural & Heritage Management Program for KZK. Through this co-management program it is anticipated that RRDC will collaboratively design, collect,	EMSRP Section 1.3.

Reference No.	Proponent Commitment ¹	Where addressed
	report, manage and communicate the results of the air and soil quality monitoring programs to RRDC citizens (including the RRDC Elders Oversight Committee). This program would be active through all Project phases and would collaboratively ensure that the soil concentrations during all Project phases are not at levels that could potentially effect the quality of country foods.	
YESAB R4-8	Fault Creek has been identified by RRDC Elders as a drinking water source. Given the importance of this creek, BMC has designed the Project to ensure that the water quality of the creek is not impacted by the proposed mine infrastructure (i.e. no mine infrastructure is proposed in the vicinity of Fault Creek). The creek will continue to be monitored through the Project phases to ensure that this avoidance mitigation measure is successful (i.e. that there are no detectable changes in the water quality from baseline).	EMSRP Chapter 5.
YESAB R4-9	Invasive species are known to spread extensively, rapidly and can outcompete indigenous species resulting in decreased biodiversity. This in turn can have impacts on the abundance of culturally important plants used for food and medicines. In order to ensure invasive species don't cause such adverse effects, BMC has implemented an invasive species management program for exploration, and this will continue throughout all the proposed Project Phases. Details of this plan are presented in Section 18.8.1 of the Project Proposal (Invasive Plant Management Plan).	EMSRP Section 9.2 and Appendix E.
YESAB R4-9	BMC has proposed a rare plant chance find procedure (Section 18.8.2 of the Project Proposal). If one of the plants listed in the procedure are confirmed to be at site, the protocol will be to contact Yukon Environment and the designated RRDC/LFN Kaska environmental contact to determine the appropriate mitigation measures to be taken if the area cannot be avoided. In this way RRDC/LFN Kaska can make the determination if the rare plant is considered culturally important and can help determine the best course of action.	EMSRP Section 9.1
Project Proposal Chapter 12 (BMC, 2017a) Project Proposal Chapter 18 (BMC, 2017a)	A chance find procedure will be implemented with particular attention in likely areas of rare plant occurrence during the construction phase and clearing activities during operations. If equipment operators (or anyone else) encounter a potential rare plant, clearing in that area will stop immediately, the plant and surrounding vegetation will be cordoned off, and the site environmental officers will be notified. The environmental officers will then have the identification confirmed by a qualified person. If the plant is determined not to be rare, then the environmental officers will give approval to continue work in that area. If the plant is confirmed to be rare, the Environmental Manager will contact Yukon Environment and the designated RRDC environmental contact to determine the appropriate mitigation measures to be taken if the area cannot be avoided.	EMSRP Section 9.1.
Project Proposal (Chapter 12)	Invasive Species Management Plan, which includes: o Minimize disturbance of the natural vegetation and exposure of soils around the Project Footprint; o Allow disturbed and reclaimed areas to revegetate naturally to the extent practicable to reduce the risk of introducing invasive plant species to the area; o Re-use salvaged soil for reclamation to promote successful regeneration of the natural seed bank; o Collection and use of local seeds for reclamation;	EMSRP Appendix E.

