Aquatic Effects Monitoring Program Design Plan

Meliadine Mine

Version 3_NWB

Prepared for:

Agnico Eagle Mines Limited
Meliadine Division
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January 23, 2024

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EXECUTIVE SUMMARY

This document describes the study design for the Aquatic Effects Monitoring Program (AEMP) for the Meliadine Mine. The AEMP is required under the Type A Water Licence (2AM-MEL1631). The purpose of the AEMP is to collect and assess data to verify that mining activities are not causing adverse effects to the aquatic environment.

The AEMP was developed in consultation with the local communities, stakeholders, and regulatory authorities and included two separate studies: the Meliadine Lake study and the Peninsula Lakes study. Meliadine Lake is the final discharge point for surface contact water collected at the Mine and the primary study area for the AEMP. The core components of the Meliadine Lake study include effluent and surface water quality monitoring, a phytoplankton study, benthic invertebrate community and sediment chemistry monitoring, and a fish health and tissue chemistry monitoring program with Threespine Stickleback and Lake Trout. The benthic invertebrate community and fish health studies were based on monitoring required under Schedule 5 (Environmental Effects Monitoring) of the Metal and Diamond Mining Effluent Regulations (MDMER). Where possible, the AEMP has been harmonized with the EEM program to avoid redundancy.

The Peninsula Lakes study was designed to monitor changes in water quality caused by non-point source discharges such as dust and aerial emissions. Three lakes were included in the Peninsula Lakes study: Lake A8, Lake B7, and Lake D7).

Version 3 of the AEMP Design Plan was prepared to support the Water Licence Amendment application to the Nunavut Water Board to allow Agnico Eagle to mine deposits that were approved in Project Certificate No. 006.

Two changes are proposed in Version 3 of the AEMP Design Plan:

- Remove the Peninsula Lakes water quality monitoring program from the AEMP and add it to the Water Quality and Flow Monitoring Plan (Appendix D in the Water Management Plan).
- Conduct the 2024 fish health study for the AEMP according to the study design for the Cycle 3 EEM program.

The rationale for these changes is discussed in **Section 1.5**.

Minor updates were also made to address comments from agencies that reviewed Version 2 of the AEMP Design Plan in 2023.

REVISION HISTORY

Version	Date	Notes
0	April 2015	Final preliminary design for submission with the Water Licence application.
1	June 2016	Prepared by Golder Associates based on principles and objectives outlined in the Conceptual AEMP Design Plan. Version 1 includes commitments made with respect to submissions received during the Technical and Public Hearing process for the Meliadine Type A Water Licence Application and based on the terms and conditions of the Type A Water Licence.
2	April 2022	Incorporated findings from the annual AEMP completed from 2016 to 2020, including the results of the Amendment No. 1 monitoring program in 2020.
2_NWB	January 2023	Submitted as part of the Type A Water Licence Amendment application for the Meliadine Extension. Comments received from regulators regarding the April 2022 Draft for Discussion. Responses to comments received from regulators are provided in **Appendix C**.
3_NWB	January 2024	Submitted with the application to amend the Type A Water Licence to allow Agnico Eagle to develop previously-approved deposits. Two updates were made to the AEMP Design Plan: (1) Incorporate the water quality monitoring program for Lake D7, and any lakes selected in the future for monitoring non-point source discharges from mining activities, into the Water Quality and Flow Monitoring Plan (Appendix D of the Water Management Plan). (2) Complete the 2024 fish health studies according the proposed study design for the Cycle 3 Environmental Effects Monitoring Program.

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GLOSSARY

Term	Definition
Aquatic Effects Monitoring Program	A monitoring program to evaluate the effect of mining activities and mitigation on the aquatic environment.
AEMP Design Plan	The "how to manual" that describes the details of the AEMP.
Assemblage	An association of interacting populations of organisms in a given waterbody.
Bathymetry	The measurement of underwater depth.
Benthic invertebrates	Aquatic animals without backbones (e.g., insects, worms, snails, clams, crustaceans) that live on/in the bottom substrate of a waterbody.
Canadian drinking water quality guidelines (CDWQG)	Health Canada guidelines used to evaluate the suitability of water for human consumption.
Canadian water quality guideline for the protection of freshwater aquatic life (FWAL)	Guidelines established by the Canadian Council of Ministers of the Environment to protect aquatic life in Canadian surface waters.
Critical effect size	A threshold above which an effect may be indicative of a higher risk to the environment.
Chlorophyll-a	A photosynthetic pigment found in plants, responsible for the conversion of inorganic carbon and water into organic carbon. The concentration of chlorophyll *a* is often used as an indicator of algal biomass.
Community	The groups of organisms living together in the same area, usually interacting or depending on each other for existence.
Effluent	The out-flow water discharged from a treatment plant. For purposes of this document, effluent is the water that is discharged from the water treatment plant to Meliadine Lake.
Ekman grab	A sampling apparatus used to collect a discrete sample of bottom sediment.
Exposure area	An area that receives direct discharge from mining operations.
Freshet	A large increase in water flow down a river or estuary, typically resulting from snowmelt during spring.

Term	Definition
General and Aquatic Effects Monitoring	Commonly included in a Nunavut Water Licence specifying what is to be monitored according to a schedule[1]. It covers all types of monitoring (i.e., geotechnical, lake levels, etc.). This monitoring is subject to compliance assessment to confirm sampling was carried out using established protocols, included QA/QC provisions, and addresses identified issues. General monitoring is subject to change as directed by an Inspector, or by the Licensee, subject to approval by the Water Board.
Inuit Qaujimajatuqangit (IQ)	Specific Inuit traditional knowledge. This is the guiding principles of Inuit social values including respect of others, relationships, development of skills, working together, caring, inclusiveness, community service, decision making through consensus, innovation, and respect and care for the land, animals, and the environment.
Interim Sediment Quality Guideline (ISQG)	In reference to the Canadian sediment quality guidelines, the concentration above which adverse effects may occur, and below which they are not expected to occur.
Metalloid	A class of chemical elements intermediate in properties between metals and non-metals; e.g., arsenic and boron.
Metals	A class of chemical elements that are good conductors of electricity and heat, and have the capacity to form positive ions in solution; e.g., aluminum, copper, iron, and zinc.
Mine Water	A general term to refer to water that is managed as a result of mining operations. It primarily refers to the contact water (i.e., water that has come into contact with any part of mining operations) and must be controlled and managed to reduce or eliminate effects to the environment.
Nutrients	Substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Parameter	A particular physical, chemical, or biological property that is being measured.
pH	The negative logarithm of the concentration of the hydronium ion (H+). The pH is a measure of the acidity or alkalinity of an aqueous solution, expressed on a scale from 0 to 14, where 7 is neutral, values below 7 are acidic, and values over 7 are alkaline.
Phytoplankton	Small, free-floating algae that are suspended in the water column.

[1] Referred to in NWT and old NWB licences as the Surveillance Network Program.

Term	Definition
Probable Effects Level (PEL)	Canadian sediment quality guideline for the protection of freshwater quality life representing the concentration above which adverse effects may but will not always occur.
Receptor	Entity that may be adversely affected by contact with or by exposure to a contaminant of concern.
Reference area	An area that is reasonably similar in terms of monitored components and features to the exposure area, though not necessarily identical, but has no potential to be affected by the mine.
Regulated Monitoring	Monitoring specified in licences or regulations, including stations to be monitored, and discharge limits that must be achieved to maintain compliance with an authorization (i.e., Water Licence) or regulation (i.e., Metal and Diamond Mining Effluent Regulations). Enforcement action may be taken if discharge limits are exceeded for a parameter.
Secchi Depth	A parameter used to determine the clarity of surface waters. The measurement is made with a Secchi disk, a black and white disk that is lowered into the water and the depth is recorded at which it is no longer visible. Higher Secchi depth readings indicate clearer water that allows sunlight to penetrate to a greater depth. Lower readings indicate turbid water that can reduce the penetration of sunlight. Limited light penetration can be a factor in diminished aquatic plant growth beneath the surface, thus reducing the biological re-aeration at greater depths.
Total suspended solids (TSS)	A measurement of the concentration of particulate matter found in water.
Verification Monitoring	Monitoring carried out for operational and management purposes by Agnico Eagle. This type of monitoring provides data for decision making and builds confidence in the success of processes being used. There is no obligation to report verification monitoring results, although some monitoring locations are mentioned in environmental management plans (i.e., sampling to verify soil remediation in the landfarm).
Water Column	The water in any waterbody from the surface down to the substrate.
Zooplankton	Small, sometimes microscopic animals that live suspended in the water column.

ABBREVIATIONS AND ACRONYMS

Abbreviation	Term
AEMP	Aquatic Effects Monitoring Program
Agnico Eagle	Agnico Eagle Mines Limited
AIC	Akaike information criterion
ANCOVA	analysis of covariance
ANOVA	analysis of variance
BA	Before-After
CALA	Canadian Association for Laboratory Accreditation Inc.
CCME	Canadian Council of Ministers of the Environment
CDWQG	Canadian Drinking Water Quality Guidelines
CES	critical effect size
CI	Control-Impact
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CP	Contact Pond
CRM	certified reference standard
CWQG-PAL	Canadian water quality guidelines for the protection of aquatic life
DL	detection limit
DO	dissolved oxygen
DQO	data quality objective
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
EWTP	Effluent Water Treatment Plant
FEIS	Final Environmental Impact Statement
FEQG	federal environmental quality guideline
GN	Government of Nunavut
GSI	gonadosomatic index
IC25	effluent concentration that causes a 25% inhibitory effect in the sublethal endpoint being measured
ISQG	interim sediment quality guideline
IQ	Inuit Qaujimajatuqangit
IR	information request
KivIA	Kivalliq Inuit Association
K-S test	Kolmogorov-Smirnov test

Abbreviation	Term
LC50	median lethal concentration
log_{10}	logarithm base 10
LSI	liver somatic Index
LSM	least squares mean
MAC	maximum average concentration
MDMER	Metal and Diamond Mining Effluent Regulations
Mine	Meliadine Mine
Mt	million tonnes
NIRB	Nunavut Impact Review Board
nMDS	nonmetric multidimensional scaling
NWB	Nunavut Water Board
PEL	probable effect level
QA	quality assurance
QC	quality control
RCA	reference condition approach
SD	standard deviation
SDI	Simpson's diversity index
SE	standard error
SR	studentized residuals
SSWQO	site-specific water quality objectives
TDS	total dissolved solids
TGD	Technical Guidance Document (EEM)
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSF	Tailings storage facility
TSS	total suspended solids
UTM	Universal Transverse Mercator
VEC	valued ecosystem component
WAD	weak acid dissociable
WRSF	Waste rock storage facility

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This report has been prepared by Azimuth Consulting Group Inc. (Azimuth), for the use of Agnico Eagle Mines Limited (Agnico Eagle), who has been party to the development of the scope of work for this project and understands its limitations. The extent to which previous investigations were relied on is detailed in the report.

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1 INTRODUCTION

1.1 Objectives

This document describes the study design for the Aquatic Effects Monitoring Program (AEMP) for the Meliadine Mine (the Mine). The AEMP is a requirement of the Type A Water Licence (2AM-MEL-1631) and is the integrated monitoring program that considers activities that take place at the Mine, and the potential effects these activities may have on the aquatic environment.

The AEMP has three main objectives:

- Determine the short- and long-term effects of the Mine on aquatic receiving environments,
- Evaluate the accuracy of predictions made in the Final Environmental Impact Statement (FEIS), and
- Assess the effectiveness of proposed mitigation and management measures by providing input to the Adaptive Management Response Framework (**Section 5**).

Other objectives include incorporating Inuit Qaujimajatuqangit (IQ) into the study design (**Section 1.4**) and providing a basis for engagement and to solicit feedback on updates presented in this document.

1.2 Background

The AEMP was developed in two stages. First, a Conceptual AEMP was prepared as part of the Final Environmental Impact Statement (FEIS; Agnico Eagle, 2014). The Conceptual AEMP defined the principles and objectives of the AEMP as required by the Nunavut Impact Review Board (NIRB) during their review of the application in 2014:

> *The Proponent shall develop an Aquatic Effects Monitoring Plan to provide information on monitoring, to address mitigation measures to be implemented to protect and minimize the impacts on aquatic system from any and all project activities occurring in or near and watercourses during construction, operation, temporary closure, final closure (decommission & reclamation), post-closure phases.*

Version 1 of the AEMP Design Plan (Golder, 2016) was developed in consultation with local communities, stakeholders, and regulatory authorities and incorporated IQ into the overall study design (**Section 1.4**). Two separate studies were included in Version 1 of the AEMP Design Plan: the Meliadine Lake study and the Peninsula Lakes study. The AEMP is primarily focuses on monitoring changes in water quality and the health of aquatic life in Meliadine Lake because it is the receiving environment for discharge of surface contact water (effluent) collected at the Mine. The Meliadine Lake study was designed based on the Environmental Effects Monitoring (EEM) program with additional monitoring requirements from the environmental assessment and Water Licence process. The core components of the AEMP include effluent and water quality, benthic invertebrates (and sediment), and fish health. The AEMP also monitors changes in the phytoplankton community and changes in fish tissue chemistry.

The Peninsula Lakes study was included in the AEMP to monitor changes in water quality from non-point source discharges and physical changes to the small watersheds near the Mine. Development of additional deposits near the Mine will require dewatering of two of the three lakes currently included in the Peninsula Lakes study (Lake A8 and Lake B7). Moving forward, Agnico Eagle recommends that water quality monitoring for small lakes near the Mine be conducted as part of the Water Quality and Flow Monitoring Plan (rationale provided in **Section 1.5**).

1.3 Applicable Regulations

The AEMP complies with existing regulations and follows available guidelines provided by the federal government and the Government of Nunavut. Applicable regulations and guidelines are:

- Fisheries Act (Government of Canada, 1985), including the MDMER (Government of Canada, 2002),
- Nunavut Environmental Protection Act (Government of Northwest Territories, 1988),
- Nunavut Land Claim Agreement Act (Government of Canada, 1993).

1.4 Incorporation of Traditional Knowledge/Inuit Qaujimajatuqangit

Inuit Qaujimajatuqangit (IQ) is the most successful and oldest monitoring practice in Nunavut, where the resource users do the observing or monitoring. Information collected can contribute to mine design and monitoring. Agnico Eagle is committed to including IQ and accounting for public concerns stemming from IQ, where practical, in the design of management and monitoring plans for the Mine.

Through the public consultation process for the Meliadine FEIS and the Traditional Use Study (FEIS, Volume 9), Meliadine Lake was identified as an important drinking water source, including use for making tea, by local residents (Agnico Eagle 2014b). Domestic fishing is an important part of the Inuit way of life, and most of the waterbodies in the study area are fished for Lake Trout and Arctic Char. Therefore, the fish health program incorporated Lake Trout as the large-bodied fish species. Based on IQ and community consultation, the importance of clean water and the health of fish and birds was emphasized by the Elders and other people in the communities who rely on these resources for traditional use.

Agnico Eagle will continue to engage with communities and Inuit organizations as the Mine proceeds through operations and closure. In addition, feedback will be sought on how to report the results to the local communities in a relevant and meaningful way. This consultation and engagement may lead to inclusion of additional IQ in future updates to the AEMP.

1.5 Updates to the AEMP Design Plan in Version 3

Version 3 of the AEMP Design Plan was prepared to support the Water Licence Amendment Application to allow Agnico Eagle to develop deposits that were included in the Approved Project. Those deposits include Pump, F Zone, Wesmeg, and Discovery. Two notable changes were made to the AEMP Design Plan as part of this submission: (1) conduct water quality monitoring for the Peninsula Lakes study within the Water Quality and Flow Monitoring Plan (Appendix D in the Water Management Plan), and (2) conduct the fish health study for the AEMP as outlined in the Cycle 3 EEM study design.

Remove the Peninsula Lakes from the AEMP

As outlined in the 2014 FEIS, Lake B7 and Lake A8 will be dewatered during the next phase of mining. Lake B7 will eventually be converted into a saline pond to store water from the underground mine. Lake A8 will be dewatered before mining the Wesmeg and Pump deposits. No construction or mining activities are planned for the area adjacent to Lake D7 (located west and south of Lake B7).

Instead of retaining Lake D7 in the AEMP, Agnico Eagle recommends incorporating the water quality monitoring program for Lake D7, and any lakes selected in the future for monitoring non-point source discharges from mining activities, into the Water Quality and Flow Monitoring Plan (The Plan; Appendix D of the Water Management Plan). The Plan operates in parallel to the AEMP to monitor the performance of waste and water management systems at the Mine. Similar to the AEMP, The Plan describes where, when, and how to sample, what parameters to measure, compliance criteria to measure performance, and an adaptive management plan. Lake D7 would fit well in the Compliance Monitoring Program. Integrating Lake D7 into The Plan would consolidate water quality monitoring for the small lakes under one program. Having two programs running in parallel to collect water quality data from small lakes near the mine is inefficient. Two programs also create unnecessary steps regarding adaptive management.

Harmonize the AEMP Fish Population Studies with the EEM Program

The fish population studies described in the current version of AEMP Design Plan (Version 2_NWB) are not consistent with the studies conducted for the Cycle 2 EEM in 2021. For example, the Lake Trout health study for the AEMP was based on a before-after study design whereas the Cycle 2 EEM program included two external reference lakes in a multiple-control impact study design. Having two separate studies creates inefficiencies in the field and when reporting the results. Furthermore, using different study designs and data increases the likelihood of drawing different conclusions regarding the health of the fish populations.

When the fish population studies were initially designed in 2016, the goal was to complete one program that satisfies the requirements of the Water Licence and MDMER so fisheries data are collected, analyzed, and interpreted as efficiently as possible. We recommend that the upcoming fish population studies scheduled for the 2024 AEMP mirror the EEM program study design to achieve this objective.

The study design for the Cycle 3 EEM program is currently being drafted. The study design will be submitted to Environment and Climate Change Canada (ECCC) in early February 2024.

2 MINE OVERVIEW

2.1 Mine Site Location and Layout

The Meliadine Mine (Mine) is in the Kivalliq District of Nunavut near the western shore of Hudson Bay (**Figure 2-1**). The nearest community is Rankin Inlet, located approximately 25 km south of the Mine on the Kudlulik Peninsula. The Mine is located within the Meliadine Lake watershed of the Wilson Water Management Area (Nunavut Water Regulations Schedule 4).

The Mine consists of the following facilities that were assessed in the Approved Project (2014 FEIS) and included in the Type A Water Licence (2AM-MEL1631): the power plant, mill, underground mine, Tiriganiaq Pits 1 and 2, camp, ore stockpiles, waste rock storage facilities (WRSF 1&3), the tailings storage facility (TSF), landfill, incinerator, landfarm, emulsion plant, a potable water and sewage collection and treatment system, contact and saline treatment system, water intake, diffuser, quarries and borrow pits, water management infrastructure (e.g., saline and contact water collection ponds, channels, dikes, berms, jetties, pump systems and pipelines, and culverts), the All-Weather-Access-Road (AWAR) and bypass road, access roads.

The layout of the Mine as of 2023 is shown in **Figure 2-2**.

2.2 Mining Operations

The Mine started commercial gold production in 2019 with mining of the Tiriganiaq deposit. Underground and open pit methods have been used to develop the Tiriganiaq deposit. In addition to Tiriganiaq, Project Certificate No. 006 granted Agnico Eagle approval to mine F Zone, Pump, Wesmeg, and Discovery. The additional deposits will extend the life of the mine to 2031.

The extent of the Mine at the end of operations in 2031 is shown in **Figure 2-3**.

2.3 Waste Rock and Tailings Management

There are three types of mine waste associated with the development of the deposits: waste rock, tailings, and overburden material. Overburden refers to the soil and till that need to be removed prior to developing the open pits. Waste rock refers to the fragment rock with no economic value that is initially removed during development of the open pit and underground workings. Tailings are the residual waste left over after the ore is processed in the mill.

Waste rock and overburden are co-managed within the Mine Waste Management Plan. The majority of the waste rock is stored in designated waste rock and overburden storage facilities (WRSFs). Two WRSFs are currently in use: WRSF1 located north of Tiriganiaq Pit 1 and WRSF3 located between Tiriganiaq Pit 2 and the Exploration Camp (**Figure 2-2**). Waste rock from the underground mine is temporarily stored in a saline WRSF on the surface before being brought back underground for permanent storage after the ore has been recovered. Additional WRSFs are planned to manage waste rock from open-pit mining at Pump (WRSF6), F Zone (WRSF7), and Discovery (WRSF9).

Geochemical testing indicates that the waste rock and overburden from the Tiriganiaq area is not acid generating, nor metal leaching (Golder, 2020). Therefore, waste rock is not expected to contribute to acidic conditions or leach metals into surface contact water. Waste rock from the Discovery deposit contains rock with potential for acid generation (PAG), or potential to leach metals and will require a thermal cover to reduce potential impacts on the environment.

The mill uses a conventional gold circuit comprising crushing, grinding, gravity separation and cyanide leaching with a carbon-in-leach circuit, followed by cyanide destruction and filtration of the tailings. The final solids content of the tailings is approximately 85% by weight, with a consistency of "damp, sandy silt" (Agnico Eagle, 2020). Tailings are either sent to the TSF ("dry stacking") or used as backfill, underground. None of the water used in the milling circuit is discharged to Meliadine Lake.

2.4 Water Management

The objective of the Water Management Plan is to minimize potential impacts to the quantity and quality of surface water from operations at the mine. The two main sources of water that require management are: (1) surface contact water and (2) saline contact groundwater from underground mining operations. An overview of surface contact water collection, treatment, storage, and disposal is provided below based on the Water Management Plan in place for the Mine.

2.4.1 Collection, Storage, and Treatment of Surface Contact Water

Surface contact water refers to precipitation and runoff that occurs within the footprint of the Mine. The general strategy for managing surface contact water is to intercept water that comes in contact with mine infrastructure and direct it towards contact water ponds (CPs) through a network of dikes, channels, and culverts. Six CPs are currently in operation (**Table 2-1**). CP2 through CP6 are located near major infrastructure (**Figure 2-2**). Water from these peripheral CPs is ultimately pumped to CP1. Other sources of water to CP1 include direct runoff from the CP1 catchment and treated wastewater from the Sewage Treatment Plant (STP).

Surface contact water in CP1 is discharged to Meliadine Lake after treatment at the Effluent Water Treatment Plant (EWTP). The purpose of the EWTP is to reduce total suspended solids (TSS) to below 15 mg/L.