Reference No.	Proponent Commitment ¹	Where addressed
	- o If necessary, procurement of seeds will be done from reputable seed suppliers with quality control programs; - o Transplant seedling to disturbed ground to encourage quick regeneration of ground cover and reduce likelihood of invasive species colonization; - o If concerns of an invasive species infestation are immediate, establish a vegetation cover as soon as practicable after ground disturbance using a native grass seed mix; - o Where practicable, limit vehicle use to existing roads and trails (included in BMC's ATV policy) to limit additional ground disturbance and therefore potential introduction of invasive species; - o Ensure equipment, vehicles, and personnel clothing are free of invasive plants prior to entering the Project by way of a check station at the Access Road gatehouse. Check station will include information on invasive species, instructions for proper disposal, and a disposal bin; - o All new equipment/vehicles entering Project area, will need to be weed free prior to site access; - o Ensure employees are briefed on proper invasive species prevention strategies during induction; and - o Use of Yukon recommended invasive plant management methods.	
Project Proposal (Chapter 18)	BMC will manage aquatic and other invasive species. Specific measures will include: - o Cleaning equipment (at its point of shipment) before transport to site; - o Unloading equipment away from watercourses; - o Environmental staff will inspect all equipment to ensure that it is free of soil and vegetation during unloading; - o Inspection results will be documented on an equipment inspection form; and - o Contaminated equipment will either be rejected or cleaned, and any material that may contain invasive species will be properly disposed.	EMSRP Appendix E.
Project Proposal (Chapter 18)	If preventative measures are unsuccessful at stopping the spread of invasive plants to the Project operations area, BMC will take action to control the spread and removal of the invasive species. BMC commits to using Yukon recommended invasive plant management methods for the control of invasive plants. Non-chemical methods for controlling the spread and removal will include hand pulling and digging out the root system, followed by revegetation. All plants and seeds removed will be placed in bags and incinerated. Following the control effort, the areas will be monitored to assess the efficiency and condition of the site and revegetation success. BMC will continue to carry out follow-up inspections and efforts to minimize invasive plants. Furthermore, BMC will remain responsive, and if one method or attempt is not successful, another will be selected. For example, if hand-pulling and digging are not effective, other methods can be applied, such as controlled burns (in consultation with Yukon Environment), matting or mowing. BMC will engage the Territorial Highways and Public Works Department regarding their maintenance and weed control on the Robert Campbell Highway right-of-way (if required). Control methods used to treat an infestation and the date and location of the control effort will be recorded in the invasive plant log. Tracking the level of success in the application of different control	EMSRP Appendix E.

Reference No.	Proponent Commitment ¹	Where addressed
	methods used in battling invasive plant infestations will assist in developing an effective control program.	
RRDC Adequacy Review R-2	Detailed monitoring and Adaptive Management Plans will be developed during permitting (i.e. during the Type A Water Licence and Quartz Mining Licence application processes). It is BMC's intention to work closely with RRDC and Dena Cho in the development of these detailed plans. The monitoring and management plans will not be submitted to the Yukon Water Board or EMR until they have been jointly reviewed by BMC and RRDC.	EMSRP Section 1.3. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Adequacy Review R-9	The parameters for effluent quality standards will be primarily related to those COPI for which treatment is required to maintain concentrations in the receiving environment that are compatible with the water quality objectives and parameters listed in the Metal Mining Effluent Regulations, which will include but are not limited to pH, TSS, ammonia, cyanide, fluoride, arsenic, cadmium, copper, nickel, lead, selenium and zinc. These will be incorporated into a monitoring, surveillance, and Adaptive Management Plan to ensure environmental protection, which will be developed with RRDC.	EMSRP Chapter 5.
RRDC Adequacy Review R-55	Detailed monitoring and Adaptive Management Plans will be developed during permitting (i.e. during the Type A Water Licence and Quartz Mining Licence application processes). In addition, a detailed MDMER monitoring program will also be developed to meet federal requirements. Conditions, locations, periods etc. will be prescribed in these plans and licences. Compliance monitoring will ensure the predictions in the effects assessment are valid and if they are not then adaptive management measures would be applied.	EMSRP Chapter 5.
RRDC Adequacy Review R-55	The conceptual plans presented in the Project Proposal will be refined/developed during the subsequent permitting process and it is BMC's intention to work with RRDC and Dena Cho in the development of these detailed plans.	EMSRP Section 1.3. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (Surface Water)	BMC will work with RRDC to establish an additional water quality monitoring station to provide a control station outside of the Project area.	EMSRP Chapter 5.
RRDC Screening Review (Surface Water)	During Operations these surface water stations will continue to be monitored and compared to existing conditions.	EMSRP Chapter 5.

Reference No.	Proponent Commitment ¹	Where addressed
RRDC Screening Review (ARD/ML)	Uranium will be included as monitoring parameter in the monitoring and adaptive management plan (AMP) that will be submitted as part of the permit applications. BMC will work with RRDC to establish appropriate thresholds and monitoring locations as part of the development of these documents. It is anticipated that the monitoring thresholds and locations will be selected such that they will provide an early warning before uranium concentrations exceed the preliminary water quality objectives (equivalent to the CCME uranium guideline) in the receiving environment. This will allow time for further characterization of any elevated uranium concentrations in waste streams and, where necessary, implementation of measures to ensure the receiving environment is not adversely affected.	EMSRP Section 1.3 and Chapter 5. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (ARD/ML)	BMC will work with RRDC to determine appropriate sampling frequency for Class C runoff and will establish associated criteria in the AMP along with contingency plans. The current thinking is that the monitoring would be monthly but this is likely to be more frequent during the early stages until our modelling is confirmed in the field.	EMSRP Section 1.3 and Chapter 5. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (Groundwater)	BMC agrees to meet with RRDC to discuss the proposed groundwater monitoring plan including spatial distribution, based on the requested wells from responses #3 to #8. BMC commits to installing at minimum 2" monitoring wells for future installations. BMC has committed to working with Dena Cho in the development of this and other management plans through the existing contractual agreements between the parties.	EMSRP Section 1.3 and Chapter 6. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (Groundwater)	Any new wells installed will be part of annual data collection, and as such the new data will be integrated with the existing well network with statistics and trend analysis as part of annual reporting.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	BMC agrees monitoring downgradient of the Class A Facility is important; during the Construction phase, 3 nested wells will be installed.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	BMC agrees to adding a shallow well near BH95G-15D. The addition of this shallow well would be part of the well network to monitor downgradient of the Class A Storage Facility prior to Operations.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	BMC agrees to add a shallow and deep well downgradient of the Class B Storage Facility prior to Operations. These wells would also be below the ROM facility and the southeast of the process plant.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	BMC agrees to add a shallow and deep well downgradient of the Processing Plant prior to Operations. The wells proposed above would meet this request as the well pair would be below the ROM and south	EMSRP Chapter 6.

Reference No.	Proponent Commitment ¹	Where addressed
	east of the Process plant. Otherwise, the Process Plant itself will be an enclosed building with a cement pad, so that the only way for contamination to leave is through the concentrate entering and leaving the facility.	
RRDC Screening Review (Groundwater)	BMC agrees to add a shallow well downgradient of the Overburden stockpile prior to Construction to make one set of shallow and deep wells with MW16-16D.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	When new wells are installed, they will be logged for stratigraphic information and added to the site water quality monitoring program for water level and water quality data. This data will then be reviewed annually to confirm the site conceptual hydrogeological model as part of annual Water Licence report.	EMSRP Chapter 6.
RRDC Screening Review (Groundwater)	BMC will be developing the adaptive management plans that will be submitted to the Waterboard and EMR as part of the Water Use Licence and Quartz Mining License Applications. This will include monitoring and management strategies for groundwater, including associated thresholds, triggers and contingency plans. BMC has committed to working with Dena Cho in the development of this and other management plans through the existing contractual agreements between the parties.	EMSRP Section 1.3 and Chapter 6. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (Dust Deposition)	For vegetation and soils, the monitoring program and adaptive management and thresholds will be developed in consideration of baseline data as well as dust deposition model results, in conjunction with relevant standards (CCME soil quality guidelines). BMC has committed to working with Dena Cho in the development of the detailed soils and vegetation monitoring and adaptive management program and other management plans through the existing contractual agreements between the parties. This will likely include selection of culturally important vegetation for monitoring, based on feedback from the Elders.	EMSRP Section 1.3 and Chapter 9. Dena Cho reviewed and contributed to all draft management plans. Once BMC had amended the plans to address Dena Cho's comments, BMC sent them to RRDC Chief and Council for review prior to BMC finalizing and submitting them to EMR.
RRDC Screening Review (Dust Deposition)	The plan will not be restricted to wetlands and will include land based plants.	EMSRP Chapter 9.
BMC Response to Public Comments on the DSR	BMC is in the process of developing the Adaptive Management Plan for the Project to support both the Water Licence and Quartz Mining Licence applications. The Environmental Monitoring, Surveillance, Reporting and Adaptive Management Plan is a requirement based on Water Board guidance (Yukon Water Board, 2012) and guidance from Yukon Government's Department of Energy, Mines and Resources (Yukon Energy, Mines and Resources, 2013). The current draft Monitoring and Adaptive Management Plan (to support the licence applications) includes seepage monitoring and adaptive management measures for seepage from the Class A and B waste storage facilities.	EMSRP Chapter 5 and Chapter 6.