Figure 2-1. Study area for the Meliadine AEMP

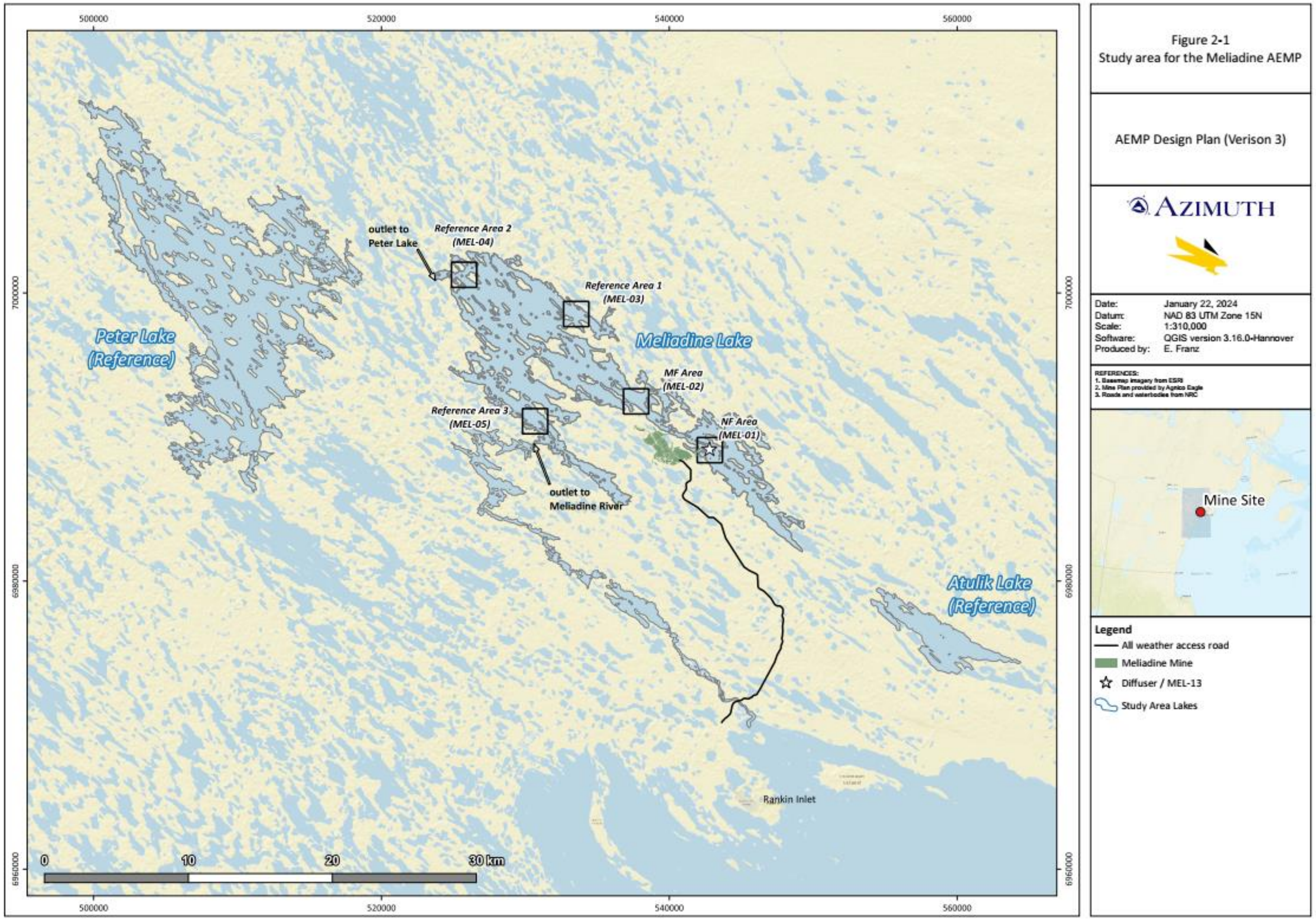


Figure 2-2. Meliadine Mine (2023)

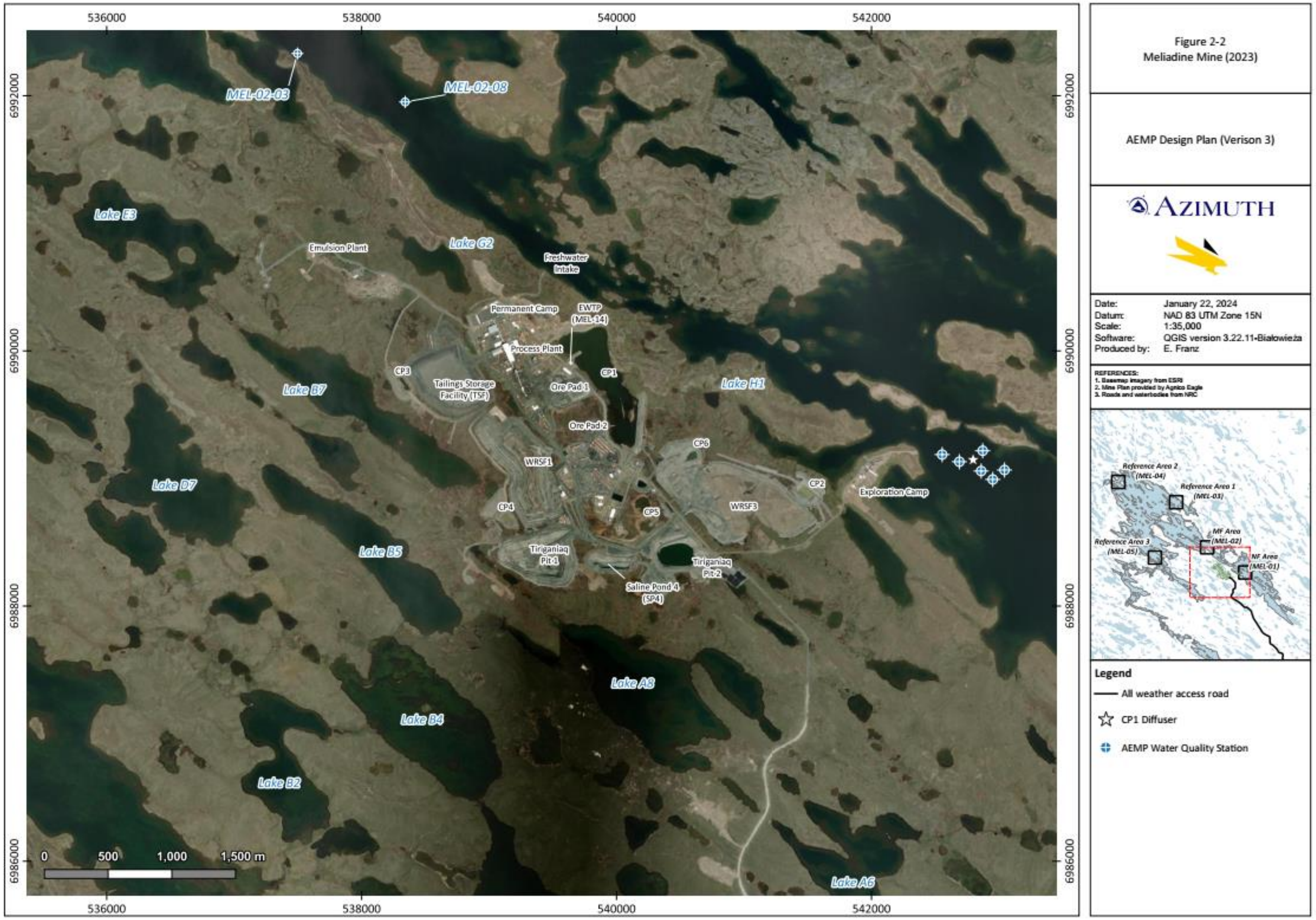


Figure 2-3. Meliadine Mine (2031)

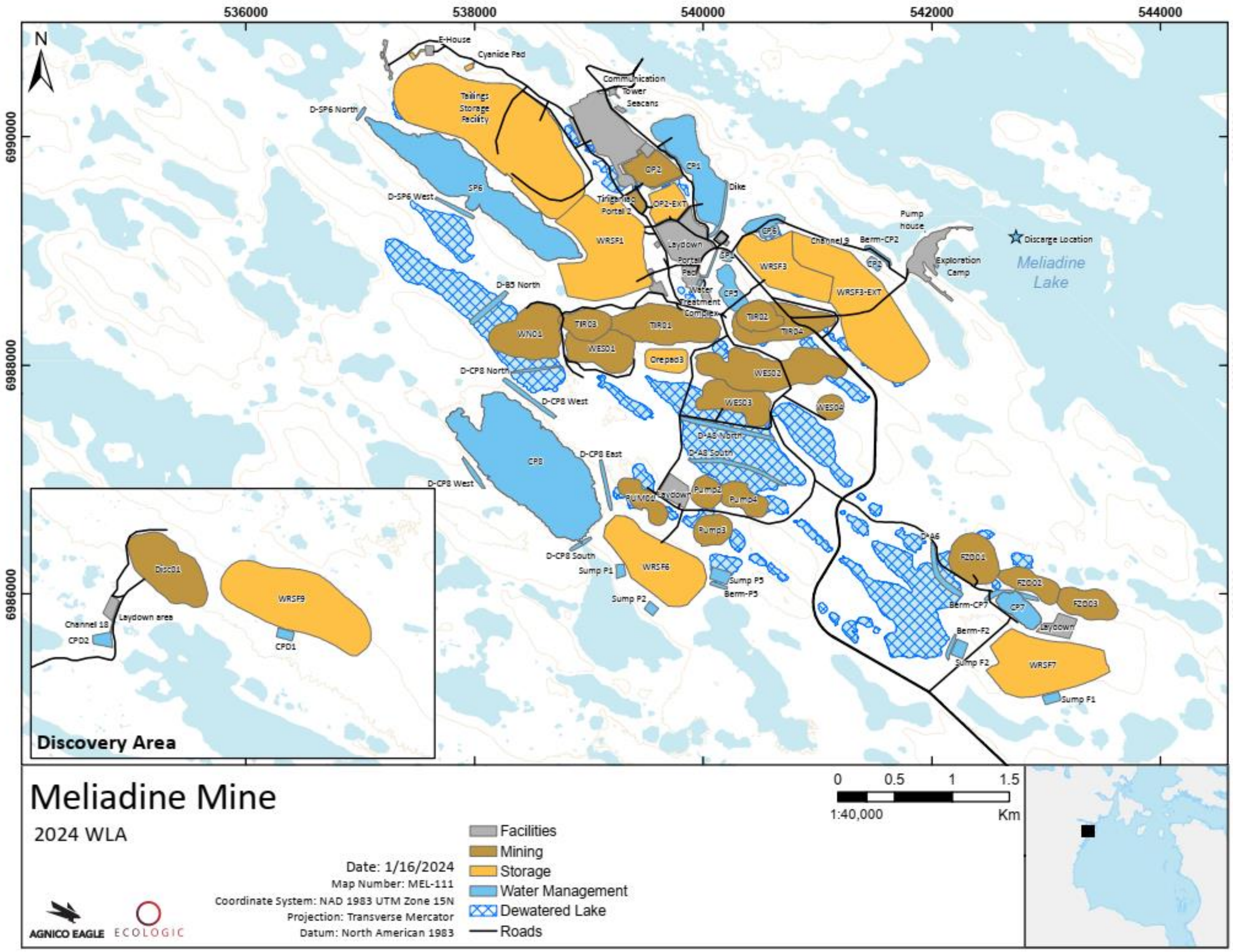


Table 2-1. Current Surface Contact Water Management

Source	Closest Contact Water Pond (CP)
Industrial Site Pad, Ore Storage Pad 2, Landfill	CP1
Waste rock storage facility 1 (WRSF1)	CP1, CP4, CP5
Waste rock storage facility 3 (WRSF3)	CP2 and CP6
Tiriganiaq Pit 1	Salinity based: CP4/CP5, SP1, or Tiriganiaq Pit 2
Tailings Storage Facility (TSF)	CP1 and CP3

2.4.2 Effluent Discharge to Meliadine Lake

The Mine is authorized to discharge surface contact water to Meliadine Lake under the Type A Amended Water Licence 2AM-MEL1631 (NWB, 2021). MEL-14 is the compliance station for effluent chemistry and toxicity testing specified under MDMER and the Water Licence. MEL-13 is the first receiving environment station in Meliadine Lake and is located where effluent enters Meliadine Lake at the permanent diffuser (located at N 6,989,147.41 and E 542,797.91). Water samples are collected monthly at MEL-13 and reference station MEL-03-01 to comply with MDMER and Water Licence reporting.

The diffuser was installed in August 2017 and is approximately 30 m in length, 40 cm in diameter, and sits 2 m above the lake bed in approximately 11 m of water. Effluent is released through 10 x 5 cm diameter ports spaced evenly every 3 m along the length of the diffuser (Tetra Tech, 2018).

2.5 Environmental Setting

Meliadine Lake is one of the larger lakes in the region with a surface area of approximately 107 km^2 and a maximum length of 31 km (SE to NW). The morphology of the lake is characterized by a highly convoluted shoreline, numerous islands, and shallow reefs. More than one third of the volume of Meliadine Lake is comprised of areas that are less than 2 m in depth, which indicates a considerable reduction in fish overwintering habitat (Golder, 2019). Maximum ice thickness is about 2 m and occurs in March/April, increasing the concentration of some ions, such as chloride, in the water near the ice-water interface. This occurs due to cryo-concentration, where ice formation excludes certain ions and increases their concentration in the water column (Wetzel 2001). This phenomenon is well documented at reference lakes and exposure areas sampled in the winter as part of the Core Receiving Environment Monitoring Program (CREMP) for the Meadowbank Mine (Azimuth 2019).

Meliadine Lake has three connected yet distinct basins based on its morphology.

- The east basin is 2,212 ha (21% of the lake area). A narrow channel separates the east basin from the rest of the lake to the northwest. This narrow area is approximately 100 to 300 m wide and 800 m long. There are several rock outcroppings in this channel and water levels are less than 2 m in several places. During the winter, the east basin may be isolated from areas to the northwest, preventing fish passage (Agnico Eagle, 2014).
- The northwest basin is the largest basin in Meliadine Lake (7,100 ha; 68 % of the lake area). The outlet to Peter Lake is located in the northwest corner of this basin.
- The southwest basin is 1,135 ha (11% of the lake area). The outlet to the Meliadine River is located at the southeast end of the is basin. Water is generally less than 4 m deep in this area.

Baseline water quality in Meliadine Lake was typical of northern latitude lakes, with low concentrations of total dissolved solids (TDS), hardness, alkalinity, specific conductivity, nutrients, and metals. Slight differences in water quality were evident among the different basins, with higher specific conductivity and higher concentrations of major cations, chloride, sulphate, and some metals (e.g., total arsenic, barium, cobalt, copper, nickel, silicon, and strontium) concentrations in the near-field area compared to the mid-field and reference areas. Natural differences in water chemistry among the basins is important to account for when assessing mining vs natural changes in water quality as well as other AEMP monitoring components.

Lakebed substrate in Meliadine Lake is characterized by coarse materials in the shallow areas close to shore. Transition areas, consisting of fine organic materials interspersed among cobble and courser substrates are common throughout most of the lake. Substrates within deeper areas of the lake are composed primarily of fine particulate organic material and silt (Golder, 2014). Under baseline conditions, concentrations of arsenic, chromium, and copper were above generic sediment quality guidelines in some areas, with the highest concentrations in the near-field stations, even after sediment chemistry was normalized to fine sediment content before analysis (Golder, 2018). Higher concentrations of these metals are indicative of the more mineralized area around the east basin compare to the mid-field and reference areas.

3 CONCEPTUAL SITE MODEL

3.1 Introduction

Conceptual site models are used extensively in ecological risk assessments to describe key relationships between natural processes (i.e., natural stressors), human activities (i.e., project-related stressors), and the plants and animals that utilize habitats in the vicinity of the study area (i.e., human and ecological receptors). Conceptual site models are also an important step when designing an effective AEMP (INAC, 2009). A conceptual site model was developed in Version 1 of the AEMP Design Plan to visualize site characteristics and provide a clear understanding of potential adverse effects of the Mine on aquatic receiving environments. Potential adverse effects from the Mine were broadly defined as either toxicological or nutrient-related:

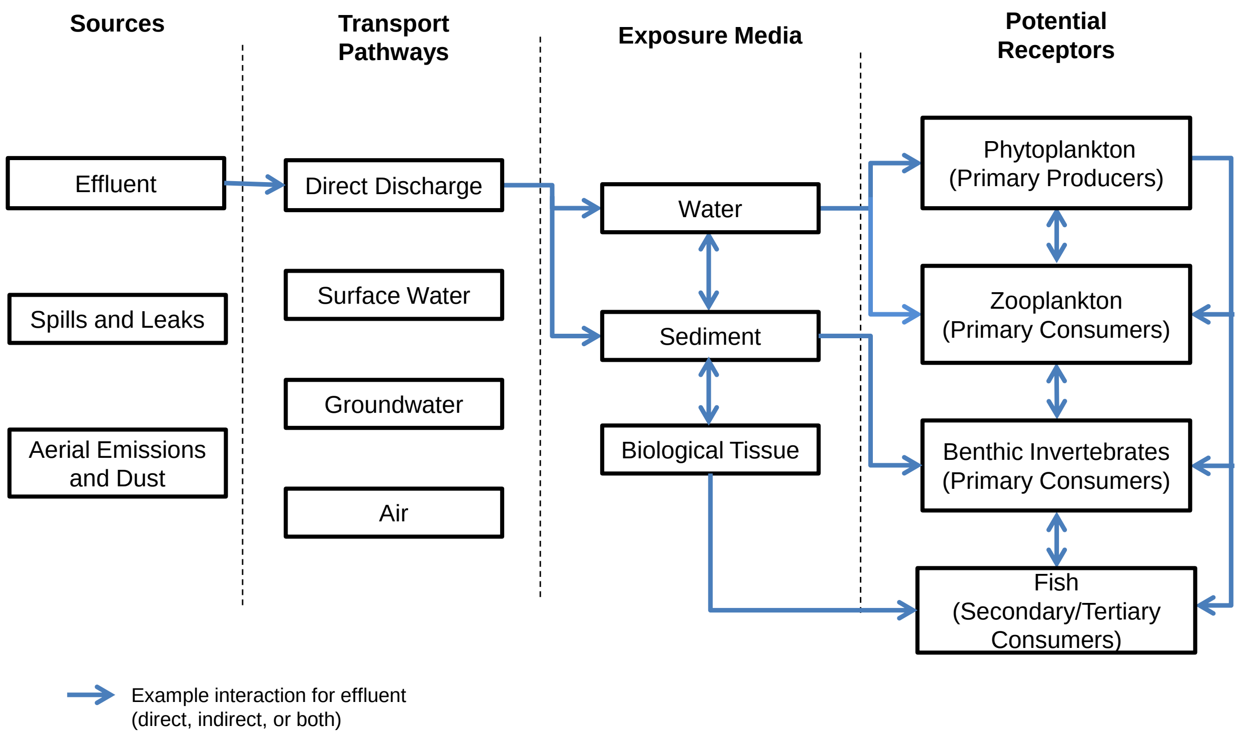
- Toxicological Impairment Hypothesis: Toxicity to aquatic organisms may occur either directly or indirectly due to the release of substances of toxicological concern. Direct interactions involve direct influences on a receptor. For example, direct toxicity to fish due to an elevated concentration of an ion or a metal represents a direct pathway. Indirect toxicological effects to fish may occur if lower trophic level communities are impacted.
- Nutrient Enrichment Hypothesis: Increased productivity may occur due to the release of nutrients (primarily phosphorus and nitrogen) in effluent. Nutrient enrichment would manifest as increased primary productivity, which can contribute to higher rates of decomposition, in turn reducing dissolved oxygen concentration and the capacity of a waterbody to support aquatic life (i.e., invertebrates and fish).

The following information was integrated into the conceptual site model in Version 1 of the AEMP Design Plan:

- The overall mine plan and major activities during construction, operation, and closure,
- Contaminants of potential concern for the aquatic receiving environment (Volume 10 of the 2014 FEIS),
- The ecology of the aquatic ecosystem in the AEMP study area (Volume 7 of the 2014 FEIS), and
- Predictions in the 2014 FEIS.

The conceptual site model focuses on environmental variables related to commitments made by Agnico Eagle and conditions stipulated during the environmental permitting process. A simple box-style conceptual site model that illustrates the stressor specific pathway for effluent discharge to Meliadine Lake is shown in **Figure 3-1**. This type of generic conceptual site model is an effective way of showing the relevant sources, stressors, transport pathways, exposure media, routes of exposure, and receptors of concern.

Figure 3-1. Conceptual Site Model for Effluent Discharge to Meliadine Lake.



3.2 Receptors of Concern and Aquatic Interactions

A receptor of concern is any organism, population, community, habitat or ecosystem that is potentially exposed to a stressor. The level of biological organization varies depending on the receptor. Phytoplankton and aquatic invertebrate are typically identified at the community level, whereas fish are usually defined at the population level (e.g., fish population). In aquatic monitoring programs, it is common to select a 'surrogate' species to represent other species that may be difficult to assess (e.g., difficult to catch). For example, Threespine Stickleback are the surrogate species used to monitor effects to all small-bodied fish species in Meliadine Lake.

The term 'receptors of concern' is generally equivalent to the term 'valued ecosystem components' used in the 2014 FEIS. The following valued ecosystem components that are relevant to the AEMP were included in the ecological risk assessment: plankton (phytoplankton and zooplankton[1]), benthic invertebrates, and fish (refer to Table 10.1-1 in the 2014 FEIS).

- Phytoplankton and periphyton form the base of the aquatic food web. Algal species use nutrients and carbon sources (i.e., internal recycling and renewed external sources) for growth, and are food for aquatic invertebrates. The structure and biomass of the

[1] Zooplankton was not integrated into the Meliadine Lake AEMP due to high variability in the zooplankton dataset (Golder, 2018).

phytoplankton and periphyton communities can change due to effluent released by a mine (e.g., increased growth from nutrient enrichment, or decreased growth from direct toxicity). Changes in the phytoplankton community can affect the zooplankton and benthic invertebrate communities.

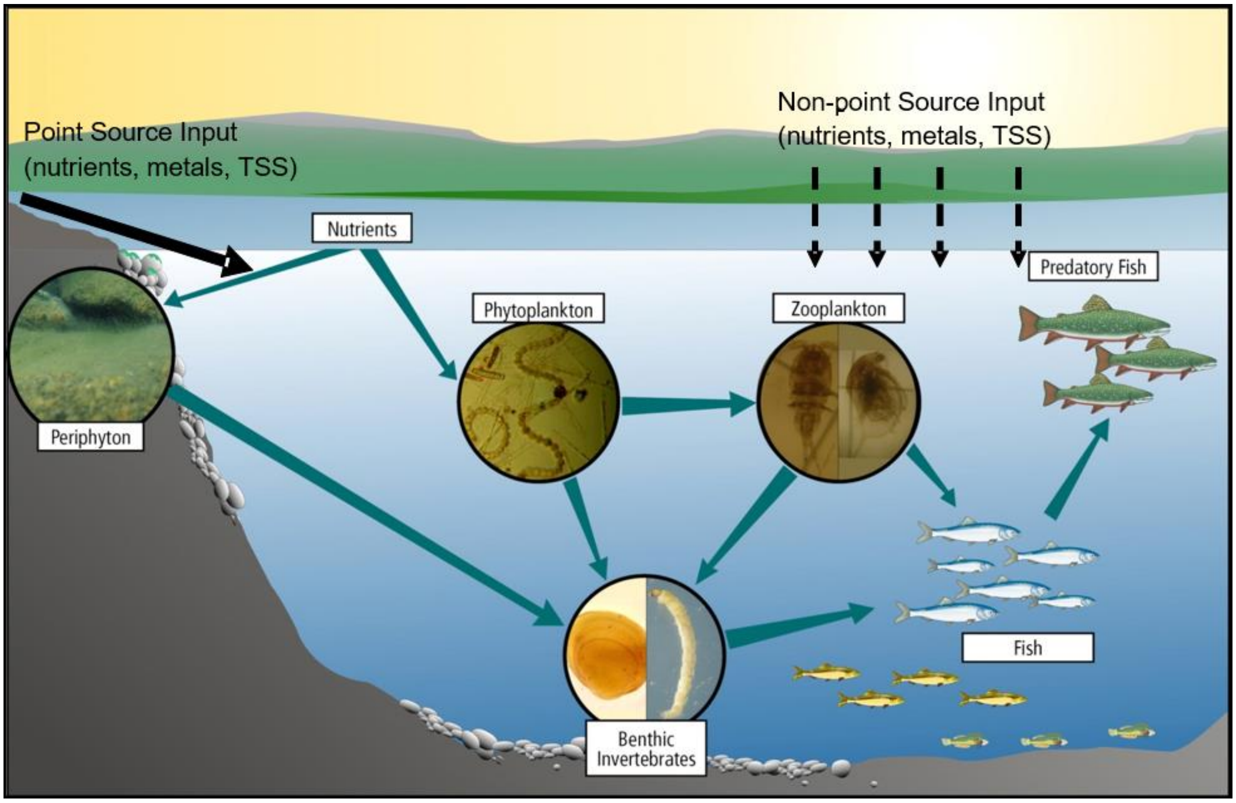
- Benthic Invertebrates play a vital role in nutrient cycling and the breakdown of detritus in the aquatic environment. They are also an important food source for small forage fish and juvenile predatory fish species. Benthic invertebrates are well-suited to monitoring changes in the environment because they are often abundant, easy to collect, and sensitive to change, showing early responses to environmental stress (Reynoldson and Metcalfe-Smith 1992; Resh and Rosenberg 1993). In the context of the Meliadine AEMP, the main stressor(s) of concern are nutrients and metals in effluent. The pattern of change for mild nutrient enrichment would typically be an increase in the abundance and number of benthic invertebrate taxa (taxon richness), whereas elevated concentrations of metals in water or sediment could lead to the loss of sensitive taxa and lower abundance (Environment Canada, 2012).
- Fish were selected as a valued ecosystem components because domestic fishing is an important part of Inuit life. Several fish species occur in the region. Lake Trout (*Salvelinus namaycush*), Arctic Char (*Salvelinus alpinus*), and Arctic Grayling (*Thymallus arcticus*) are important species for subsistence use; Lake Trout and Arctic Grayling are important recreational species. Small forage species such as Threespine Stickleback (*Gasterosteus aculeatus*) and Slimy Sculpin (*Cottus cognatus*) provide food for larger, predatory species.

3.3 Stressors and Transport Pathways

In the context of the AEMP, stressors are chemical or physical agents that have the potential to cause adverse effects to the receiving environment. Transport pathways determine how stressors will move from source(s) to the aquatic environment where they may affect aquatic receptors. The most obvious transport pathway for the aquatic receiving environments is surface water, but other pathways such as groundwater and air (e.g., erosion or dust) are also relevant. In the aquatic environments, most stressors would be present initially in the water column. However, once in the water column, stressors may partition among water, sediment, and tissues depending on their characteristics.

The pathways considered in the Meliadine Lake study conceptual site model that could cause changes in the aquatic ecosystem include the discharge of treated effluent and air emissions (acidifying emissions, dust, and associated metals [**Figure 3-2**]). These activities, alone or in combination, during construction and operations could potentially cause a change in water and sediment quality, as well as affect aquatic habitats and lower trophic levels, the abundance and distribution of fish, and the continued use of fish by traditional users.

Figure 3-2. Conceptual representation of interactions between stressors and receptors in an aquatic Ecosystem



3.4 Assessment Endpoints and Measurement Endpoints

Assessment and measurement endpoints are terms commonly used in environmental assessments to describe the valued component to be protected and the indicators used to measure potential effects. Assessment endpoints identify what is to be protected (e.g., healthy fish populations) and measurement endpoints are the quantifiable metrics used to measure potential effects. The assessment endpoints for the AEMP were selected based on the following valued components identified in the FEIS:

- water is safe for human and wildlife consumption,
- fish are safe to eat for human and wildlife consumption, and
- the ecological function of the aquatic ecosystem is maintained (e.g., there is adequate food for fish, and fish are able to survive, grow, and reproduce).

Assessment and measurement endpoints currently included in the AEMP Design Plan are listed in **Table 3-1**. The assessment and measurement endpoints are considered as part of the Response Framework (**Section 5**) and in the integration of results in the AEMP report (**Section 6**).

Table 3-1. Assessment and Measurement Endpoints in the AEMP

Assessment Endpoint (attribute to protect)	Measurement Endpoints
Water and sediment quality support a healthy aquatic ecosystem	Effluent quality, surface water quality, sediment chemistry Acute and chronic toxicity tests using standardized aquatic test species
Maintenance of a health phytoplankton community compared to baseline conditions and/or reference communities	Phytoplankton biomass, density, and taxa richness Chlorophyll-a concentrations (supporting metric)
Benthic invertebrate communities are characteristic of an oligotrophic subarctic lake	Total invertebrate density and densities of dominant invertebrate groups, Taxonomic richness
Self-sustaining and healthy fish populations compared to baseline and/or reference area populations	Measurement endpoints for the AEMP are aligned with the scope of the EEM Program. Endpoints typically considered in fish population studies for EEM programs include: Survival, age, length, weight, condition, length-frequency distribution, size-at-age.
Continued opportunity for use of surface water and fisheries for traditional and non-traditional human use	Surface water quality Fish tissue metal concentrations that are consistent with baseline/reference conditions

4 AEMP STUDY DESIGN

The core components of the Meliadine Lake AEMP include:

- Effluent and surface water quality (**Section 4.3**)
- Phytoplankton community (**Section 4.4**),
- Benthic invertebrate community (**Section 4.5**),
- Sediment quality (**Section 4.6**),
- Fish health (small-bodied and large-bodied species; **Section 4.7**), and
- Fish tissue chemistry (**Section 4.8**).

The fish health studies described in **Section 4.7** may need to be refined after the Technical Advisory Panel reviews the Cycle 3 EEM study design. The goal is to complete one program that satisfies the requirements of the Water Licence and MDMER so fisheries data are collected, analyzed, and interpreted as efficiently as possible.

No changes are proposed to the frequency or timing of sample collection for other components of the Meliadine Lake AEMP.

4.1 Key Questions

Key questions were developed for each component of the AEMP to help define the study design focus analysis and interpretation of the monitoring data. The Key Questions in **Table 4-1** are directly related to the assessment endpoints described in **Section 3.4**.

Table 4-1. Key questions for each component of the AEMP

Component	Key Questions
Water Quality	Are concentrations of key parameters in effluent less than the limits specified in the Water Licence?
	Has water quality in the exposure areas changed over time, relative to reference/baseline areas?
	Is water quality consistent with predictions in the FEIS and below guidelines to protect aquatic life and human health?
Phytoplankton Community	Is the phytoplankton community affected by potential mine-related changes in water quality in Meliadine Lake?
Benthic Invertebrate Community	Is the benthic invertebrate community affected by potential mine-related changes in water and sediment quality in Meliadine Lake?

Table 4-1. Key questions for each component of the AEMP

Component	Key Questions
Fish Health	Is fish health affected by changes in water and sediment quality in Meliadine Lake?
Fish Tissue Chemistry	Are tissue metal concentrations in fish from Meliadine Lake increasing due to mining activities?
	Are tissue metal concentrations in fish from Meliadine Lake increasing relative to reference areas or baseline?

4.2 Sampling Plan

The sampling locations in Meliadine are shown in **Figure 4-1**.

Station depths and coordinates for the co-located surface water, phytoplankton, sediment, and benthic invertebrate stations are provided in **Table 4-2**.

The frequency of sampling by area and monitoring component is presented in **Table 4-3**.

4.2.1 Study Areas

The Meliadine Lake study areas were selected based on the spatial extent of effects predicted in the FEIS, concerns raised through the FEIS process about potential far downstream effects, and requirements under the federal MDMER EEM program. Predictions for the Mine (as reported in the FEIS) were that water quality concentrations at the edge of the mixing zone would not exceed Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the protection of freshwater aquatic life (FWAL; CCME, 1999), or Canadian Drinking Water Quality Guidelines (GCDWQ; Health Canada 2020). However, reviewers of the FEIS were concerned about potential far-field changes in Meliadine Lake and potential changes as far downstream as Peter Lake. To address these concerns, monitoring areas were established throughout Meliadine Lake to detect mine-related changes and define the spatial and temporal extent of those changes. The study design includes two exposure areas (near-field, mid-field) and three reference areas to provide spatial context when interpreting potential changes within and between years.

- Near-field (MEL-01) – The near-field area (MEL-01) is located in the east basin around the diffuser. Changes in water quality and effects to the biological communities caused by effluent discharged to Meliadine Lake would be expected to occur at MEL-01 first.
- Mid-field (MEL-02) – The mid-field area (MEL-02) is located approximately 6 km downstream from MEL-01 past “the narrows” that separates the east and northwest basins. Monitoring data from MEL-02 helps define the spatial extent of potential changes observed at MEL-01.

- Three internal reference areas are included in the study design to provide insights into regional trends that would be expected to influence all sampling areas. Reference Area 1 (MEL-03) is located in a bay in the northwest basin of Meliadine Lake. Reference Area 2 (MEL-04) is located in a northwest area of the lake near the outlet to Peter Lake. Reference Area 3 (MEL-05) is located in the southwest basin near the outlet to the Meliadine River.

Reference Area Considerations

Nearby reference lake(s) with similar morphology, fish assemblage, and accessibility that meets health and safety needs, were not identified during the baseline period when data was collected to support the FEIS. Furthermore, sending field crews to far off locations to collect biological data is a high-risk activity. To reduce the health and safety risks but still meet the regulatory needs of the AEMP, reference areas as close to the Mine as possible are a preferred alternative. Internal reference areas are still considered suitable for most components of the AEMP based on the following considerations:

- The quantity of effluent is small relative to the volume of Meliadine Lake. Bathymetry surveys were completed in the east and south basins, and the volume of water in each domain is estimated at 98,851,000 m^3 and 48,429,000 m^3, respectively. The largest volume of water discharged from CP1 to Meliadine Lake was 1 mM in 2020. Furthermore, the Mine is only authorized to discharge water during the open water season, typically late June through September.
- The distance between the diffuser, the three reference areas, and the lake outlets are as follows:
    - Reference Area 1 (MEL-03) – 16 km
    - Reference Area 2 (MEL-04) – 19 km
    - Reference Area 3 (MEL-05) – 21 km
    - Outlet to Peter Lake (MEL-04) – 20 km
    - Outlet to the Meliadine River (MEL-05) – 48 km
    - Due to the seasonal discharge to Meliadine Lake, the conservatism in the site water balance and water quality discharge model, the size of Meliadine Lake (107 km^2 in surface area), the distance between the diffuser and Reference Areas, and the natural mixing processes in Meliadine Lake, in-lake reference areas are still suitable for the AEMP.
- Concentrations at the edge of the mixing zone (100 m from the diffuser) are consistently less than water quality guidelines to protect aquatic life and human health (Azimuth, 2023).
- Some of the species observed in Meliadine Lake do not co-occur in neighboring lakes in sufficient numbers to support the AEMP. This was particularly evident for small-bodied fish,

which are sampled in the AEMP and EEM program. Threespine Stickleback (*Gasterosteus aculeatus*) was the dominant small-bodied species at Meliadine Lake, but they were not captured at any of the reference lakes sampled during the baseline period (Table 4 3). Threespine Stickleback was selected as the sentinel species for the AEMP due to their small size, early age-of-maturity, small home-range size, and high abundance in Meliadine Lake.

Based on these considerations, internal reference areas are acceptable for assessing mining-related impacts to phytoplankton, benthic invertebrates, and small-bodied fish because each of these components of the aquatic ecosystem have relatively small home ranges. This is important for assessing differences among the near-field, mid-field, and reference area populations in Meliadine Lake.

Unlike small-bodied fish species, large-bodied fish species like Lake Trout have larger home ranges which makes it difficult to accurately estimate fish exposure to effluent discharged in the east basin. Radiotelemetry data collected during the baseline period indicated Lake Trout migrate extensively within Meliadine Lake and as far downstream as the Meliadine River (Golder, 2012). Because there is no true control or reference area within Meliadine Lake, the Lake Trout study design in Version 1 of the AEMP Design Plan was a before-after study. The main limitation with before-after study designs is they cannot distinguish between natural and mining-related changes if differences in the measurement endpoints are detected. Recognizing this limitation, the lake trout population study for the Cycle 2 EEM study was conducted using two external reference lakes (Peter Lake and Atulik Lake).

The Cycle 3 EEM program study design due to ECCC in early February 2024. The plan is to conduct a repeat of the Cycle 2 EEM with Atulik Lake and Peter Lake as the external reference areas. This is the most scientifically-defensible program for assessing mining-related effects to Lake Trout in Meliadine Lake.

Figure 4-1. Sampling Areas and Stations for the Meliadine Lake AEMP.

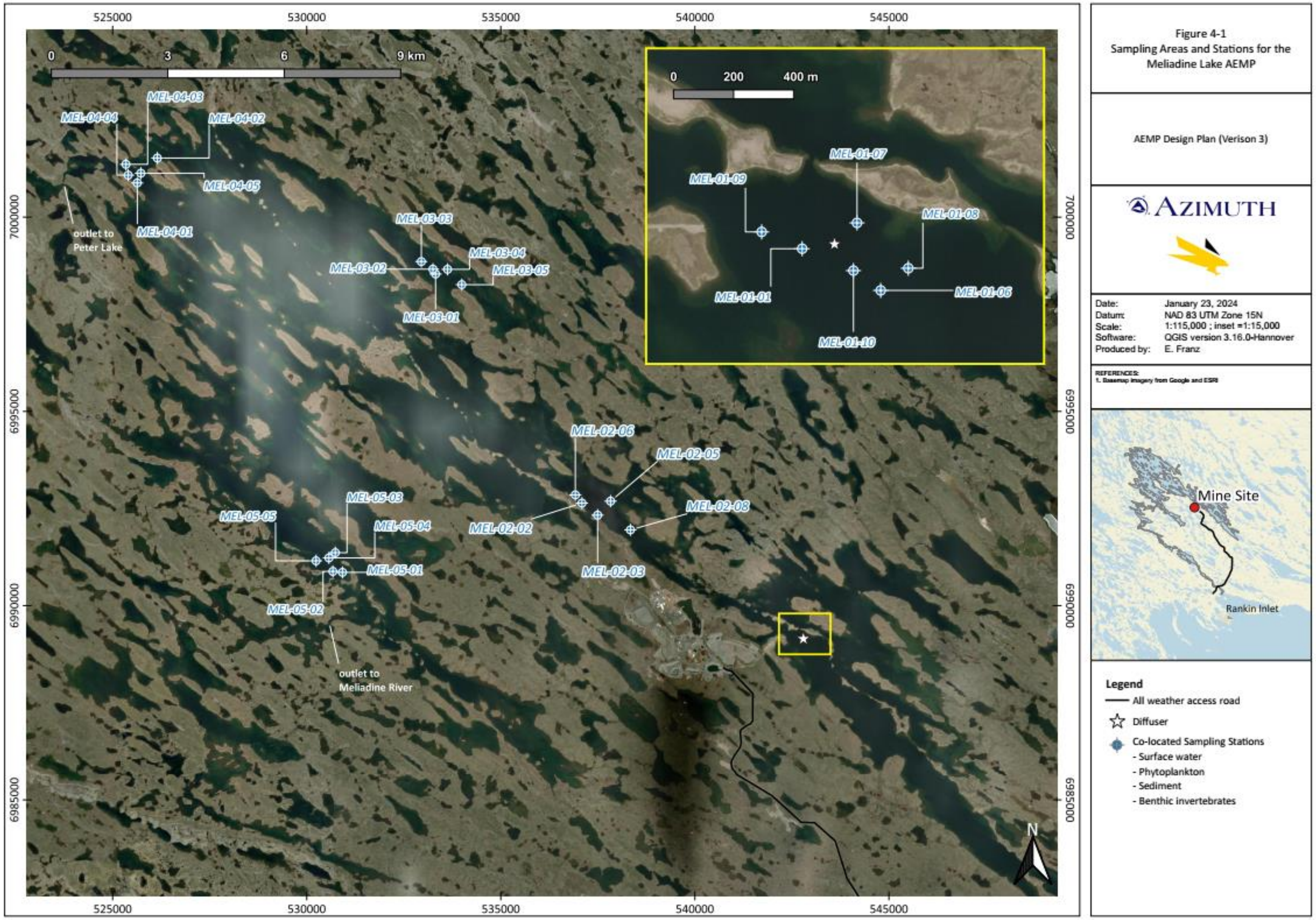


Table 4-2. Sampling Stations for Meliadine Lake Study (NAD 83, Zone 15N).

Area	Station ID	Water and Phytoplankton			Sediment and Benthic Invertebrates		
		Depth(m)	Easting	Northing	Depth(m)	Easting	Northing
Near-field Area water quality phytoplankton, sediment quality, benthic invertebrates	MEL-01-01	9.4	542690	6989132	9	542674	6989120
	MEL-01-06	8.8	542952	6988993	8.9	542739	6989050
	MEL-01-07	7.7	542873	6989218	8.7	542876	6989070
	MEL-01-08	7.5	543044	6989067	8.5	543064	6989183
	MEL-01-09	7.1	542555	6989188	7.9	542552	6989120
	MEL-01-10	10.5	542861	6989059	-	-	-
Mid-field Area water quality phytoplankton, sediment quality, benthic invertebrates	MEL-02-02	10.0	537093	6992642	10	537103	6992630
	MEL-02-03	9.8	537497	6992332	9.8	537497	6992327
	MEL-02-05	9.4	537831	6992692	9.4	537774	6992496
	MEL-02-06	10.2	536922	6992853	10.2	536951	6992914
	MEL-02-08	9.7	538342	6991952	9.7	538324	6991957
Reference Area 1 water quality phytoplankton, sediment quality, benthic invertebrates	MEL-03-01	9.5	533321	6998540	9.5	533492	6998645
	MEL-03-02	10.5	533253	6998664	10.5	533310	6998690
	MEL-03-03	10.5	532954	6998860	10.5	532989	6998869
	MEL-03-04	8.0	533629	6998660	8	533580	6998653
	MEL-03-05	8.1	533997	6998265	8.1	533999	6998274
Reference Area 2 water quality phytoplankton	MEL-04-01	8.3	525634	7000884	-	-	-
	MEL-04-02	9.8	526151	7001525	-	-	-
	MEL-04-03	10.7	525343	7001363	-	-	-
	MEL-04-04	8.9	525401	7001085	-	-	-
	MEL-04-05	8.5	525727	7001134	-	-	-

Table 4-2. Sampling Stations for Meliadine Lake Study (NAD 83, Zone 15N).

Area	Station ID	Water and Phytoplankton			Sediment and Benthic Invertebrates		
		Depth(m)	Easting	Northing	Depth(m)	Easting	Northing
Reference Area 3 water quality phytoplankton, sediment quality, benthic invertebrates	MEL-05-01	9.6	530922	6990859	9.6	530716	6991054
	MEL-05-02	9.8	530675	6990883	9.8	530692	6990913
	MEL-05-03	8.6	530737	6991365	8.6	530726	6991399
	MEL-05-04	9.9	530573	6991231	9.9	530658	6991206
	MEL-05-05	10.5	530241	6991156	10.5	530305	6991196

4.2.2 Monitoring Components

The scope of the Meliadine Lake study includes effluent and surface water quality monitoring, phytoplankton, benthic invertebrates and sediment quality, fish health, and fish tissue chemistry. The schedule, timing, and level of replication for each component is provided in **Table 4-3**. The scope of the Threespine Stickleback and Lake Trout population studies may change depending on comments from the Technical Advisory Panel for the Cycle 3 EEM study design.

Table 4-3. Aquatic Effects Monitoring Program Design Plan for the Meliadine Lake Study.

Component	Monitoring Areas	Frequency	Timing	Samples Per Event	Parameters/Endpoints
Effluent Chemistry	MEL-14	Annual	Weekly during discharge	1	Chemistry: as per MDMER and the Water Licence
Acute Toxicity	MEL-14	Annual	Monthly during discharge	1	Rainbow Trout and *Daphnia magna*
Sublethal Toxicity	MEL-14	Annual	Up to 2 times per year	1	Lemna minor growth inhibition[a]
Surface Water	MEL-01, MEL-02	Annual	March or April + July, August, September	6 for MEL-01; 5 for MEL-02	Field measurements, full suite of laboratory parameters (e.g., major ions, nutrients, metals, cyanide)
	MEL-03	Annual	July, August, September	5 per area	
	MEL-04, MEL-05	Annual	August	5 per area	
Phytoplankton	All Meliadine Areas	Annual	August	6 for MEL-01; 5 for the other areas	Phytoplankton community (biomass and density at the lowest practical level of identification) chlorophyll-a
Benthic Invertebrates and Sediment	MEL-01, MEL-02, MEL-03, and MEL-05	3-year cycle	August	5 per area	Benthic invertebrate taxonomy (abundance at the lowest practical level of identification) Sediment chemistry (grain size, TOC, metals, nutrients)
Threespine Stickleback Population	MEL-01, MEL-03, MEL-04	3-year cycle	August	A non-lethal survey is Proposed for the Cycle 3 EEM program[b]	Length, weight, and external health assessment; non-lethal study, so no internal health assessment of lethal endpoints (e.g., liver weight) [b].
Lake Trout Population	MEL-01, Atulik Lake, Peter Lake	3-year cycle	August	Lethal Survey: approximately 30 fish combined for both sexes[b]	Age, length, weight, condition, sex, fecundity, size at age, external and internal health (including gonad and liver weights)
Threespine Tissue Chemistry	MEL-01, MEL-03, MEL-04	3-year cycle	August	10-20 fish in each area	Carcass (viscera removed) Metals, moisture,
Lake Trout Tissue Chemistry	MEL-01, Atulik Lake, Peter Lake	3-year cycle	August	Approximately 20-30 fish across a range of size classes	Muscle (liver and kidney archived) Metals, moisture,

Notes
[a] The most sensitive test species based on sublethal toxicity test results (2018 to 2020)
[b] Subject to refinement based on input from the Technical Advisory Panel in their review of the Cycle 3 EEM program.