Reference No.	Proponent Commitment ¹	Where addressed
RRDC Review of Draft Management Plan	The annual report provided to EMR and WB will identify if there were any air quality exceedances during the monitoring period.	EMSRP Chapter 3.
RRDC Review of Draft Management Plan	Annual reports will be provided to Kaska.	EMSRP Section 1.3.
RRDC Review of Draft Management Plan	The seep stations are planned to be monitored, but locations may be updated based on the presence of seeps as required over time.	EMSRP Chapter 5.
RRDC Review of Draft Management Plan	More detailed groundwater monitoring methods will be added to the final plan.	EMSRP Chapter 6.
RRDC Review of Draft Management Plan	Groundwater wells in the vicinity of fuel storage areas will be monitored for hydrocarbon presence absence (in the event of a reportable spill in the vicinity).	EMSRP Chapter 6.
RRDC Review of Draft Management Plan	During construction this water will be monitored at the Pit Rim Pond which is designed to treat for sediment removal. If water quality requires additional treatment BMC will treat water before discharge.	EMSRP Section 11.1.
Decision Document #7	The Proponent shall conduct ongoing investigations into waste rock storage area (WRSA) liners and cover systems to ensure that the expected liner and cover performance is achieved during all Project phases.	EMSRP Chapter 6 and Chapter 7.
Decision Document #8	The Proponent shall commit to ongoing geochemical studies for tailings and waste rock storage areas, and studies to optimize the performance of all water treatment facilities and processes to address the potential for acidic conditions to develop in the future.	EMSRP Chapter 7.
Decision Document Condition #12	The Proponent shall ensure that LFN and RRDC have opportunities to participate in and influence the development of environmental and socioeconomic management plans and closure objectives developed for the Project to ensure that Kaska can collaboratively design, collect, report, manage and communicate the results of the monitoring programs and adaptive management plans to their community members. The Proponent will make participant funding available to Kaska to support the incorporation of Kaska perspectives on Kaska laws as well as support the inclusion of Kaska members, including Elders and land stewards, in the regulatory process, the monitoring of impacts, the implementation of adaptive management and the Proponent's commitments for the life of the Project (regulatory to reclamation).	EMSRP Section 1.3.
Decision Document Condition #13	The Proponent shall ensure that LFN has the opportunity to be part of the Proponent-Kaska environmental, cultural and heritage management program.	EMSRP Section 1.3.
Decision Document Condition #32	The Proponent shall assess the effluent, as well as predicted concentrations in the receiving environment, for acute toxicity and chronic effects to fish and benthic organisms in the Project's receiving environment. This should be included in environmental monitoring, reporting and adaptive management plans and reflect the species and populations in the receiving environment.	EMSRP Chapter 5 and Chapter 8.
Decision Document Condition #36	As a part of regulatory applications, the Proponent shall develop and implement adaptive management measures based on monitoring for the onset of acidic conditions, that allows for early detection, management, and mitigation of acidic conditions and metal leaching developing on site during operations, closure and post-closure.	EMSRP Chapter 7.

Reference No.	Proponent Commitment ¹	Where addressed
Decision Document Condition #37	The Proponent shall develop an ambient air monitoring and adaptive management plan for all Criteria Air Contaminants (CACs), based on updated (2025) standards.	EMSRP Chapter 3.
Decision Document Condition #44	The Proponent shall submit, to the Government of Yukon, a performance audit report on the actual performance of mine components relative to approved design or expected performance. The Proponent shall provide RRDC and LFN with a copy of any performance audit report submitted to the Government of Yukon under this term subject to the redaction of confidential material. a. The report must be of sufficient detail to enable an understanding of current performance and to identify trends that could materially affect mine outcomes. b. The timing and frequency of reporting shall be indicated by the Government of Yukon regulator.	EMSRP Section 11.6.
Decision Document Condition #45	Prior to the commencement of operations of an Engineered Structure, and at any time or frequency indicated by the Government of Yukon, the Proponent shall submit a third-party engineering audit for that facility. The Proponent shall provide RRDC and LFN with a copy of any third-party engineering audit report submitted to the Government of Yukon under this term subject to the redaction of confidential material. The audit must be sufficiently detailed to provide an independent assessment of whether the facility has been constructed and is capable of operating in accordance with approved designs, specifications, and operating plans. Each engineering audit must: a. be prepared by a qualified independent professional engineer or engineering firm acceptable to the Government of Yukon; b. be funded by the Licensee; c. assess whether the Engineered Structure has been constructed in accordance with approved designs, permits, and specifications; d. assess the readiness of the facility to operate safely and effectively within its design parameters; e. identify any deficiencies, departures from approved designs, commissioning issues, or conditions that may affect operational performance, environmental protection, or closure obligations, and; f. satisfy any scope requirements identified by the Government of Yukon. Where an engineering audit identifies deficiencies or conditions requiring corrective action, the proponent must address those deficiencies to the satisfaction of the Government of Yukon prior to commencing or continuing operation.	EMSRP Section 11.6.