4.3 Effluent Characterization and Surface Water Quality

No changes are proposed to the effluent and water quality monitoring program in Version 3 of the AEMP Design Plan.

4.3.1 Objectives

The primary objectives of the water quality component of the Meliadine Lake study are as follows:

- Characterize effluent quantity and quality at MEL-14 to assess compliance with MDMER and Water Licence requirements and to support interpretation of effects in the receiving environment,
- Characterize water quality at the edge of the mixing zone and within Meliadine Lake to assess compliance with Water Licence requirements, meet MDMER requirements, and to support interpretation of effects in the receiving environment,
- Determine whether the Mine is causing changes to water quality in Meliadine Lake,
- Evaluate the accuracy of predicted changes in water quality,
- Assess whether mitigation measures are effective at reducing impacts to the aquatic environment, and
- Provide recommendations (as required) for follow-up monitoring or mitigation to lower the impact of mining-related activities on changes in water quality.

These objectives are addressed by answering the following key questions:

- Are concentrations of parameters in the effluent less than limits specified in the Water Licence?
- Has water quality in the exposure areas changed over time, relative to reference/baseline areas?
- Is water quality consistent with predictions outlined in the FEIS and are concentrations less 75 % of the applicable water quality guidelines set as AEMP Benchmarks)[2]?

4.3.2 Study Design and Schedule

Effluent Characterization

Effluent quality samples are collected according to MDMER and Water Licence requirements. Samples for effluent characterization are collected at MEL-14 located in the Effluent Water Treatment Plant

[2] The AEMP Benchmarks correspond to the lowest water quality guidelines for the protection of aquatic life and human health, or site-specific water quality objectives in the case of fluoride, arsenic, and iron. AEMP Benchmarks are listed in **Appendix B**.

(EWTP). This is the regulated monitoring station and at the last point of control before surface contact water is discharged to Meliadine Lake. The parameters and schedule for the effluent quality monitoring program are shown in **Table 4-4**. More detailed information on effluent sampling and water quality sampling for compliance and verification monitoring purposes can be found in the current Water Management Plan.

Table 4-4. Meliadine Lake Effluent Characterization Details: Point of Discharge and Edge of Mixing Zone

Location (Station ID)	Parameters(a)	Frequency
EWTP (MEL-14)	Volume (m^3)	Daily during periods of discharge
	Field effluent quality measurements	Weekly during periods of discharge
	Parameters as listed in 'Schedule I Full Suite' and 'Group 3 (MDMER and the Water Licence)	Prior to discharge and weekly during periods of discharge
	Acute toxicity testing Rainbow Trout & *Daphnia magna*	Once prior to discharge and monthly during discharge
	Lemna minor sublethal toxicity testing as per MDMER[b]	Two times per year
Receiving Environment at the Diffuser (MEL-13)	Field measurements and 'Schedule I Full Suite' and 'Group 3 (MDMER and the Water Licence)	Monthly during discharge

Notes:
[a] Detailed parameter list in Table 4-6.
[b] Schedule 5, Part 1, Section 6(3): After three years, sublethal testing can be conducted once per calendar quarter on test species that with the lowest inhibition concentration that produces a 25% effect or an effective concentration of 25%.

Meliadine Lake Surface Water Quality

The surface water quality program includes five areas in Meliadine Lake (i.e., Near-field area, Mid-field area, and three Reference areas). Sampling is completed four times per year at MEL-01 and MEL-02, once in the winter (March or April) and monthly in July, August, and September. Reference Area 1 (MEL-03) is sampled monthly during the open water season to pair with the data from MEL-01 and MEL-02. MEL-04 is sampled in August, coinciding with the phytoplankton study. The list of parameters included in the surface water quality program is outlined in **Table 4-5**.

Table 4-5. Meliadine Lake Receiving Water Quality Design Plan Details

Location	Stations per area	Parameter[a]	Sampling Frequency
Near-field (MEL-01)	6	Field measurements and parameters as listed in 'Schedule I Full Suite' and 'applicable Group 3 (MDMER)' of the 2AM-MEL1631 NWB Water Licence	Annual; Four times per year[b]
Mid-field (MEL-02)	5	Field measurements and parameters as listed in 'Schedule I Group 2'	
Reference Area 1 (MEL-03)	5	Field measurements and parameters as listed in 'Schedule I Group 2' and 'applicable Group 3 (MDMER)' of the 2AM-MEL1631 NWB Water Licence	Annual; Three times per year[c]
Reference Area 2 (MEL-04)	5	Field measurements and parameters as listed in 'Schedule I Group 2' of the 2AM-MEL1631 NWB Water Licence	Annual; Once per year[d]
Reference Area 3 (MEL-05)	5		

Notes:
[a] Detailed parameter list in **Table 4-6.** Further details in Water Licence (2AM-MEL1631)
[b] Samples collected once during under-ice period (typically in April) and three times during the open-water period (July, August, September).
[c] Samples collected three times during the open-water period (July, August, September).
[d] Sampled once in the late open-water period (August or September).

4.3.3 Field and Lab Methods

Field Measurements

Field measurements of specific conductivity, dissolved oxygen (DO; concentration and percent saturation), pH, and water temperature will be taken at each water quality station using a water quality multi-meter. Measurements will be taken near the surface and at 1 m intervals from surface to near the sediment. Secchi depth will be measured during open-water conditions to provide a visual measure of water clarity. During winter programs, ice thickness will be measured at each station after ice-auguring using an ice-thickness gauge before sampling and total water depth below the ice will be measured with a sounding line or equivalent. Additional information recorded in the field will include total water depth, station coordinates, date and time of sample collection, sample collection depth, and weather conditions.

Surface Water Sampling

Water samples are collected from approximately mid-depth in the water column using a Kemmerer sampler (or equivalent) during the open-water season, and with an electric diaphragm pump with tubing during the ice-cover season. Sample bottles are provided by an accredited analytical laboratory and samples will be processed (i.e., filtered and/or preserved as required, and refrigerated) according to the instructions provided by the laboratory. Water samples requiring filtration will be filtered through a 0.45 µm syringe filter and preserved according to specifications from the lab. Water samples will be kept refrigerated before shipping and ice-packs will be added to the coolers during transport. Samples will be shipped to the analytical laboratory as soon as feasible after sample collection and processing. Quality control samples (duplicate and blanks) will be collected at randomly selected stations to represent at least 10% of all samples collected. Effluent samples will be collected for chemical analysis as per the Water Licence at the effluent water treatment plant discharge location (MEL-14).

The suite of parameters to be analyzed in the water quality samples is listed in **Table 4-6**. Water quality samples will be analyzed by an accredited laboratory at detection limits lower than applicable water quality guidelines. The corresponding information for effluent quality sampling is provided in the Water Licence and Water Management Plan.

Table 4-6. List of Water Quality Parameters

Group	Parameters
Field	Field pH, specific conductivity, dissolved oxygen, and temperature, Secchi depth (open-water), total depth, ice thickness (winter)
Group 2	*Conventional Parameters*: bicarbonate alkalinity, chloride, carbonate alkalinity, turbidity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, total dissolved solids (TDS; calculated [a,b]), total suspended solids (TSS), total cyanide, free cyanide, and weak acid dissociable (WAD) cyanide *Nutrients*: ammonia-nitrogen, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, ortho-phosphate, total phosphorus, total organic carbon, dissolved organic carbon, and reactive silica *Total and dissolved metals*: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc
Group 3 / MDMER	*Deleterious Substance*: pH, temperature, TSS, metals (arsenic, copper, lead, nickel, zinc), cyanide, radium-226[c], and un-ionized ammonia[d] *MDMER parameters*: conductivity, turbidity, hardness, alkalinity, chloride, nitrate, total ammonia, phosphorus, sulphate, aluminum, cadmium, chromium, cobalt, iron, manganese, mercury, molybdenum, selenium, thallium, uranium
Full Suite	Group 2, total petroleum hydrocarbons, and turbidity

Notes
[a] Standard Methods (Method 1030E, APHA 20121).
[b] TDS calculated (mg/L) = (0.6 x Total Alkalinity as CaCO3) + Sodium + Magnesium + Potassium + Calcium + Sulfate + Chloride + Nitrate + Fluoride + Silicate
[c] Sampled as part of the MDMER sampling at the Near-field area and Reference Area 1. Monitoring of radium-226 is not required if concentration in effluent is lower than 0.037 Bq/L for 10 consecutive weeks (MDMER; Schedule 5; Part 1, Section 7(d)(ii)).
[c] Un-ionized ammonia is not listed in the Water Licence, but it is included in the list of Prescribed Deleterious Substances in the MDMER.

4.3.4 Data Analysis and Interpretation

Effluent Characterization

Effluent samples are screened against the MDMER limits for deleterious substances and concentration limits in the Water Licence. The results from acute and sublethal toxicity testing on the final effluent will also be reported to meet these requirements. Standard endpoint calculations and associated parameters (e.g., LC50 and IC25 results) will be completed by the laboratory and reviewed before reporting in the AEMP.

Meliadine Lake Receiving Water Quality

The water quality assessment for Meliadine Lake includes the following elements: (1) screening against aquatic life and human health drinking water guidelines (AEMP Benchmarks), assessing temporal and spatial trends, and evaluating current water quality against predictions in the FEIS.

Water Quality Screening Assessment (AEMP Benchmarks)

AEMP Benchmarks refer to water quality guidelines for the protection of aquatic life, guidelines for the protection of human drinking water quality, or site-specific water quality objectives (SSWQO) developed for the Mine (arsenic, fluoride, iron). Water chemistry results are screened against the AEMP Benchmarks each year. To provide an added level of protection, 75 % of the AEMP Benchmark is used as an early warning 'trigger' as part of the adaptive management strategy (**Section 5**).

To simplify the screening assessment, the lowest of the freshwater aquatic life and drinking water guidelines for each parameter are adopted as the AEMP Benchmark (and corresponding trigger). Except for fluoride, arsenic, and iron, which have SSWQOs, and antimony which has a lower health-based drinking water quality guideline, the aquatic life guidelines are more conservative (i.e., lower). Therefore, if the concentration of a given parameter is below the AEMP Benchmark for aquatic life, the Benchmark for drinking water quality is also met.

AEMP Benchmarks for toxicological effects on aquatic life are adopted from the most recent guidelines published by the following sources:

- Canadian Council of Ministers of the Environment (CCME) – The freshwater aquatic life guidelines published by CCME were adopted as the AEMP Benchmarks for the protection of aquatic life unless more recent guidelines are available.
- Federal Environmental Quality Guidelines (FEQG) – As stated on the ECCC website, the FEQGs are being developed where there is a federal need for a guideline but where the CCME guidelines for the substance have not yet been developed or are not reasonably expected to be updated in the near future. FEQGs are similar to CCME WQGs in that they are based on toxicological effects data using the same methods of derivation, where adequate data exists.

Parameters with more recent FEQG include vanadium (2016), cobalt (2017), lead (2020), strontium (2020), copper (2021), and aluminum (2023).

- Guidelines published by the British Columbia Ministry of Environment and Climate Change Strategy (BC ENV) for parameters not covered under either CCME or FEQGs (e.g., sulphate).
- Guidelines from other jurisdictions (e.g., TDS guideline for Alaska of 500 mg/L [ADEC 2012]).
- Canadian drinking water quality guidelines (Health Canada, 2020).

Temporal and Spatial Trends

Temporal and spatial trends are evaluated by comparing water quality results from the open water period to the normal range and visually examining the data. Appropriate statistical methods are incorporated into the assessment to support the discussion, as needed. Normal range refers to the natural water quality conditions in Meliadine Lake. The normal range is equal to the upper 90th percentile concentration measured in samples collected throughout Meliadine Lake during the open water period from 1995 to 2013 and samples collected from the reference areas to the end of 2020. The methods used to calculate the normal range are presented in the 2019 AEMP report (Azimuth, 2020).

The normal range assessment is limited to data from the open water season for three reasons: (1) reference areas are not sampled during the winter, (2), conditions under ice at the reference areas were not characterized during the baseline period, (3) effluent is only discharged during the open water period.

A generalized workflow was developed to short-list the number of parameters that are carried forward for closer examination.

- Parameters with fewer than 50% detected concentrations are excluded from the spatial and temporal trend assessment. Monthly water quality results are examined to verify that the frequency of non-detects is consistent in each month.
- Parameters that exceed the normal range in any of the samples collected from MEL-01 or MEL-02 in the current year are added to a “long list”. Sample-by-sample screening is a coarse tool for assessing changes in water quality because in any given event there may be results that naturally exceed the normal range. Parameters measured in water from the MEL-01 and MEL-02 are considered outside the normal range if the mean or median concentration from the open water period exceeds the normal range. The mean calculation can be affected by outliers (high or low concentrations) that do not influence the median. Therefore, the median concentration serves as a “check” for potential outliers in the normal range assessment.

The "short list" of parameters that exceed the normal range based on the annual mean/median is discussed in detail in the AEMP report to understand if the observed increase is due to activities at the Mine or natural variability.

Comparison to Predictions in the FEIS

An important aspect of the water quality assessment for Meliadine Lake is determining if the pattern, timing, and magnitude of changes in water quality generally align with the predicted changes based on the approved design plan for the Mine. Predicted future changes in water quality also provide a point of comparison with which to evaluate how effectively the Mine is managing water quality on site. Parameters that are increasing over time are compared against the prediction presented in the 2014 FEIS:

Water quality in the east basin of Meliadine Lake is predicted to change relative to baseline conditions, but aquatic life and health-based guidelines would be met at 100 m from the diffuser.

The narrative statement of "water quality meeting guidelines at the edge of the mixing zone" was based on modelling of effluent mixing and dilution estimates completed as part of the FEIS in 2014. Predicted concentrations were developed for several parameters at the edge of the mixing zone, as well as for TDS, chloride, and sodium beyond the mixing zone in the east basin. The model was based on the extent of the approved mine plan in the 2014 FEIS, conservative assumptions regarding effluent quality, and the preliminary diffuser design. The *far-field*[3] effluent mixing model in Volume 7 of the FEIS predicted TDS, chloride, and sodium would increase gradually over time in the East Basin to maximum concentrations of 176 mg/L for TDS, 66 mg/L for chloride, and 19 mg/L for sodium in the last year of operations. The major inputs to the 2014 model (e.g., mine plan and effluent quality) are no longer valid. Therefore, water quality data collected from MEL-01 stations will be evaluated against the most up-to-date water quality model predictions as that information becomes available.

4.3.5 Quality Assurance and Quality Control

Quality assurance and quality control procedures determine data integrity and are relevant to sample collection through to data analysis and reporting. Quality assurance (QA) encompasses management and technical practices designed at the outset to confirm that the data generated are of consistent, acceptable quality. Quality control (QC) is an aspect of QA and includes the procedures used to measure and evaluate data quality, and the corrective actions to be taken when data quality objectives (DQOs) are not met.

[3] Far-field in this case means the broader east basin. This is not to be confused with the reference areas in Meliadine Lake

A summary of QA/QC procedures for assess data quality for the water chemistry monitoring program are presented below. These procedures are used to confirm that the water quality data are representative of known quality, properly documented, and scientifically defensible.

Field Collection

Samples will be collected by qualified field staff who have received appropriate training. Fieldwork will be completed according to approved specific work instructions and established technical procedures. Specific work instructions are standardized forms that describe exact sampling locations and provide specific sampling instructions, equipment needs and calibration requirements, sample labelling protocols, shipping protocols, and laboratory contacts.

Careful documentation and handling of samples and data is a key component of QA/QC for the water quality field program. Sample containers are labeled with the sample ID, the date, and project identification. They are kept or stored according to laboratory handling instructions as necessary. Field data are recorded on data sheets and entered in Agnico Eagle's EQuIS database. Field data are sent to Azimuth at the end of each sampling event and used to validate data entry in EQuIS.

Chain-of-custody forms are included in each shipment. Electronic copies are emailed to the account manager when samples leave the Site. Samples are typically shipped within one week of collection, typically on Monday, Tuesday, or Wednesday to avoid having samples in transit over a weekend.

Laboratory QC

ALS Environmental is a CALA[4] certified laboratory with a rigorous QA/QC system that includes:

- Setting holding times according to test methods and any exceedances are flagged.
- Determining detection limits (DL), which is the minimum concentration of an analyte detectable by a test method in a medium and values below this limit are reported as less than DL.
- Including several QA/QC samples in their standard analytical procedures:
    - Matrix spikes are a quality assurance measure used to determine the resolution of a test method to detect an analyte in a specific medium (matrix) and assess matrix interferences.
    - Matrix blanks are analyzed to assess background contamination that exists in the analytical system that could lead to elevated concentrations or false positive data. These samples are comprised of analyte-free water.

[4] Canadian Association for Laboratory Accreditation

- Laboratory control samples are comprised of a mixture of analyte-free water to which known amounts of the method analytes are added. They are essentially an internal version of certified reference material.
- Certified/standard reference materials are commercially-made with pre-determined analyte concentrations and are sampled systematically to ensure accuracy.

- Analysis of laboratory replicate samples to determine variability in reported analyte concentrations.
- Verifying reports by repeat analysis of a sample if the original result is unexpected (e.g., detecting a parameter in blank samples and deviations from historical results). Repeat analysis may be requested by the client or consulting team.

Data Quality Objectives (DQOs) are numerically definable measures of analytical precision and completeness. Analytical precision is a measure of the variability associated with duplicate analyses of the same sample in the laboratory. Laboratory duplicate results are assessed using the relative percent difference (RPD) between measurements. The equation used to calculate the RPD is:

$$RPD = \frac{(A-B)}{(\frac{A+B}{2})} x\ 100$$

where: A = analytical result; B = duplicate result.

RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. Consistently positive or negative values may indicate a bias. Large variations in RPD values are often observed between duplicate samples when the concentrations of analytes are very low and approaching the detection limit; and therefore, a difference (DIFF) metric is often relied upon in these cases. The DIFF metric is defined as the absolute difference between a sample result and the sample duplicate result for each analyte.

$$DIFF = ABS\ [A-B]$$

where: A = analytical result; B = duplicate result; ABS = Absolute value (i.e., positive)

The chemistry laboratory DQOs for this project are:

- Analytical precision targets set by the lab are parameter-specific but typically are approximately 20% RPD or a difference (DIFF) between the laboratory replicates of greater than 2-times the DL (or in some cases 3-times the DL); meeting either metric is acceptable. If the RPD or DIFF metrics are not met, the result is flagged.
- Other QA/QC metrics flagged by the laboratory are evaluated to determine any implications on chemistry results. These include: laboratory holding time, laboratory control sample, matrix

spike, method blank, certified/standard reference materials, detection limit, and reported result verified by repeat analysis.

Field QC

The standard QA procedures included thoroughly rinsing sampling equipment between stations to prevent cross-contamination. Field QC procedures include collecting and analyzing field duplicates, and three types of *blank* samples: travel blanks, field blanks (de-ionized water), and equipment blanks.

Field Duplicates

An independent collection of water samples at the same time and location as the original, as a measure of consistency in sampling methodology and heterogeneity of chemical parameters at discrete locations. One field duplicate is collected for every 10 samples (approximately 10% frequency).

The DQOs for field duplicates were 1.5-times the laboratory RPDs or the DIFF between field duplicate results of less than 3-times the DL (i.e., 1.5x the difference objective for laboratory duplicates). This approach has been adopted for both water chemistry and sediment chemistry since 2019. The adjustment of field DQOs above laboratory RPD levels accounts for the fact that field duplicates are inherently more variable compared to laboratory duplicates partly because field duplicate samples are collected from a large sample volume as opposed to a small well-mixed sample volume (i.e., the single sample container in the laboratory). The Canadian Council of Ministers of the Environment (CCME) states that acceptance limits for field-based QC are broader than laboratory QC and are typically 1.5 to 2 times the laboratory QC limits (CCME, 2016).

Blanks

Three types of “blanks” are collected as part of water quality QC assessment according to best practices and guidance published by BC Ministry of Environment (2013) and CCME (2011).

- Travel Blanks – Travel blanks, or trip blanks, consist of de-ionized (DI) water provided in sampling bottles by ALS and receive the same treatment as field samples during shipment, handling, storage, and laboratory analysis. Trip blanks are meant to detect any widespread contamination resulting from the container (including caps) and preservative during transport and storage. Travel blanks should (1) be included in sample container shipments, (2) come directly from the analytical laboratory and (3) be stored in a cool place (e.g., refrigerator).
- Field Blank (*aka deionized water blank [DI blank])* – Laboratory-supplied deionized water is poured directly into the sample bottles. Field blanks are used to detect potential contamination caused by from bottles, collection methods, the atmosphere, and preservatives. The field blank mimics the water sample except the deionized water does not come in contact with the sampling device (pump and tubing in the winter and Kemmerer during the open water season).

- Equipment Blanks – At the beginning or end of a field sampling episode, after routine rinsing of the pump and tubing or Kemmerer, distilled water is run through the equipment and placed in sampling bottles for analysis of a wide suite of parameters (e.g., metals, nutrients, and major ions). This sample tests for possible cross-contamination of samples from the water sampling equipment.

Blank sample collection, particularly equipment blank samples, required careful planning, attention to detail, focus on the importance of cleanliness, and generally provided a good opportunity to refine sample collection skills. Blank samples are collected once per sample event and submitted blind to the laboratory to ensure they were treated the same as field-collected samples during analysis.

Blanks are examined for detectable concentrations of any of the parameters measured. Ideally, no parameter in either blank should exceed laboratory DLs. If a parameter in either blank is detectable, the corresponding field sample results are assessed for their reliability in the water chemistry dataset. The approach utilized is a "5 x blank censoring approach", relying primarily on the EB[5] for each event, and using the following rating system for detected analytes in blanks:

- Unreliable – When the concentration in a field sample is within 5-times the concentration in the EB blank, and the field result is elevated relative to historical data for the station, results are deemed unreliable (potentially impacted by cross-contamination). These data are excluded from data analysis and interpretation.
- Cautionary – When the concentration in a field sample is less than 5-times higher than the detected analyte concentration in the EB blank, but the field result appears consistent with historical data for this lake/basin, results are flagged as cautionary. Results are considered within natural variability and are retained for data interpretation.
- Reliable – When the concentration in a field sample is more than 5-times higher than the detected analyte concentration in the EB blank or is less than the DL, the field result is considered reliable. These data are retained for data interpretation with no denotation in the tables and figures. If only the DI has a detected parameter (not EB), results are considered reliable. Reliable flags are documented in the QA/QC screening table.

The approach to evaluating blanks has been standardized to the extent possible, but ultimately best professional judgement is used to determine which data get excluded from analysis.

[5] If a parameter was detected in both the EB blank and DI blank, then the detected concentration in the DI blank was subtracted from the EB blank, before comparing EB blank concentrations to field sample results.

4.4 Phytoplankton

No changes are proposed to the benthic invertebrate community monitoring program in Version 3 of the AEMP Design Plan.

Phytoplankton and zooplankton monitoring were included as targeted studies in Version 1 of the AEMP Design Plan. The targeted plankton study included sampling and analysis of depth-integrated nutrients, chlorophyll a, phytoplankton, and zooplankton over three years in Meliadine Lake (2015, 2016, and 2017) and two years in the Peninsula Lakes[6] (2015 and 2016) (Golder, 2018). Phytoplankton studies have provided meaningful insight into the structure and function of the phytoplankton community in Meliadine Lake as the mine transitioned from the pre-construction phase (2015) to operations. Furthermore, as the only biological monitoring program conducted annually under the AEMP, the phytoplankton study provides important information on the health of the aquatic environment in Meliadine Lake in years when fish and benthic invertebrate studies aren't completed as part of the 3-year AEMP and EEM cycle (2018, 2021, 2024, etc.). As of 2020, phytoplankton monitoring has been included as a core component of the AEMP.

4.4.1 Objectives

The primary objective of this component is to determine whether treated Mine effluent has potential short or long-term effects on phytoplankton communities due to changes in water quality in Meliadine Lake. Specific monitoring objectives are as follows:

- Compare phytoplankton variables (i.e., chlorophyll a, phytoplankton abundance, biomass, and composition of major taxonomic groups) in Near-field and Mid-field areas within Meliadine Lake relative to within-lake reference areas,
- Compare phytoplankton variables between monitoring years to assess temporal trends,
- Monitor the effectiveness of proposed mitigation,
- Recommend appropriate changes to the water quality component of the AEMP for future years, and
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to phytoplankton communities in Meliadine Lake.

4.4.2 Study Design and Schedule

Phytoplankton monitoring is conducted in August at the water quality sampling locations at the five study areas in Meliadine Lake. August was selected as the most appropriate month due to lower

[6] Chlorophyll a was also sampled at the peninsula lakes in 2017.

variability in phytoplankton monitoring endpoints compared to other sampling events (Golder 2018). Depth-integrated water samples will also be collected at these locations for analysis of chlorophyll-a.

4.4.3 Field and Lab Methods

At each sampling station, Secchi depth, total water depth, and limnology profiles will be measured prior to the collection of the plankton samples (see **Section 4.3.3** for details). After these measurements are taken, a depth integrated sample for phytoplankton and chlorophyll-a will be collected from the euphotic zone. The euphotic zone is defined as the extent of the water column that is exposed to sufficient sunlight for photosynthesis to occur (typically to a depth in the water column where 1% of the surface irradiance is measured). In the field, the euphotic zone will be calculated as two times the Secchi depth (Koenings and Edmundson 1991; Alberta Environment [AENV 2006]). Once the euphotic zone depth is determined, a Kemmerer sampler (or equivalent) will be used to collect discrete water samples starting at the surface, and continuing every 2 m through the extent of the euphotic zone. If the total water column depth is more than 10 m, sampling would continue every 2 m through the extent of the euphotic zone. If the total water depth is less than two times the Secchi depth, then a water sample will be collected every 2 m from the surface to 2 m above the lake-bed.

Equal volumes of water from each discrete depth will be combined into a large, clean bucket to create a composite, depth-integrated sample. From this composite sample, a single subsample will be collected for phytoplankton community analysis (i.e., enumeration and identification), and triplicate subsamples for chlorophyll-a analysis.

The phytoplankton samples are collected in 50 mL plastic vials and preserved with 3-4 drops of acidified Lugol’s solution. Samples are stored in the dark and shipped to Plankton R Us, Winnipeg, Manitoba, for taxonomic identification to the lowest taxonomic level, and abundance and biomass estimates.

The subsamples for chlorophyll-a are filtered at the lab on to 47 mm glass fibre type C filters with a nominal pore size of 1.2 µm. The filters are provided by the lab. A sufficient volume of water must be filtered to discolour the filter, approximately 500 mL or more per filter. Once the filtering is complete, the filter will be taken off the tower, folded in half and put into a pre-labelled Petri dish. The volume filtered will be recorded on the data sheet as well as the sample label. Samples are wrapped in aluminum foil, to prevent light penetration, and frozen. Chlorophyll-a analysis is done at the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta using spectrophotometric analysis.

4.4.4 Data Analysis and Interpretation

Phytoplankton effects endpoints (i.e., density, biomass, and community composition) are evaluated, using both statistical (quantitative) and visual (qualitative) methods, to determine if mining activities have contributed to changes to the phytoplankton community.

Temporal and Spatial Trends

Time series plots organized by sampling area were used to highlight spatial and temporal patterns in nutrients, chlorophyll-a, and phytoplankton metrics. Statistical analyses may be used to evaluate subtle differences in phytoplankton community structure between the Near-field area, Mid-field area, and the three within-lake reference areas. Phytoplankton populations grow and shrink seasonally, meaning species richness, biomass, and density are expected to vary annually, in response to regional climate patterns, and spatially in response to basin-specific factors such as morphology, timing of ice off, and nutrient status. A fundamental premise of the temporal and spatial trend assessment is the phytoplankton community in the various areas of Meliadine Lake in August will vary from year-to-year, but the near-field, mid-field, and reference area communities should follow the same pattern of change each year. If, however, the phytoplankton community in near-field and/or mid-field areas diverge from previous years and from the reference areas, it may indicate water quality is influencing the structure of the community.

Community Structure

Differences in the phytoplankton community among areas and over time are determined using non-metric multidimensional scaling (nMDS). nMDS is an ordination method that takes multidimensional taxonomic data (e.g., biomass for each taxon by station-year combination) and collapses the information into two or three dimensions that capture major patterns of variation in the underlying data. Azimuth follows a nMDS approach based on the reference condition approach (RCA) outlined in the TGD (Environment Canada, 2012). The fundamental premise of RCA is that a suitably large set of baseline and/or reference data can be used to characterize unimpaired conditions in terms of a variety of biological attributes. Patterns in reference area phytoplankton community structure are examined first, to determine the range of reference conditions. Patterns in community structure at the exposure areas are explored in the context of the results for the reference areas.

Below is an overview of the nMDS workflow from the 2020 AEMP report (Azimuth, 2021):

- Data were compiled for major taxa biomass and major taxa richness: 6 major taxa x 2 endpoints [biomass and richness] = 12 metrics.
- The above data set was turned into a Bray-Curtis distance matrix. Next, nMDS was run on the matrix; Shepard plots and stress values were used to optimize results. Stress, in the context of nMDS, refers to how distorted the representation of the data are in two or three dimensions relative to the original multi-dimensionality of the data. Lower stress means a better fit of the data in the reduced dimensionality. Multiple iterations of the analysis are completed to determine which position (or ordination) of points in two or three dimensions produces the lowest stress value. Clarke (1993) suggests the following guidelines for acceptable stress values: <0.05 = excellent, <0.10 = good, <0.20 = usable, >0.20 = not acceptable.

- nMDS results were visualized by first plotting 90th, 95th and 99th percentile probability ellipses using the reference data only. The next step involves adding nMDS scores for MEL-01 and MEL-02 areas each year. The 90th, 95th and 99th percentile probability ellipses provide a concise way of visualizing if the phytoplankton communities at MEL-01 and MEL-02 are within the range of baseline/reference conditions for Meliadine Lake.

In the future, other statistical approaches may be implemented on a case-by-case basis to supplement the RCA analyses if the underlying data support a more detailed investigation of spatial and temporal trends.

Trophic Status

Trophic status is a means of classifying estimated productivity of a lake based on concentrations of key nutrients and chlorophyll-a, and on water transparency. The three main categories of productivity are:

- Oligotrophic (low nutrients, low productivity),
- Mesotrophic (intermediate productivity), and
- Eutrophic (high nutrients, high productivity).

Three parameters are used in the classification of trophic status: total phosphorus, chlorophyll-a, and water transparency. Phosphorus is the primary nutrient used in trophic status indexes because it often limits primary productivity in freshwater systems. Chlorophyll-a is the primary pigment used for photosynthesis in phytoplankton and is used as a surrogate measure of primary production. Water transparency, measured with a Secchi disk, is also used as a coarse indicator of phytoplankton biomass.

Three trophic status indices are included in the assessment:

- Vollenweider (1968) – A general classification scheme based on ranges of TP, chlorophyll-a and Secchi depth (**Table 4-7**).
- CCME (2004) – A total phosphorus-specific scheme using trigger ranges (**Table 4-8**).
- Carlson (1977) – Independent index scores for TP, chlorophyll-a and Secchi depth (**Table 4-9**), calculated as follows:

$$TSI_{TP} = 10\,(6 - \left[\frac{\ln\,(^{48}/_{TP})}{\ln 2}\right])$$

$$TSI_{Chl} = 10\,(6 - \left[\frac{2.04 - 0.68(\ln Chl)}{\ln 2}\right])$$

$$TSI_{Secchi} = 10\,(6 - \left[\frac{\ln\ \text{Secchi}}{\ln 2}\right])$$

Table 4-7. Trophic classification for lakes based on ranges of total phosphorus, chlorophyll-a and Secchi depth (Vollenweider, 1968).

Trophic Status	Total Phosphorus (mg/L)		Chlorophyll-a (µg/L)		Secchi Depth (m)	
	Mean	Range	Mean	Range	Mean	Range
Oligotrophic	0.008	0.003 to 0.018	1.7	0.3 to 4.5	9.9	5.4 to 28.3
Mesotrophic	0.027	0.011 to 0.096	4.7	3.0 to 11.0	4.2	1.5 to 8.1
Eutrophic	0.084	0.016 to 0.386	14.3	3.0 to 78.0	2.5	0.8 to 7.0

Note:
Reference = Vollenweider 1968

Table 4-8. Trophic classification for lakes based on total phosphorus trigger ranges (CCME, 2004).

Trophic Status	Total Phosphorus (mg/L)
Ultra-oligotrophic (very nutrient-poor)	<0.004
Oligotrophic (nutrient-poor)	0.004 to 0.010
Mesotrophic (containing a moderate level of nutrients)	0.010 to 0.020
Meso-eutrophic (containing moderate to high levels of nutrients)	0.020 to 0.035
Eutrophic (nutrient-rich)	0.035 to 0.100
Hyper-eutrophic (very nutrient-rich)	>0.100

Note:
Reference = CCME 2004

Table 4-9. Trophic status index and general trophic classifications for lakes (Carlson, 1977).

Trophic State Index	Total Phosphorus (mg/L)	Chlorophyll-a (µg/L)	Secchi Depth (m)	General Trophic Classification
<30 to 40	0 to 0.012	0 to 2.6	>8.0 to 4	Oligotrophic
40 to 50	0.012 to 0.024	2.6 to 20	4 to 2	Mesotrophic
50 to 70	0.024 to 0.096	20 to 56	2 to 0.5	Eutrophic
70 to 100+	0.096 to 0.38+	56 to 155+	0.5 to <0.25	Hyper-eutrophic

Note:
Reference = Carlson 1977

4.4.5 Quality Assurance and Quality Control

The QA/QC procedures will be applied during all aspects of the plankton component to verify that the data collected are of acceptable quality. Data entered electronically will be reviewed for data entry errors and appropriate corrections will be made.

Field duplicates are collected for phytoplankton to assess sampling variability and sample homogeneity. A RPD of 50% for density and biomass concentrations is considered acceptable.

As a measure of laboratory QA/QC on the enumeration method, replicate counts are performed on 10% of the samples. Replicate samples are chosen at random and processed at different times from the original analysis to reduce biases. The laboratory replicate is a new aliquot (10 ml) from the sample jar and is counted from the start in the same manner as the original aliquot (10 ml) taken from the jar.

The data will be reviewed for unusually high or low values (i.e., greater or less than 10 times typical lake values), which would suggest erroneous results. Unusually high or low results will be validated on a case-by-case basis. All invalidated data will be retained in the appendix tables, but a flag will be appended to the data indicating that the sample was considered unreliable or the results were designated as not correct due to an internal review of the data.

4.5 Benthic Invertebrates

No changes are proposed to the benthic invertebrate community monitoring program in Version 3 of the AEMP Design Plan.

4.5.1 Objectives

The objectives of the benthic invertebrate community monitoring program are:

- Compare benthic invertebrate communities in Near-field and Mid-field areas within Meliadine Lake relative to within-lake reference areas, based on benthic invertebrate effect endpoints (e.g., invertebrate density, taxonomic richness, evenness, and similarity to reference communities) for the purpose of identifying Project-related effects.
- Verify predictions made in the FEIS and other submissions to the NWB, as applicable, relating to benthic invertebrate communities.
- Meet the requirements of the MDMER
    - Note: Benthic invertebrate community sampling is not required for the Cycle 3 EEM program because there were no confirmed effects to the benthic invertebrate community endpoints in Cycle 1 (2018) and Cycle 2 (2021).
- Recommend any necessary and appropriate changes to the benthic invertebrate community component of the AEMP for future years.
- Monitor the effectiveness of proposed mitigation.
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to benthic invertebrate communities in Meliadine Lake.

4.5.2 Study Design and Schedule

The benthic invertebrate community study is conducted every three years in mid-to-late August when the benthic invertebrate communities are the most diverse and stable (prior to freeze up). The next program is in 2024. Four study areas are sampled in Meliadine Lake: MEL-01, MEL-02, MEL-03, and MEL-05 (**Table 4-2**).

4.5.3 Field and Lab Methods

Sampling Methods

Benthic invertebrate samples are collected within a water depth range of approximately 7 to 10 m in areas with similar sediment composition. Sediment samples are collected using a Petite Ponar (15.24 × 15.24 cm bottom sampling area of 0.0232 m^2). Five replicate samples are collected in each area (e.g., MEL-01) and each sample is a composite of five individual grabs[7]. The contents of each composite grab are sieved through a 500 µm mesh screen. Material retained in the mesh is placed into a pre-labelled container and preserved in 10% neutral buffered formalin. An internal waterproof label is added to each jar.

Sediment grab samples are also collected for chemistry (e.g., metals, nutrients, and carbon content) and particle size distribution as described in **Section 4.6.3**. The following supporting data will be collected at each benthic invertebrate sampling station:

- Station location information (e.g., coordinates, water depth, weather observations),
- Habitat description (e.g., water clarity and colour),
- Notes on the sediment substrate (e.g., colour, texture, moisture content, odour, macrophytes),
- Benthic sample-related information (grab type, mesh size, sampler fullness, preservative), and
- Photographs of the sampling areas and representative samples.

Taxonomic Analysis

Preserved benthic invertebrate samples are sent to qualified taxonomist for processing, enumeration, and identification to the lowest taxonomic level (typically genus), using current literature and nomenclature. Organisms that cannot be identified to the desired taxonomic level (e.g., immature, or

[7] Pooling of subsamples in the field to form a single composite sample for taxonomic analysis from a station is commonly done to reduce analytical cost, without an effect on study results. Analysis of data collected during EEM and AEMP surveys is based on station as the unit of replication and does not require data for separate subsamples. Analyses of separate subsamples is useful to initially evaluate within-station variation, but once the number of subsamples required is determined, collection of subsample data is no longer necessary.

damaged specimens) are reported as a separate category at the lowest level of taxonomic resolution possible.

4.5.4 Data Analysis and Interpretation

General Approach

Benthic invertebrate effect endpoints (i.e., metrics such as invertebrate density, densities of dominant invertebrates, taxonomic richness, evenness, and similarity to reference communities) will be evaluated, using both statistical (quantitative) and visual (qualitative) methods, to determine whether changes in the benthic invertebrate community have occurred. Appropriate statistical analyses will be conducted to evaluate potential differences in benthic community structure between the Near-field area, Mid-field area, and the two within-lake Reference areas.

If changes in the benthic invertebrate community are observed, the results will be further evaluated to determine whether the changes in the benthic community are within FEIS predictions and are potentially mine-related. The magnitude and direction of change in the benthic invertebrate communities will be considered, as well results from multiple evaluation methods, and results from other monitoring components such as water and sediment quality.

Data Management

Raw invertebrate abundance data will be received from the taxonomist in electronic format. To meet EEM requirements, benthic invertebrate and supporting data will be entered into the latest version of Environment and Climate Change Canada's (ECCC) Excel template for submission to the EEM electronic reporting system.

Review of raw invertebrate abundance data for subsequent data analysis will involve removal of non-benthic organisms (e.g., Cladocera, Copepoda), meiofauna that are not reliably enumerated using 500 µm mesh sampling gear (e.g., Nematoda and Harpacticoida; Environment Canada 2012, 2014), and terrestrial invertebrates. Consistent with a recommendation by Environment Canada (2014) and the subsequent approach taken by Golder (2019), Ostracoda will also be excluded from the dataset prior to analysis because these invertebrates can be found in patches of extremely high numbers and can there therefore bias sample densities, thus affecting the benthic community analysis.

Descriptive statistics will be calculated for the above metrics, including the arithmetic mean, median, minimum, maximum, standard deviation, and standard error. Benthic community variables will be presented graphically for each sampling area to allow visual evaluation of spatial and temporal patterns. Community composition will be further represented by relative abundances (i.e., as percentage of total density) of major taxonomic groups. Changes in benthic invertebrate community composition over time at the major group level will be assessed by plotting mean relative densities of major taxa by sampling area, as stacked bar graphs.

Benthic Invertebrate Effect Endpoints

Benthic community metrics for the AEMP and EEM studies are presented in **Table 4-10** and described below.

Total density (N/m^2) and taxa richness are determined at the lowest practical level of identification. Density and richness at the level of major taxa group (MTG; Class or Order). The five MTG are Diptera (e.g., chironomids), Oligochaeta, Amphipoda, Bivalvia (clams), and Gastropoda (snails). Species that make up a minor component of the benthic invertebrate community are classified as “Other” for the purpose of calculating summary statistics and plotting. Mayflies (Ephemeroptera) and caddisflies (Trichoptera) are excluded from the dataset to stay consistent with the approach outlined in the 2018 AEMP (Golder, 2019). These taxa are typically found in streams and rivers and are not commonly found in depositional areas in lakes.

Simpson’s Diversity (1-D) considers both the abundance and taxonomic richness of the community. Values in this index range from 0 to 1 with 0 representing no diversity and 1 representing infinite diversity. D is calculated according to the formula in the TGD:

$$1 - \mathrm{D} = \sum_{i-1}^{s} (p_i)^2$$

Where:
D = Simpson’s Diversity
p_i = the proportion of the ith taxon at the station,
S = the total number of taxa at the station (i.e., taxa richness)

Simpson’s Evenness is another way of measuring the diversity of the community that takes into consideration how the total abundance is distributed among the various taxa groups. Values range from 0 to 1, with 1 representing a community with completely equal distribution of the number of individuals among the taxa. Evenness is calculated using the density data set as follows:

$$\mathrm{E} = \frac{1}{D}\, x\, \frac{1}{S}$$

Where:
E = Simpson’s Evenness
D = Simpson’s Diversity (see above)
S = the total number of taxa at the station (i.e., taxa richness)

Table 4-10: Summary of Benthic Invertebrate Community Endpoints for the EEM and AEMP.

Variable	EEM (Family Level)[(a)]	AEMP (Lowest Level)
Total invertebrate density (number of organisms/m^2)	Effect Endpoint (MDMER-required)	AEMP Variable
Total taxonomic richness (number of taxa per station)	Effect Endpoint (MDMER-required)	AEMP Variable
Simpson's diversity index	Supporting Endpoint	AEMP Variable
Simpson's evenness index	Effect Endpoint (MDMER-required)	AEMP Variable
Bray-Curtis Index	Supporting Endpoint	AEMP Variable
Presence/absence by each taxon	Supporting Endpoint	Supporting Endpoint
Community composition as percentages of major taxonomic groups	Supporting Endpoint	AEMP Variable
Densities of dominant invertebrates:	-	AEMP Variable

Notes
(a) As presented in the EEM TGD (Environment Canada, 2012) and/or the MDMER (Government of Canada 2002).
(b) Henceforth reported as relative density.
- = not applicable; AEMP = Aquatic Effects Monitoring Program; EEM = Environmental Effects Monitoring; MDMER = Metal and Diamond Mining Effluent Regulations

The Bray-Curtis dissimilarity co-efficient is a distance measurement that reaches a maximum value of "1" for two samples that are entirely different and a minimum of "0" for two samples that possess identical descriptors (Bray and Curtis, 1957). Bray-Curtis is calculated according to methods prescribed in the TGD:

$$\mathrm{BC} = \frac{\sum_{i=1}^{n} |y_{i1} - y_{i2}|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

Where:

BC = Bray-Curtis distance between sites 1 and 2,

Y_{i1} = count for taxon i at site 1,

Y_{i2} = count for taxon i at site 2, and

n = the total number of taxa at the two sites.

Statistical Analysis

Statistical analyses will be conducted as per the EEM Technical Guidance Document (TGD) and other approaches where warranted. Univariate (e.g., analysis of variance [ANOVA]) and multivariate statistical analysis techniques (e.g., nonmetric multidimensional scaling [nMDS], Mantels Test) may be used. If significant differences are observed between the exposure and reference areas, relationships between habitat variables and the benthic invertebrate metrics will be evaluated using tools such as calculating Spearman rank correlation coefficients and examining scatter plots. Statistical tests will be considered significant at a P-value ≤0.10, as recommended in the EEM TGD.

Univariate Analysis

With the exception of the Bray-Curtis Index, univariate statistical analyses will be undertaken to evaluate whether there are statistically significant differences in the benthic endpoints among sampling areas (i.e., Near-field, Mid-field, and Reference areas). Prior to statistical analysis, data will be evaluated for normal distribution and equality of variances to inform whether the data should be transformed and whether appropriate parametric (e.g., one way ANOVA) or non-parametric (e.g., Kruskal-Wallis one-way ANOVA) tests should be employed. Selection of the appropriate parametric or non-parametric test will depend on applicability after reviewing the data and whether test assumptions are met. It should be noted that ANOVA is generally considered robust for detecting difference even if the data violate assumptions of normality.

The magnitude of differences between area means will be calculated for significantly different pairwise comparisons. The critical effect size (CES) will be calculated as plus or minus two standard deviations (±2 SD) of the reference area mean according to the EEM TGD. Magnitudes of differences between reference and the exposure areas will be considered biologically significant if they exceeded the CES.

Post hoc power analysis will be conducted for non-significant results to determine the actual power to detect an ecologically meaningful effect in the relevant endpoints.

Non-metric Multidimensional Scaling (nMDS)

To further assess differences in benthic community composition between sampling areas, community structure will also be summarized using the non-parametric ordination method of multidimensional scaling (Clarke, 1993). This ordination method allows visual identification of community-level differences among areas by representing abundance data in two or three dimensions. A Bray-Curtis resemblance matrix will be generated on log(x+1) data, and the nMDS procedure will be applied to this matrix where, using rank order information, the relative position of stations in terms of taxa abundances can be determined on an ordination plot. Goodness-of-fit will be determined by examining stress values. Lower stress values (i.e., less than 0.10) indicate a greater goodness-of-fit of ordination results to the input data, whereas higher stress values (i.e., greater than 0.20) must be interpreted with caution, and higher dimensions (i.e., 3-D) might be needed to describe the dataset (Clarke, 1993).

Assessment of Relationships with Habitat Variables

If warranted based on the magnitude of habitat variation, relationships between habitat variables and the benthic invertebrate endpoints will be evaluated using Spearman rank correlation coefficients and examining scatter plots. Habitat variables to be considered will include water depth, sediment grain size (e.g., percent fine sediments), and total organic carbon content, and potentially other variables. In addition, where appropriate, the findings of the benthic invertebrate data analysis will be further interpreted in light of results of other monitoring components, such as changes in sediment and water quality.

Comparison to FEIS Predictions

If the above analysis identifies a biologically significant difference between reference and exposure area benthic communities that is outside of the normal range, results will be evaluated further to determine whether the observed change in the benthic community is within FEIS predictions.

4.5.5 Quality Assurance and Quality Control

The QA/QC procedures employed in the collection, processing, and analysis of benthic invertebrate samples and supporting information will be consistent with the EEM TGD.

Samples will be collected following standard sampling protocols by qualified personnel using appropriate sampling equipment. Samples will be analysed by qualified taxonomists using techniques consistent with the EEM TGD. Quality control procedures will include estimating sample sorting efficiency and subsampling accuracy and precision, should subsampling be required. Ten percent of the samples will be re-sorted. A reference collection will be prepared, consisting of several representative specimens from each taxon. The reference collection will be archived with the taxonomist, for possible comparative purposes with benthic invertebrate community data from future studies and QC of future taxonomic identification.

Office-related QA will include using appropriately trained personnel for each task, senior review of work, standardized data handling/summary tools, and filing of original data. A second person will make quality checks of supporting data entered from field data sheets, spot checks of calculations performed during the data summary and analysis stage, and review of tables containing both summary data and statistical results.

4.6 Sediment Quality

No changes are proposed to the sediment chemistry monitoring program in Version 3 of the AEMP Design Plan.

4.6.1 Objectives

The objectives of the sediment quality monitoring program are:

- Verify predictions made in the FEIS in relation to sediment quality in Meliadine Lake,
- Characterize sediment quality,
- Collect supporting data for the benthic invertebrate and water quality components to aid interpretation of results (as per the MDMER), and
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to sediment quality in Meliadine Lake.

4.6.2 Study Design and Schedule

The sediment quality monitoring program is conducted every three years in mid-August. The sediment sampling stations are co-located with the benthic invertebrate stations at MEL-01, MEL-02, MEL-03, and MEL-05. Coordinates and water depth at each station are provided in **Table 4-2**.

4.6.3 Field and Laboratory Methods

Bottom sediment samples will be collected within each area during the benthic invertebrate program in accordance with the EEM TGD and specific handling requirements of the accredited laboratory. Prior to collection of the sediment samples, supporting environmental information of field water column profiles (i.e., pH, temperature, DO, conductivity, turbidity), total water depth, will also be collected as described in **Section 4.5.3**.

Samples will be collected using a petite Ponar from each of the five replicate stations in each area. The top 5 cm of the grab is retained for analysis, and material from up to five grabs will be combined and homogenized into a composite sample in the field. Physical descriptions of the sediment samples will be recorded, and photographs of representative samples taken. Samples will be collected in containers provided by an accredited analytical laboratory and shipped in coolers with ice-packs. The standard suite of parameters and target detection limits are provided in **Table 4-11**.

4.6.4 Data Analysis and Interpretation

Sediment data from the exposure areas will be evaluated by a multi-step process that focuses on comparing current sediment chemistry results in the exposure areas with data collected from the baseline period.

Comparisons to Sediment Quality Guidelines

Sediment quality data will be compared to applicable Canadian Sediment Quality Guidelines developed by the CCME will (i.e., ISQGs and probable effect levels [PELs]; CCME 1999, 2002). The ISQG is the concentration of a substance below which an adverse effect on aquatic life is unlikely, and the PEL is the concentration of a substance above which adverse effects are expected to occur frequently, but not always. In practice, the application of generic numeric guidelines has yielded a high percentage of false positives (Chapman and Mann, 1999). The observation of a sediment concentration above the PEL value for a given parameter should not be interpreted as an indication that actual ecological harm has occurred or will occur, but rather that this is a possibility.

Table 4-11. Sediment parameters and target detection limits

Physical Tests	Detection Limit	Metals (mg/kg dry weight)	Detection Limit
pH (1:2 soil:water)	0.1	Iron (Fe)	50
Particle Size (%)		Lead (Pb)	0.5
Cobbles (>3in.)	1	Lithium (Li)	2
Gravel (4.75mm - 3in.)	1	Magnesium (Mg)	20
Medium Sand (0.425mm - 2.0mm)	1	Manganese (Mn)	1
Fines (<0.075mm)	1	Mercury (Hg)	0.05
Coarse Sand (2.0mm - 4.75mm)	1	Molybdenum (Mo)	0.1
Fine Sand (0.075mm - 0.425mm)	1	Nickel (Ni)	0.5
Organic Carbon (%)		Phosphorus (P)	50
Total Organic Carbon	0.05	Potassium (K)	100
Metals (mg/kg dry weight)		Selenium (Se)	0.2
Aluminum (Al)	50	Silver (Ag)	0.1
Antimony (Sb)	0.1	Sodium (Na)	50
Arsenic (As)	0.1	Strontium (Sr)	0.5
Barium (Ba)	0.5	Sulfur (S)	1000
Beryllium (Be)	0.1	Thallium (Tl)	0.05
Bismuth (Bi)	0.2	Tin (Sn)	2
Boron (B)	5	Titanium (Ti)	1
Cadmium (Cd)	0.02	Tungsten (W)	0.5
Calcium (Ca)	50	Uranium (U)	0.05
Chromium (Cr)	0.5	Vanadium (V)	0.2
Cobalt (Co)	0.1	Zinc (Zn)	2
Copper (Cu)	0.5	Zirconium (Zr)	1

Temporal Trends

Version 1 of the AEMP Design Plan specified that the normal ranges for sediment chemistry would be use to provide context when interpreting changes in sediment chemistry (Golder, 2016). Normal range estimates presented in the 2018 AEMP pooled all reference and baseline data collected in Meliadine Lake instead of calculating a normal range for each basin (Golder, 2019). The concentrations of some metals often show considerable spatial heterogeneity in lakes located close to mineralized areas. Metals concentration in sediment are often naturally variable in lakes close to mineralized areas.

The relevant point of comparison is whether concentrations are changing within the near-field and mid-field areas over time, as opposed to assessing differences between the near-field, mid-field, and reference areas. Changes in sediment chemistry over time within the exposure areas (MEL-01 and MEL-02) will be assessed statistically, for example with a before-after model that compares sediment chemistry data from the baseline period (pre-2018) to the current year. Before-after statistical models assumes that annual variability in sediment chemistry is negligible in absence of mining-related inputs.

4.6.5 Quality Assurance and Quality Control

Field Collection

Sample collection procedures described for the water sampling program are implemented to ensure the sediment chemistry data are reliable and accurate.

Laboratory QA/QC

Laboratory QA/QC procedures for sediment are described above for water in **Section 4.3.5**.

Field QA/QC

Field QA consists of taking care between sampling areas by rinsing and cleaning the sampling gear for sediment grabs (Petite Ponar grab, stainless steel compositing bowls and spoons) using site water and phosphate-free cleaning detergent, to avoid the possibility of cross-contamination.

Field QC measures include collection and analysis of at one field duplicate for every 10 samples (approximately). The DQOs for field duplicates are 1.5-times the laboratory RPDs. If the concentrations are less than 3-times the DL, the DQO is <1.5-times the difference between field duplicates.

4.7 Fish Health

The fish health studies proposed in Version 3 of the AEMP Design Plan match the proposed study design for the Cycle 3 EEM program. The program includes a lethal study for Lake Trout and non-lethal study for Threespine Stickleback. The Cycle 3 study design is due to ECCC in early February 2024 (six months before the field program in August). The study will undergo a thorough review by the Technical Advisory Panel to ensure the 2024 monitoring program is scientifically-defensible and appropriate for monitoring effects to fish in Meliadine Lake from activities at the Mine.

4.7.1 Objectives

The objectives of the fish health component are as follows:

- Determine whether Mine effluent has an effect on fish populations in Meliadine Lake,
- Verify predictions made in the FEIS pertaining to fish health,
- Meet the requirements of the MDMER,
- Recommend appropriate changes to the fish health program for future years, and
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to fish health in Meliadine Lake.

4.7.2 Key Considerations for the Fish Health Study

Sentinel Species

The AEMP fish health study includes a small-bodied species (Threespine Stickleback) and a large-bodied species (Lake Trout). Within the scope of the EEM program, neither species is ideal for monitoring potential effects from exposure to effluent[8]. The main drawback for both species is effects to reproductive endpoints are difficult or impractical to assess. Threespine Stickleback are batch spawners and at any given time the gonads of mature males and females can be either ripe or resting. This means gonad endpoints cannot be reliably assessed. For Lake Trout, an unacceptably large number of fish would need to be lethally sampled to meet the sample size requirements to detect effects for gonad endpoints. None of the males captured from Atulik Lake and Peter Lake in 2021 were ripe, and the numbers of ripe females in Meliadine Lake, Atulik Lake, and Peter Lake were 4, 1, and 3, respectively (Azimuth and Portt, 2022).

[8] Selection of sentinel species for EEM programs is discussed in detail in Section 3.3 of the EEM Technical Guidance Document. Some of the attributes of an ideal sentinel species include: (1) benthic-dwelling, (2) limited mobility relative to the size of the study area, (3) abundant and easy to catch.

Another disadvantage with using Lake Trout as large-bodied fish species for EEM is they are highly mobile, which means exposure to effluent is likely transient. In general, the greater the likelihood that a fish species is exposed to effluent, the greater its value as a monitoring species.

Despite the disadvantages with using Threespine Stickleback and Lake Trout as sentinel species, there are no viable alternatives based on the catch data from the 2021 field program (minnow traps in **Table 4-12**; gillnets in **Table 4-13**).

Table 4-12. Species-specific catch summary from minnow traps from the Cycle 2 EEM in Meliadine Lake in August 2021.

Area	Total soak time (hrs)	Species-specific catch summary[a]						THST CPUE[b]
		THST	NNST	SLSC	LKTR	BURB	RNWH	
MEL-01	6268.2	533	9	1	0	0	0	0.085
MEL-03	13596.9	2143	327	14	6	6	0	0.158
MEL-04	13492.0	1512	204	8	6	18	2	0.112

[a] Species include: THST = Threespine Stickleback, NNST = Ninespine Stickleback, SLSC = Slimy Sculpin, LKTR = Lake Trout, BURB = Burbot, RNWH = Round Whitefish.
[b] CPUE = catch per unit effort = (fish/hr soak time)

Table 4-13. Species-specific catch summary from gill nets during Cycle 2 EEM in Meliadine, Peter, and Atulik lakes August 2021.

Lake	Total soak time (hrs)	Species-specific catch summary					Lake Trout CPUE[a]
		Lake Trout	Arctic Char	Whitefish	Cisco	Arctic Grayling	
Meliadine	38.2	67	0	2	7	0	1.75
Peter	78.6	45	5	0	16	1	0.48
Atulik	71.6	38	0	0	19	0	0.63

[a] CPUE = catch per unit effort = (fish/hr soak time)

Recent Fish Health Studies

Two monitoring programs have been completed since the Mine started discharging surface contact water to Meliadine Lake in 2018. The first study was conducted in August 2018 and included a lethal and non-lethal sampling for Threespine Stickleback. The program was designed specifically to meet EEM sampling requirements and was not carried out to meet specific requirements of the AEMP (e.g., only one reference area was sampled [MEL-03] and the Lake Trout program was not completed). None of the endpoints exceeded their respective critical effect sizes. No changes to the EEM study design were recommend for subsequent EEM studies.

The fish study in 2021 was completed to satisfy Water Licence (AEMP) and MDMER (EEM) monitoring requirements. Effort was made to harmonize the two programs where possible, but there were some notable differences between the AEMP and EEM. Those differences are summarized below:

Threespine Stickleback

- **AEMP**: The AEMP study was a lethal study that targeted unparasitized male and female fish in the exposure area (MEL-01) and two reference areas (MEL-03 and MEL-04). Unparasitized fish were sampled to control for the potential confounding effect of parasitism on survival (age), growth (size-at-age), and condition (body weight at length, relative liver size). Reproductive endpoints were not used to determine effects to Threespine Stickleback.
- **EEM**: The study design for Cycle 2 that was first submitted to ECCC was identical to the AEMP study described above except only one reference area was originally proposed (MEL-03; control-impact study design). However, ECCC recommended that the lethal study should also include parasitized Threespine Stickleback to determine if the conclusions about the health of the population depend on which portion of the population is targeted for monitoring. The EEM lethal study was completed as ECCC requested for parasitized and unparasitized males and females from all three study areas (MEL-01, MEL-03, MEL-04).
- **Key findings from the Cycle 2 EEM**: Threespine Stickleback endpoints were generally similar between exposure and reference areas regardless of parasite status. When differences were observed for a given endpoint, the direction of change was inconsistent between the exposure and reference areas (MEL-01 vs MEL-03 or MEL-04) and differences were occasionally observed between the two reference areas, MEL-03 and MEL-04 (Azimuth and Portt, 2022). In conclusion, the Cycle 2 EEM results indicated that the status of parasitism was not an important factor when assessing the potential effects of effluent exposure on Threespine Stickleback in Meliadine Lake.

Lake Trout

- **AEMP**: The Lake Trout study in Version 1 of the AEMP Design Plan is a before-after study design where results from the operational phase (after 2018) are compared to results from the baseline period (2015). Before-after studies are effective at determining if a change has occurred, but they cannot discern if the change is related to mining activities or natural.
- **EEM**: Two external reference lakes were included in the Lake Trout study for the Cycle 2 EEM program. The reference areas were Peter Lake and Atulik Lake. The AEMP and EEM program shared the same Lake Trout data from the exposure area (MEL-01). Reproductive endpoints

were not included in the analyses, so sexes were pooled to assess effects to survival, growth, and condition endpoints.

- **Key findings from the Cycle 2 EEM**: Lake Trout from Meliadine Lake were older and heavier on average compared to Lake Trout from the reference lakes. Weight-at-age was the only endpoint that exceeded the CES between Meliadine Lake and the reference lakes.

Justification for a non-lethal study for Threespine Stickleback

The FEIS (Agnico Eagle, 2014) predicted that nutrients in effluent discharged to Meliadine Lake could have residual effects to fish habitat, which would include forage fish such as Threespine Stickleback. Adverse effects from exposure to contaminants were not predicted because water quality was expected to meet aquatic life guidelines at the edge of the mixing zone. Results collected so far under the AEMP validate this prediction. Water quality in Meliadine Lake has consistently met water quality guidelines meant to protect against toxicological effects to aquatic life. Furthermore, there is evidence that conditions in the east basin are more productive than other areas of Meliadine Lake (e.g., higher phytoplankton biomass and chlorophyll-a in MEL-01 compared to the reference areas [Azimuth, 2023]). In the Cycle 2 EEM, length and weight frequency distributions indicated that Threespine Stickleback collected from MEL-01 tended to be longer and heavier on average than fish collected from MEL-03 or MEL-04. This implies conditions may be more favourable for fish in the east basin compared to the reference areas (Azimuth and Portt, 2022). A non-lethal study would provide the data necessary to assess whether productivity-related changes to small-bodied fish populations are occurring as predicted in the FEIS.

4.7.3 Study Design and Schedule

The next fish population study is scheduled for August 2024. The Lake Trout health study for 2024 is repeat of the Cycle 2 EEM program with MEL-01 as the exposure area and Atulik Lake and Peter Lake as the external reference areas (multiple-control impact study design). Twenty-six (26) Lake Trout (both sexes combined) are required to achieve target power of 0.9 for based on the liver weight versus length endpoint.

A non-lethal survey is recommended for Threespine Stickleback with condition (length vs weight) as the primary effect endpoint to determine if mining-activities are contributing to nutrient enrichment in the east basin.

The effect indicators and endpoints for lethal and non-lethal surveys are presented in **Table 4-14**.

Table 4-14. Lethal and non-lethal effect endpoints for the Lake Trout and Threespine Stickleback health studies in 2024 (adapted from the EEM TGD).

Effect Indicator	Lake Trout Study (lethal) MEL-01, Peter Lake, Atulik Lake ~ 30 fish/area (pooled sexes)	Threespine Stickleback Study (non-lethal) MEL-01, MEL-03, MEL-04 Sample sizes TBD[a]
Survival	*Age *Age-frequency distribution Length-frequency distribution	*Length-frequency distribution
Energy Use (Growth)	*Size-at-age (body weight at age) Length-at-age	~~*Length of YOY (age 0) at end of growth period~~[b] ~~*Weight of YOY (age 0) at end of growth period~~[b] Size of the 1+ fish Size at age (if possible)
Energy Storage (Condition)	*Body weight at length *Liver size at body weight Liver weight at length	*Body weight at length

Notes:
*Endpoints used for determining effects to fish, defined here as statistically significant differences between exposure and reference areas. Other supporting endpoints can be used to support analyses.
[a] Sample sizes will be finalized based on the power analysis presented in the Cycle 3 study design (in prep).
[b] No young-of-the-year Threespine Stickleback were captured in 2018 (Golder, 2019) and 2021 (Azimuth and Portt, 2022). These endpoints are not included in the study design.

4.7.4 Field and Lab Methods

Threespine Stickleback

Use of unbaited gee-style minnow traps (1/4" square mesh; 9" x 16") is an effective method for capturing Threespine Stickleback from shoreline areas in Meliadine Lake. Set date and time, lift date and time, water depth, substrate (dominant and sub-dominant), and the number of individuals captured of each species are recorded for each trap set. Non-target species are released after completing an external assessment.

Specific conductance (µS/cm), pH, dissolved oxygen (mg/L and % saturation), and water temperature (°C) data are collected in the field within the exposure and reference areas.

Individual fish retained for the non-lethal survey will undergo an external examination according to recommendations outlined in Chapter 3 of the EEM TGD. Features of the fish that do not appear normal, for example wounds, tumors, parasites, fin fraying, gill parasites or lesions, will be reported in detail.

The following information will be determined for each Threespine Stickleback:

- total length in mm, to the nearest mm,
- total weight in g, to the nearest 0.001 g, and
- presence of external deformities, lesions, tumors, or parasites.

Lake Trout

Gill nets will be set in the exposure area within the extent of the 1% plume. If Lake Trout cannot be captured within this area in sufficient numbers, fish will be collected as close to the 1% effluent plume as practicable. Nets used in 2021 consisted of a gang of four North American standard large mesh gill nets (1.83 m x 24.7 m). Each standard net consisted of 8 panels of different mesh sizes (76 mm, 114 mm, 51 mm, 89 mm, 38 mm, 127 mm, 64 mm, and 102 mm). Specific conductance (µS/cm), pH, dissolved oxygen (mg/L and % saturation), and temperature (°C) will be determined in the vicinity of the gill net locations to confirm effluent presence and absence of stratification.

The geographic coordinates of each end of each net will be recorded, as will the depth and the date and time of deployment and retrieval. Set duration will be determined in the field based on local conditions, with the objective of meeting the sample size requirements while also minimizing the mortality of additional Lake Trout and incident catch. The number of individuals of each species captured in each net will be recorded.

The following information will be determined for each Lake Trout that is part of the lethal sampling:

- fork length in millimeters, to the nearest mm;
- total weight in grams, to within 1% of total weight;
- presence of external deformities, lesions, tumors, or parasites;
- liver weight in grams, to the nearest 0.1 g;
- sex, gonad condition, and gonad weight in grams, to the nearest 0.1 g;
- mean egg weight for mature females that will spawn in the current year; and
- presence of internal deformities, lesions, tumors, or parasites.

For mature females spawning in the current year, mean egg weight will be estimated by weighing and counting a subset of eggs (minimum of 100 eggs) and standardizing to the total ovary weight. Otoliths will be collected and placed in envelopes labeled with the sampling area, date, species, and specimen number. Otoliths will be mounted whole on a glass slide, ground to the core on one side, flipped to adhere the core area to the glass, and then ground to a thin section on the other side. Age will be estimated based on the number of annuli counted using transmitted light and a stereo microscope. As a QA/QC measure, annuli will be counted by a second person for at least 10% of the otoliths.

4.7.5 Data Analysis for Lethal Surveys

Assessment and interpretation of the Lake Trout and Threespine Stickleback data will follow the approach outlined in the EEM TGD and any requirements stemming from the Technical Advisory Panel's review of the EEM study design. The workflow and analyses described below are for a standard lethal study.

Initial Data QA/QC

Data will be entered into spreadsheets and compared with original datasheets. Any errors or omissions that are identified will be corrected. Scatterplots of length versus weight will be prepared. If aberrant values are identified, original data sheets will be re-checked to ensure that these are not due to transcription errors. Any transcription errors found will be corrected. If clearly aberrant values for length or weight occur in the original data, these will be eliminated from the dataset.

Catch Data Summary

Catch-per-unit-effort provides an estimate of abundance by standardizing catch data according to fishing effort. For all fish captured during the health survey, catch-per-unit-effort will be calculated and summarized by area and sampling method to document the amount of effort expended to collect the required number of fish. Total numbers of fish collected and processed will be presented in summary tables by area.

Calculated Indices

Condition (K) will be calculated using the formula:

$$K = \frac{total\ weight}{total\ length^3} \times 100{,}000$$

Gonado-somatic index (GSI) will be calculated using the formula:

$$GSI = \frac{gonad\ weight}{total\ weight} \times 100$$

Liver somatic index (LSI) was calculated using the formula:

$$LSI = \frac{liver\ weight}{total\ weight} \times 100$$

Summary Statistics

Summary statistics (sample size, mean, median, minimum, maximum, standard deviation, standard error) will be calculated for each species and measurement endpoint evaluated in the study.

Length and Weight Distributions

Both length and weight distributions will be compared between sampling areas using pooled data. Skewness and kurtosis will be determined for both raw and $\log_{10}$ transformed distributions at each and divided by their respective standard errors. A value greater than two will be taken to indicate that a distribution deviates significantly from normal. As normality is an assumption of ANOVA, if either the raw or transformed data have values of skewness or kurtosis divided by their respective standard errors that are less than two, then the data will be analyzed using an ANOVA. Otherwise, the Kruskal-Wallace test will be used to compare distributions between areas.

Analysis of Covariance

ANCOVA is used to assess whether significant differences between the exposure and reference areas were present in the following relationships:

- total weight versus fork length,
- fork length versus age,
- total weight versus age,
- liver weight versus fork length, and
- liver weight versus total weight.

ANCOVA is used to test for significant differences in intercepts and slopes between the areas using $\log_{10}$ transformed values where appropriate. Significant differences are evaluated using alpha and beta equal to 0.1 (Environment Canada, 2012a). In cases where the interaction term was not significant (i.e., homogeneity of slopes between the exposure and reference areas), the reduced model was used to assess significance and effect sizes. In cases where the interaction term was significant, but accounted for <2% of the total variation in the response variable, the reduced model was considered appropriate and used to assess significance and effect sizes as per Barrett et al. (2010). If differences in either slopes or intercepts existed, then pair-wise comparisons were used to determine which pairs differed.

Residuals from each ANCOVA were examined for normality and outliers. Observations producing large Studentized residuals (i.e., >4), if present, were removed from the dataset, and the analysis was repeated. Any changes in conclusions after removing outliers were carefully considered. This process was continued until no additional outliers were identified.

The percent difference in least-square means ($\bar{\chi}$) between the exposure area in Meliadine Lake and the reference lakes was calculated as:

$$\%Difference = \frac{\bar{\chi}_{exposure} - \bar{\chi}_{reference}}{\bar{\chi}_{reference}} \times 100$$

For log-transformed values, the least-square mean values are antilogs of the calculated values.

Table 4-15. Effect indicators, endpoints, and statistical tests used to determine effects to fish.

Effect Indicator	Endpoint	Dependent Variable	Covariate	Statistical Procedure	Critical Effect Size
Survival	Age	-	-	ANOVA	25%
Size	Length-frequency distribution	-	-	Kolmogorov-Smirnov Test	-
	Length	-	-	ANOVA	-
	Total Weight	-	-	ANOVA	-
Growth (Energy Use)	Size-at-age	Total Weight	-	ANOVA	25%
		Length	-	ANOVA	25%
Condition (Energy Storage)	Condition	Total Weight	Length	ANCOVA	10%
		Carcass Weight	Length	ANCOVA	10%
	Relative Liver Size	Liver Weight	Length	ANCOVA	25%
		Liver Weight	Carcass Weight	ANCOVA	25%

Statistical Analysis

Length, Weight, and Age Distributions

Length, weight, and age distributions will be compared between sampling areas for male and females. Skewness and kurtosis will be determined for both raw and $\log_{10}$ transformed distributions at each and divided by their respective standard errors. A value greater than two will be taken to indicate that a distribution deviates significantly from normal. As normality is an assumption of ANOVA, if either the raw or transformed data have values of skewness or kurtosis divided by their respective standard errors that are less than two, then the data will be analyzed using an ANOVA. Otherwise, the Kruskal-Wallace test will be used to compare distributions between areas.

Weight and length versus age

Given that ages are likely to span four years or less and that some ages will be poorly represented, size at age will be compared for ages that are well-represented using ANOVA or, if warranted due to violation of assumptions, the Mann-Whitney test.

Analysis of Covariance

ANCOVA will be used to determine if significant differences between the exposure and reference area occur in the following relationships:

- total weight versus total length,
- liver weight versus total weight, and
- gonad weight versus total weight.

Using $\log_{10}$ transformed values where appropriate, ANCOVA will be used to test for significant differences in intercepts and slopes between the areas. Significant differences will be evaluated using an alpha (α) of 0.1 (Environment Canada 2012a). In cases where the interaction term is not significant (i.e., homogeneity of slopes between the exposure and reference area), the reduced model will be used to assess significance and effect sizes. In cases where the interaction term is significant, but accounts for <2% of the total variation in the response variable, the reduced model will be considered appropriate and used to assess significance and effect sizes as per Barrett et al. (2010).

Residuals from each ANCOVA will be examined for normality and outliers. Observations producing large Studentized residuals (i.e., >4) will be removed from the dataset, and the analysis will be repeated. Any changes in conclusions will be considered. This process will be continued until no additional outliers are identified.

The percent difference in least-square means ($\bar{\chi}$) between the exposure and reference areas in Meliadine Lake will be calculated as:

$$\%Difference = \frac{\bar{\chi}_{exposure} - \bar{\chi}_{reference}}{\bar{\chi}_{reference}} \times 100$$

When log transformed data are analyzed, the least-square mean values used will be antilogs of the calculated values.

Power Analysis

Power analysis was used to determine, *a posteriori*, the probability of detecting a 10% (weight versus length) or 25% (gonad weight versus total weight, liver weight versus total weight) increase in the parameters of interest, assuming a 10% probability of committing a Type I error, and given the sample sizes, mean values, and the unexplained variability (i.e. the population standard deviation) from this study. Power was calculated by re-arranging the following power equation (Green, 1989):

$$n = \frac{1.5(t_\alpha + t_\beta)^2 \sigma^2}{\delta^2}$$

Where:

n is the number of fish,

σ is the population standard deviation,

δ is the specified effect size,

t_α is the Student's *t* statistic for a two-tailed test with significance level α,

t_β is the Student's *t* statistic for a one-tailed test with significance level β.

In cases where no significant differences are observed in effect endpoints, *post-hoc* power analyses will be performed to determine if there was sufficient power to detect differences equivalent to the respective CES in the population.

4.7.6 Quality Assurance/Quality Control

The QA/QC procedures are designed such that field sampling, laboratory analyses, data entry, data analyses, and report preparation produce technically sound and scientifically defensible results. As part of routine QA/QC for field operations, equipment (e.g., water quality meters, weigh scales) will be calibrated and samples will be collected by experienced personnel and will be labelled, preserved, and shipped according to standard protocols. Specific work instructions outlining each field task in detail will be provided to the field personnel by the task manager and reviewed prior to the start of the field program.

Field notes will be recorded in waterproof field books and on pre-printed waterproof field data sheets in either pencil or indelible ink. Data sheets and all sample labels will be checked at the end of each field day for completeness and accuracy. Chain-of-custody forms will be used to track the shipment of all samples. For aging structures, 10% of the prepared sections will be re-aged by an independent fish ageing specialist. If there is a discrepancy greater than 10% between the specialist's results and the initial results, all samples will be re-analyzed. For every ten fecundity samples, one sample will be recounted by a second person. If the re-count of the sample is within 10% of the initial count, the initial count will be regarded as acceptable and no re-count of the remaining samples will be required. If the re-count is not within 10% of the initial count, the initial count will be regarded as unacceptable and the remaining nine samples will be re-counted. The QA/QC procedure will be repeated until re-counts are within 10% of the previous count.

The QA/QC for data entry involves checking a minimum of 10% of the data for data entry errors, transcription errors, and invalid data. This checking will be done by an independent person from the person who entered the data. If an error is found, every datum will be checked. Statistical results will be independently reviewed by a qualified senior biologist. Tables containing summary data and statistical results will be reviewed and values verified by a second person.

4.8 Fish Tissue Chemistry

4.8.1 Background

The AEMP includes fish tissue chemistry monitoring for Lake Trout and Threespine Stickleback. The Lake Trout tissue chemistry monitoring program was included in the AEMP primarily to verify that the Mine is not contributing to changes in tissue chemistry that would affect the useability of the fishery for traditional and recreational purposes. Threespine Stickleback were included in the study design to characterize bioaccumulation and trophic transfer of contaminants through the food web (i.e., link between the lower trophic levels and predatory fish species).

The combined effect of warmer temperatures and increased precipitation were cited in the 2014 FEIS as potential factors that could lead to higher concentrations of metals in Arctic fish species (Carrie et al., 2010; Barletta et al., 2012; Dijkstra et al., 2013). However, the overall conclusion was that the effect of mining activities on fish, including changes in tissue chemistry, would be negligible compared to the spatial and temporal scale of climate-related changes.

In Version 1 of the AEMP Design Plan, Lake Trout muscle, liver, and kidney samples were collected and submitted for metals analysis. Liver and kidney samples are included to help interpret the results of the Lake Trout health assessment if adverse effects to survival, energy use, and/or energy storage are identified. For efficient use of resources, the liver and/or kidney samples will be analyzed only if results from the Lake Trout health assessment indicate there are adverse mining-related effects to Lake Trout in Meliadine Lake.

4.8.2 Objectives

The objectives of the fish tissue chemistry component are as follows:

- Determine if effluent is causing an increase in metal concentrations in fish tissue in Meliadine Lake, including whether fish tissue chemistry has been altered in such a way as to limit fish use by humans,
- Verify predictions made in the FEIS pertaining to fish tissue metal concentrations,
- Meet the requirements of the MDMER,
- Aid in the interpretation of the fish health study,
- Recommend appropriate changes to the fish tissue chemistry program for future years, and
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to fish tissue chemistry in Meliadine Lake.

These objectives for fish tissue chemistry are addressed through the following key question:

- Are tissue metal concentrations in fish from Meliadine Lake exposure areas increasing due to mining activities?

4.8.3 Study Design and Schedule

Fish tissue chemistry will be collected from Threespine Stickleback (carcasses) and Lake Trout (muscle) every three years coinciding with the fish health study. The next sampling program is scheduled for 2024. The samples sizes for each species, area, and tissue type are summarized in **Table 4-16**. Sample sizes are subject to change as additional data is collected to understand the variability within and between areas.

Table 4-16. Overview of the fish tissue sampling programs for the AEMP.

Species	Year	Lake/Area	Area Status	Phase	Sample Sizes			
					Muscle	Liver	Kidney	Carcass[a]
Lake Trout	1998	Meliadine Lake	Control	Baseline	34	34	33	-
	2015	Meliadine Lake	Control	Baseline	60	60	60	-
	2021	Meliadine Lake	Impact	Operations	42	42	42	-
		Atulik Lake	Control	Reference	24	0	0	-
		Peter Lake	Control	Reference	24	0	0	-
Threespine Stickleback	2015	MEL-01	Control	Baseline	-	-	-	60
	2017	MEL-03	Control	Reference	-	-	-	67
		MEL-04	Control	Reference	-	-	-	67
	2021	MEL-01	Impact	Operations	-	-	-	40
		MEL-03	Control	Reference	-	-	-	40
		MEL-04	Control	Reference	-	-	-	40

Notes:
[a] Carcass refers to the dissected Threespine Stickleback (viscera removed).

4.8.4 Field and Lab Methods

Threespine Stickleback and Lake Trout from the fish health assessment will be processed for tissue metals analysis. For the Threespine Stickleback study, specimens will be selected from the 52 mm to 72 mm size class for comparisons with the 2021 results. Fish in this size range are typically three to four years old. Prior to analysis, the lab will be consulted to verify that the mass of individual fish is sufficient to meet the target detection limits (**Table 4-17**).

For Lake Trout, subsamples of muscle, liver and kidney tissue will be collected from all of the lethally sampled fish in each area. The muscle samples will be submitted for analysis, with a target sample size in each area of 20 to 30 fish (pooled sexes). The liver and kidney samples will be archived at the Mine or at the lab. Analysis of kidney and/or liver samples may be undertaken on some or all of the Lake Trout to support interpretation of results from the fish health assessment.

Field tools will be cleaned between dissections to minimize the potential for cross contamination between samples, or new disposable tools will be used for each fish (e.g., scalpels). Tissue samples will be weighed, packaged, and labelled with the appropriate fish identification number.

Table 4-17. Parameters and target detection limits (mg/kg wet weight) for fish tissue analysis.

Target Detection Limits (mg/kg wet weight) [a]							
Aluminum	0.4	Cesium	0.001	Mercury	0.001	Strontium	0.01
Antimony	0.002	Chromium	0.01	Molybdenum	0.004	Tellurium	0.004
Arsenic	0.004	Cobalt	0.004	Nickel	0.04	Thallium	0.0004
Barium	0.01	Copper	0.02	Phosphorus	2	Tin	0.02
Beryllium	0.002	Iron	0.6	Potassium	4	Titanium	0.05
Bismuth	0.002	Lead	0.004	Rubidium	0.01	Uranium	0.0004
Boron	0.2	Lithium	0.1	Selenium	0.01	Vanadium	0.02
Cadmium	0.001	Magnesium	0.4	Silver	0.001	Zinc	0.1
Calcium	4	Manganese	0.01	Sodium	4	Zirconium	0.04

Notes:
The detection limits are from the 2021 AEMP.

4.8.5 Data Analysis and Interpretation

Descriptive statistics (i.e., sample size, mean, standard deviation, standard error, minimum, and maximum) and statistical comparisons will be presented in an appendix for all metals concentrations.

Data analysis will focus on comparing concentrations among the exposure and reference areas and over time. Parameters that are detected in less than 50 % of the samples from the Meliadine Lake exposure areas in the current year will not be carried forward for statistical analysis.

Spatial and temporal patterns for the Threespine Stickleback data will be assessed using analysis of variance (ANOVA) and pair-wise comparisons (Tukey's honestly significant difference test) among the area-year combinations.

Lake Trout have longer lifespans than small-bodied fish species like Threespine Stickleback, and progressively accumulate bioaccumulative metals such as mercury and selenium in their tissue over time. This can lead to size-related differences in tissue concentrations, which can lead to biased results if the underlying size-metal relationships are not considered. ANCOVA explicitly considers the influence of size-related covariates (e.g., length, weight, or age) when testing for differences in tissue metals concentrations between or among years. ANCOVA analysis will be conducted with length as the covariate according to approach outlined in the Lake Trout health assessment (**Section 4.7.5**).

4.8.6 Quality Assurance and Quality Control

The analytical laboratory will analyze a series of sample blanks, spikes, and laboratory duplicates, and certified reference standards (CRMs) will be run in parallel with the tissue chemistry samples. The results of these internal QA/QC processes will be reported with the laboratory data and any deviations from acceptable data quality objectives will be reported. If acceptable limits are exceeded, samples will be re-assessed and, if necessary and possible, re-analyzed.

Laboratory data will be screened in a manner similar to the water quality data (**Section 4.3.5**). Data entry will be reviewed to verify completeness (e.g., no data entry errors, transcription errors, and invalid data). Statistical test results will be independently reviewed by a second, competent statistician. Tables containing both summary data and statistical results will be reviewed and values verified by a second, independent individual.

5 RESPONSE FRAMEWORK

The AEMP Response Framework links monitoring results to management actions to maintain the assessment endpoints within acceptable ranges. It is a systematic approach for evaluating AEMP results and responding appropriately, such that unexpected effects are identified early and mitigation is undertaken to prevent a significant adverse effect. This is accomplished by continually evaluating monitoring data and implementing follow-up actions (e.g., confirmation, further study, mitigation) at pre-defined levels of change in measurement endpoints (i.e., Action Levels).

The Response Framework described in this section provides information for adaptive management by the Mine. Action Levels and management responses will be further developed or amended based on new data generated in the AEMP.

Action Levels (i.e., Low, Moderate, and High) will be used within the Response Framework to determine if follow-up action is required to manage and reverse any detected changes in the aquatic environment. If a Low Action Level is reached for one or more components of the AEMP, a response action will be initiated. Specific terms used in the Response Framework include: Benchmarks, Action Levels, and Significance Threshold, and are defined as follows:

- **AEMP Benchmark**. the aquatic life guidelines (e.g., CCME or Federal Environmental Quality Guidelines), generic drinking water guidelines, or site-specific water quality guidelines (SSWQOs) used to screen the water chemistry data. As an added level of protection, early warning 'triggers' (equal to 75 % of the AEMP Benchmark) are used to identify parameters that are trending higher. This ensures that corrective action is taken before exceedance of an AEMP Benchmark.
- **Action Levels**. Low, Moderate, and High Action Levels are pre-defined levels of environmental change. They are often linked to benchmarks, results of statistical tests, or a combination of the two. A Low Action Level exceedance serves as an early-warning indication of the potential for adverse effects on an ecosystem component. Exceedance of a Low Action Level indicates a measurable change has occurred, but the magnitude is below the Significance Threshold. Moderate and High Action Levels are designed to identify measurable effects that are trending towards the Significance Threshold, and may trigger follow-up management actions or responses to slow, stop, and reverse the trend.
- **Significance Threshold**: a level of change that would result in significant adverse effects to key values of the environment that are to be protected. This is considered an unacceptable level of change or 'no go condition'. Significance Thresholds are based on the assessment endpoints. Failure to meet the assessment endpoints (e.g., suitability of water to support an aquatic ecosystem) would result in the Significance Threshold being met.

If a change in the monitoring data is detected that exceeds a Low Action Level, the best course of action will depend upon the type of effect observed. Examples of response actions are provided in **Table 5-1**.

Figure 5-1. Overview of the Aquatic Effects Monitoring Program Response Framework.

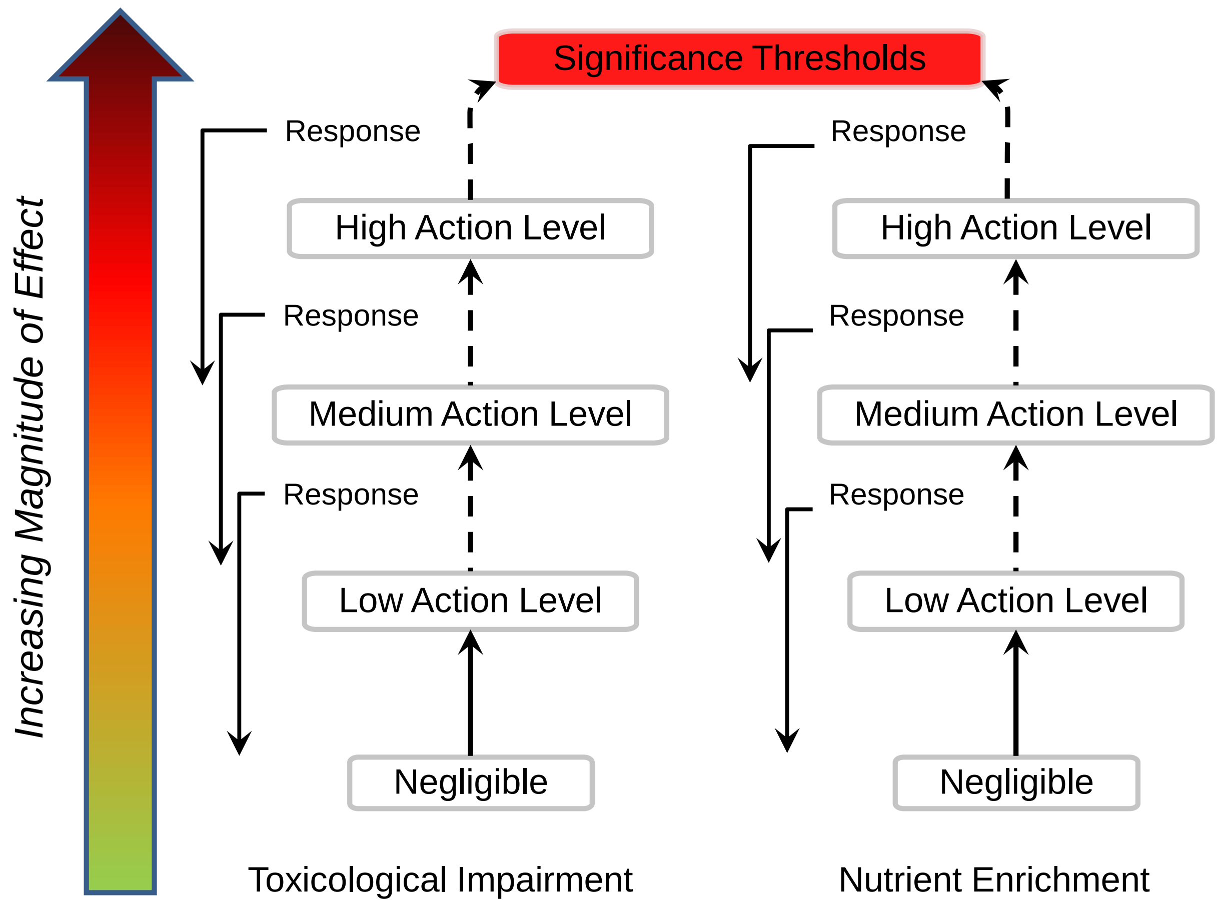


Table 5-1. Examples of Action Levels and Responses for Water Chemistry

Action Level	Example of Action Level to Support Impact Hypothesis "Toxicological Impairment"	Example of Action Level Response
Negligible[a]	no difference between reference and exposure areas or from baseline conditions; values of measurements endpoints within normal ranges	(none required)
Low	difference between reference and exposure areas, but below an applicable benchmark increasing trend toward conditions outside of normal range, or toward a benchmark	AEMP best practices Confirm Low Action Level trigger Compare to FEIS predictions Investigate further to identify contributing factors from the Mine Examine ecological relevance Identify potential mitigation options Increase monitoring Re-evaluate benchmark and revise if necessary Set Moderate and High Action Levels Establish new stations if the plume appears to be moving faster and farther than expected (e.g., establish new stations in the "narrows" between the Near-field and Mid-field)
Moderate	significant difference between reference and exposure areas, and benchmark exceeded consistently increasing trend approaching benchmark exceedance	AEMP best practices Notify Board Confirm Moderate Action Level trigger Compare to FEIS predictions Prepare a response plan Investigate further to identify contributing factors from the Mine Examine ecological relevance and implications Implement mitigation and examine effectiveness of mitigation Update monitoring design
High	benchmarks consistently exceeded, or effect is above predictions but below the Significance Threshold[b]	AEMP best practices Notify Board Confirm High Action Level trigger Compare to FEIS predictions Prepare a response plan Identify and implement improved mitigation to reverse trend Remediate

Notes

AEMP Best Practices: evaluate causation/linkage to the proposed Mine, examine trends, predict trends where appropriate, examine linkage between exposure, toxicity, and field biological responses, examine ecological significance, confirm that benchmarks are appropriate and revise if warranted.

[a] Not an Action Level but is listed to provide an indication of the estimated magnitude of background variation.

[b] Significance Threshold is defined as the point at which an environmental change would be considered significantly adverse. The adaptive management actions are used to prevent a Significance Threshold from being reached.

5.1 Significance Thresholds

Significance Thresholds focus on key values to protect rather than the numeric values set as Action Levels. The Significance Thresholds span all monitoring components and both impact hypotheses (toxicological impairment and nutrient enrichment). They are the "no-go" condition for the Mine. The proposed Significance Thresholds include the following key "values" that are to be protected:

- water is safe for human and wildlife consumption,
- fish are safe for human and wildlife consumption, and
- the ecological function of the aquatic environment is maintained (i.e., there is adequate food for fish, and fish are able to survive, grow, and reproduce).

Based on these values, Significance Thresholds proposed for the AEMP are as follows:

- Water is not drinkable (human health and/or wildlife risk):
  - Safety of water for consumption will be considered through a human health and/or wildlife risk assessment for drinking water.
- Fish are not safe for consumption (human health and/or wildlife risk):
  - No contaminants of potential concern (COPCs) were identified in fish tissue in Meliadine Lake; this pathway was considered to be incomplete and was not retained for further assessment in the HHRA (Volume 10, 2014 FEIS). Risk assessment tools may be considered if the concentrations of COPCs in fish tissue are statistically significantly higher than other lakes in the region. Mercury is a special case because concentrations often exceed the Health Canada mercury consumption limit of 0.5 mg/kg wet weight because of the propensity for mercury to bioaccumulate in large, old lake trout in northern aquatic ecosystems.
- Ecological Function is not maintained:
  - Inadequate food for fish, fish are unable to survive, grow, or reproduce, and/or sustained absence of a fish species.

5.2 Action Levels

The Action Levels for Meliadine Lake provide advanced warning of potential adverse effects to fish and other aquatic receptors. The Low Action Levels for toxicological impairment (**Table 5-2**) and nutrient enrichment (**Table 5-3**) are designed so that if a Low Action Level is exceeded, the results are reported, documented, investigated, and ultimately addressed (i.e., mitigation or operational changes are implemented) before Significance Thresholds would ever be reached. If a Low Action Level is reached, Medium and High Action Levels (with response actions) will be developed to support adaptive management.

Table 5-2. Low Action Levels for Toxicological Impairment for Meliadine Lake

Component	Assessment	Low Action Level Assessment Criteria[a]
Water Quality	End of Pipe Toxicity	Confirmed sublethal toxic effects on test organisms other than fish in end-of-pipe samples AND No sublethal toxic effects on fish in end-of-pipe samples
	Aquatic Life	Near-field mean above the normal range AND Statistically significant higher concentration in the Near-field compared to Reference AND Near-field mean exceeds 75 % of an AEMP Benchmark
	Human Consumption	Statistically significant higher concentration in the Near-field area compared to Reference AND Drinking water parameters in exposure area above 75 % of Health Canada's human health drinking water quality guideline (maximum acceptable concentration)
Phytoplankton	Aquatic Life	Phytoplankton community metrics at the Near-field area outside the range of baseline/reference conditions AND Change in direction and magnitude that are indicative of toxicological impairment
Benthic Invertebrates	Aquatic Life	Statistically significant difference in Near-field total density or richness compared to Reference AND Change in direction and magnitude indicative of toxicological impairment AND Difference in invertebrate density or richness with magnitude ≥CES[b] between reference and exposure areas
Fish Health	Aquatic Life	Statistically significant differences in fish health endpoints[c] between Near-field and Reference AND Change in direction and magnitude indicative of impairment of fish health AND Magnitude of effect above the CES[c]
Fish Usability	Human Consumption	Statistically significant difference in metal concentrations relative to reference AND Mean metal concentrations above a fish consumption guideline that is protective of human health

Notes:
[a] Only Low Action Levels are developed initially; Moderate and High Action Levels will be developed if the Low Action Level is reached.
[b] Critical effect size (CES) for benthic invertebrate community is two standard deviations of the current monitoring year's reference area data.
[c] Refer to **Table 4-15** for the fish health endpoints and corresponding critical effect sizes

Table 5-3. Proposed Action Low Action Levels for Nutrient Enrichment for Meliadine Lake

Component	Assessment	Low Action Level Assessment Criteria[a]
Water Quality	Aquatic Life	Concentrations of total phosphorus (TP) in the Near-field area above the normal range, supported by temporal trends AND A statistically significant relative difference between the Near-field area and Reference for TP AND Average TP concentration in the Near-field area that exceeds 75 % of AEMP Benchmark
Phytoplankton	Aquatic Life	Near-field mean for total phytoplankton biomass above the upper bound of the normal range AND Change in direction and magnitude indicative of nutrient enrichment
Benthic Invertebrates	Aquatic Life	Statistically significant difference in total density or richness between Near-field and Reference Areas AND Change in direction and magnitude indicative of nutrient enrichment AND Difference in invertebrate density or richness with magnitude ≥CES[b] between reference and exposure areas
Fish	Aquatic Life	Statistically significant differences in fish health endpoints[c] AND Changes is in direction and magnitude that are indicative of nutrient enrichment AND Magnitude of effect above the CES[c]

Notes:
[a] Only Low Action Levels are developed initially; Moderate and High Action Levels will be developed if the Low Action Level is reached.
[b] Critical effect size for benthic invertebrate community will be two standard deviations of the current monitoring year's reference area data.
[c] Refer to **Table 4-15** for the fish health endpoints and corresponding critical effect sizes

5.3 Plan Effectiveness

The AEMP is intended to provide a clear and defensible monitoring design, and through annual reporting of monitoring results, verify that mitigation and management measures are effective at avoiding adverse effects on the freshwater receiving environment, and that relevant laws and regulations are met. Agnico Eagle may also conduct periodic evaluations of the efficacy of monitoring, mitigation and management activities using relevant methods, such as power analysis or time series analysis. If new and relevant monitoring methods become available, or the existing design is found to lack statistical power, updated methods will be proposed. This plan will be updated periodically as required.

6 REPORTING

Per Part B Item 2 of the Water Licence, an Annual Report must be submitted to NWB no later than March 31st of every year. Per Schedule B Item 17 of the Water Licence, this Annual Report must include the results of monitoring related to the AEMP. These results will be presented in an AEMP Report, which will be an attachment to the main Annual Report. The AEMP Report will include:

- A summary of Project activities during the monitoring interval.
- A summary of the monitoring data obtained during the most recent reporting period.
- Description of the methods used for data collection and analysis.
- Evaluation of Project-related effects on the measurement endpoints.
- Results of the Action Level assessment.
- Recommendations (e.g., additional sampling or analysis, adaptive management).

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APPENDICES

Appendix A:

Recommendations, Conditions, and Commitments Related to the Aquatic Effects Monitoring Program

The Mine underwent an environmental assessment with the Nunavut Impact Review Board (NIRB) and a Type A Water Licence application process. A series of recommendations and conditions were listed In the NIRB decision report (NIRB, 2014). In addition, Agnico Eagle Mines Limited (Agnico Eagle) committed to a series of recommendations raised by various interveners during both the environmental assessment and the Water Licence process. A summary of the recommendations and conditions, and commitments made by Agnico Eagle to interveners during the regulatory process, which are directly relevant to the AEMP, are provided in **Table A-1**.

Table A-1. Recommendations, Conditions, and Commitments Related to the Aquatic Effects Monitoring Program

Commitment Number and Source	Recommendation / Condition / Commitment Details	Reference
Environmental Assessment		
NIRB Decision Report (NIRB 2014) Condition 30	The Proponent shall update its AEMP to include, at a minimum: Details for additional reference lakes to be included within its sampling and monitoring programs; Updates to include sedimentation within relevant monitoring programs; and Results from additional testing for mercury in fish tissue, and include test results in updated baseline data.	Reference Area: Section 4.2.1 Sedimentation: not included in the AEMP Design Plan Mercury: Golder (2018)
FEIS KIA-IR-06	Agnico Eagle will engage the Inuit to ensure their assessment of whether the “Opportunity for traditional and non-traditional use” has been impaired.	Section 1.4
FEIS KIA-IR-11	Agnico Eagle will monitor water quality in the receiving environment to enable the identification of trends and additional adaptive management strategies, if required, including potential sediment and erosion control.	Meliadine Lake: Section 4.3.4
FEIS KIA-IR-22	The KIA are concerned about dissolved oxygen concentrations during vulnerable times of the year (i.e., low flow or under-ice). They recommended modelling of under-ice dissolved oxygen in the mixing zone. Agnico Eagle commits to monitoring under-ice dissolved oxygen concentrations in the mixing zone of Meliadine Lake.	DO modelling: FEIS Appendix 7.4A (Agnico Eagle, 2015) DO under ice: Section 4.2
FEIS KIA-IR-29	Agnico Eagle will conduct a survey to collect fish tissue chemistry to provide a recent baseline dataset.	Baseline fish tissue chemistry in Golder (2018) & Section 4.8
FEIS KIA-IR-NEW-08	KIA are concerned that water quality downstream in Peter Lake (downstream of the northwest outlet of Meliadine Lake) could be impacted, and have recommended a monitoring location in the Diana River watershed.	Agnico Eagle committed to monitoring water quality in Meliadine Lake near the northwest outlet (MEL-04) as an early warning to potential far downstream effects.
FEIS KIA-IR-NEW-09	For the purposes of future water quality monitoring programs, the term "differing from baseline" will be defined through calculations of normal range.	Section 5
FEIS KIA-IR-NEW-11	Agnico Eagle will assess the impact of Mine activities in part through the changes observed in the benthic macroinvertebrate community composition and density.	Section 4.5

Commitment Number and Source	Recommendation / Condition / Commitment Details	Reference
FEIS KIA-IR-NEW-12	Agnico Eagle has committed to analyzing tissue from fish in Meliadine Lake and select peninsula lakes.	Meliadine Lake fish tissue chemistry: Section 4.8 The Peninsula Lakes study has been removed from Version 3 of the AEMP Design Plan
FEIS GN-1	Agnico Eagle has committed to monitoring water quality during different seasons of the year including under-ice and early spring.	Section 4.3.2
Water Licensing Process		
EC-15	Agnico Eagle has committed to providing Benchmarks and Low Action Level management responses	Low Action Levels were updated in the 2018 AEMP (Golder, 2019) Water quality Benchmarks for the AEMP were updated in the 2020 AEMP Report (Azimuth, 2021)
10 KIA-WL-07	Agnico Eagle has committed to collect water quality data (i.e., field water quality profiles and water quality samples) from three stations (in a triangulated arrangement) at approximately 100 m from the diffuser, during the period of discharge.	Table 4-2
EC-9 and EC-10	Updated the reference area sampling frequencies	Completed in V1 of the AEMP Design Plan. See Table 4-2 (stations) and Table 4-3 (frequency)
KIA-WL-16	List of parameters to be analyzed and the minimum acceptable detection limits.	Parameters and detection limits are provided in each of the respective sections of the AEMP Design Plan.
KIA-WL-11	Agnico Eagle has discussed Significance Thresholds and adaptive management in response to reaching an Action Level.	Sections 8.1; Table 8-1
EC-9 and EC-13	Agnico Eagle has updated the study types for Water Quality Meliadine Lake and Peninsula Lakes programs (i.e., before- after or control impact designs).	Meliadine Lake: Section 4.3.4 Agnico Eagle recommends moving the Peninsula Lakes study to the Water Quality and Flow Monitoring Plan (Appendix D in the Water Management Plan)
EC-7	Agnico Eagle has provided clarification on the monitoring and adaptive management to be implemented to detect changes and prevent impacts to lake productivity in the effluent mixing area.	Phytoplankton Study: Section 4.4 Action Levels: Section 5.2
EC-12	Clarification on selection of sampling location for fish based on information request from ECCC	Section 4.2 The scope of the fish health studies for the AEMP may be refined based on comments and recommendations received from the Technical Advisory Panel in their review of successive EEM study designs.

Notes:
AEMP = Aquatic Effects Monitoring Program; NIRB = Nunavut Impact Review Board; FEIS = Final Environmental Impact Statement; KIA = Kivalliq Inuit Association; GN = Government of Nunavut; IR = information request.

APPENDIX B:
WATER QUALITY SCREENING CRITERIA (AEMP BENCHMARKS)

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP (from the 2021 AEMP report).

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
Field Measurements									
DO (%)	%	-	-	-	-	-	-	-	-
DO (mg/L)	mg/L	-	-	-	-	-	-	6.5	6.5
pH (field)	units	-	7.1 | 7.95	-	6.5 | 9	-	-	6.5 | 9.0	6.5 | 9.0
Sp. Conductivity (field)	uS/cm	-	-	-	-	-	-	-	-
Temperature	C	-	-	-	-	-	-	-	-
Turbidity (field)	NTU	-	-	-	-	-	-	-	-
Conventional Parameters									
Conductivity (lab)	uS/cm	1	77.5	-	-	-	-	-	-
Hardness	mg/L	0.2 | 1	23.4	-	-	-	-	-	-
pH (lab)	units	0.1	-	-	6.5 | 9	-	-	6.5 | 9.0	6.5 | 9.0
Total Dissolved Solids	mg/L	13	54	68	500	-	1000	375	500
TDS (Calculated)	mg/L	1	39.6	68	500	-	1000	375	500
Total Suspended Solids	mg/L	1	1	3.1	-	-	-	-	-
Turbidity (lab)	NTU	0.1	-	-	-	-	-	-	-
Major Ions									
Alkalinity, Bicarbonate	mg/L	1.2	25	-	-	-	-	-	-
Alkalinity, Carbonate	mg/L	0.6	-	-	-	-	-	-	-
Alkalinity, Hydroxide	mg/L	0.34	-	-	-	-	-	-	-
Alkalinity, Total	mg/L	1	20.5	-	-	-	-	-	-
Bromide	mg/L	0.1	-	-	-	-	-	-	-
Calcium (D)	mg/L	0.01	-	-	-	-	-	-	-
Calcium (T)	mg/L	0.01	7.33	-	-	-	-	-	-
Chloride	mg/L	0.1	9.56	14	120	-	-	90	120
Fluoride	mg/L	0.02	0.028	0.0084	0.12	1.5	2.8	2.1	2.8
Magnesium (D)	mg/L	0.004	-	-	-	-	-	-	-
Magnesium (T)	mg/L	0.004	1.18	-	-	-	-	-	-
Potassium (D)	mg/L	0.02	-	-	-	-	-	-	-
Potassium (T)	mg/L	0.02	0.954	-	-	-	-	-	-
Reactive Silica (SiO2)	mg/L	0.01	0.268	-	-	-	-	-	-
Sodium (D)	mg/L	0.02	-	-	-	-	-	-	-
Sodium (T)	mg/L	0.02	4.85	5.3	-	-	-	-	-
Sulphate	mg/L	0.3	3.87	38	-	-	-	-	-
Nutrients									
Ammonia (as N)	mg/L	0.005	0.0174	0.54	18.1	-	-	13.6	18.1
Nitrate (as N)	mg/L	0.005	0.018	0.25	2.9	10	-	2.17	2.9
Nitrate + Nitrite (as N)	mg/L	0.0051	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	0.001	0.001	0.051	0.06	1	-	0.045	0.06
Nitrogen	mg/L	0.005	-	-	-	-	-	-	-
Orthophosphate (PO4-P)	mg/L	0.001	0.001	-	-	-	-	-	-
Total Diss Phosphorus	mg/L	0.001	0.00314	-	-	-	-	-	-
Total Dissolved Nitrogen	mg/L	0.05	-	-	-	-	-	-	-
Total Kjeldahl Nitrogen	mg/L	0.05	0.25	-	-	-	-	-	-
Total Kjeldahl Nitrogen (diss)	mg/L	0.05	-	-	-	-	-	-	-
Total Phosphorus	mg/L	0.001	0.006	0.0049	-	-	-	-	-
Organic/Inorganic Carbon									
Dissolved Organic Carbon	mg/L	0.5	2.72	-	-	-	-	-	-
Total Organic Carbon	mg/L	0.5	3	-	-	-	-	-	-
Total Metals									
Aluminum	ug/L	1	5.32	9.1	100	-	-	75	100
Antimony	ug/L	0.02	0.02	0.51	-	6	-	4.5	6
Arsenic	ug/L	0.02	0.275	3.8	5	10	25	18.8	25
Barium	ug/L	0.02	8.05	77	-	1000	-	750	1000
Beryllium	ug/L	0.005	0.005	-	-	-	-	-	-
Bismuth	ug/L	0.005	0.005	-	-	-	-	-	-
Boron	ug/L	5	6.52	23	1500	5000	-	1120	1500
Cadmium	ug/L	0.005	0.005	0.05	0.0427 | 0.0665	5	-	0.032 | 0.0499	0.0427 | 0.0665
Cesium	ug/L	0.005	-	-	-	-	-	-	-
Chromium	ug/L	0.1	0.103	1.1	5	50	-	3.75	5
Cobalt	ug/L	0.005	0.016	-	0.78	-	-	0.585	0.78
Copper	ug/L	0.05	0.86	2	-	2000	-	1500	2000
Gallium	ug/L	0.05	-	-	-	-	-	-	-
Iron	ug/L	1	15	42	300	-	1060	795	1060
Lanthanum	ug/L	0.01	-	-	-	-	-	-	-
Lead	ug/L	0.01	0.0222	0.15	-	5	-	3.75	5
Lithium	ug/L	0.5	0.72	-	-	-	-	-	-
Manganese	ug/L	0.05	3.06	5.5	-	120	-	90	120
Mercury	ug/L	0.5	8.00E-04	0.02	0.026	1	-	0.0195	0.026
Molybdenum	ug/L	0.05	0.107	5.2	73	-	-	54.8	73
Nickel	ug/L	0.05	0.441	2.7	25	-	-	18.8	25
Niobium	ug/L	0.1	-	-	-	-	-	-	-
Phosphorus	ug/L	50	-	-	-	-	-	-	-
Rhenium	ug/L	0.005	-	-	-	-	-	-	-

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP (from the 2021 AEMP report).

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
Rubidium	ug/L	0.005	-	-	-	-	-	-	-
Selenium	ug/L	0.04	0.049	0.16	1	50	-	0.75	1
Silicon	ug/L	50	-	-	-	-	-	-	-
Silver	ug/L	0.005	0.005	0.1	0.25	-	-	0.188	0.25
Strontium	ug/L	0.02	36.1	-	2500	7000	-	1880	2500
Sulfur	ug/L	500	-	-	-	-	-	-	-
Tantalum	ug/L	0.1	-	-	-	-	-	-	-
Tellurium	ug/L	0.02	-	-	-	-	-	-	-
Thallium	ug/L	0.005	0.005	0.1	0.8	-	-	0.6	0.8
Thorium	ug/L	0.005	-	-	-	-	-	-	-
Tin	ug/L	0.02	0.0384	-	-	-	-	-	-
Titanium	ug/L	0.05	0.17	-	-	-	-	-	-
Tungsten	ug/L	0.01	-	-	-	-	-	-	-
Uranium	ug/L	0.001	0.0164	1.5	15	20	-	11.2	15
Vanadium	ug/L	0.05	0.05	-	-	-	-	-	-
Yttrium	ug/L	0.005	-	-	-	-	-	-	-
Zinc	ug/L	0.5	1.7	6.7	-	-	-	-	-
Zirconium	ug/L	0.01	-	-	-	-	-	-	-
Dissolved Metals									
Aluminum	ug/L	1	-	-	-	-	-	-	-
Antimony	ug/L	0.02	-	-	-	-	-	-	-
Arsenic	ug/L	0.02	-	-	-	-	-	-	-
Barium	ug/L	0.02	-	-	-	-	-	-	-
Beryllium	ug/L	0.005	-	-	-	-	-	-	-
Bismuth	ug/L	0.005	-	-	-	-	-	-	-
Boron	ug/L	5	-	-	-	-	-	-	-
Cadmium	ug/L	0.005	-	-	-	-	-	-	-
Cesium	ug/L	0.005	-	-	-	-	-	-	-
Chromium	ug/L	0.1	-	-	-	-	-	-	-
Cobalt	ug/L	0.005	-	-	-	-	-	-	-
Copper	ug/L	0.05	-	-	0.297 | 3.83	-	-	0.223 | 2.87	0.297 | 3.83
Gallium	ug/L	0.05	-	-	-	-	-	-	-
Iron	ug/L	1	-	-	-	-	-	-	-
Lanthanum	ug/L	0.01	-	-	-	-	-	-	-
Lead	ug/L	0.01	0.0125	-	4.52 | 6.36	-	-	3.39 | 4.77	4.52 | 6.36
Lithium	ug/L	0.5	-	-	-	-	-	-	-
Manganese	ug/L	0.05	1.2	-	210 | 330	-	-	158 | 248	210 | 330
Mercury	ug/L	0.5	-	-	-	-	-	-	-
Molybdenum	ug/L	0.05	-	-	-	-	-	-	-
Nickel	ug/L	0.05	-	-	-	-	-	-	-
Niobium	ug/L	0.1	-	-	-	-	-	-	-
Phosphorus	ug/L	50	-	-	-	-	-	-	-
Rhenium	ug/L	0.005	-	-	-	-	-	-	-
Rubidium	ug/L	0.005	-	-	-	-	-	-	-
Selenium	ug/L	0.04	-	-	-	-	-	-	-
Silicon	ug/L	50	-	-	-	-	-	-	-
Silver	ug/L	0.005	-	-	-	-	-	-	-
Strontium	ug/L	0.02	-	-	2500	-	-	1880	2500
Sulfur	ug/L	500	-	-	-	-	-	-	-
Tantalum	ug/L	0.1	-	-	-	-	-	-	-
Tellurium	ug/L	0.02	-	-	-	-	-	-	-
Thallium	ug/L	0.005	-	-	-	-	-	-	-
Thorium	ug/L	0.005	-	-	-	-	-	-	-
Tin	ug/L	0.02	-	-	-	-	-	-	-
Titanium	ug/L	0.05	-	-	-	-	-	-	-
Tungsten	ug/L	0.01	-	-	-	-	-	-	-
Uranium	ug/L	0.001	-	-	-	-	-	-	-
Vanadium	ug/L	0.05	-	-	-	-	-	-	-
Yttrium	ug/L	0.005	-	-	-	-	-	-	-
Zinc	ug/L	0.5	1.9	-	5.96 | 12.4	-	-	4.47 | 9.3	5.96 | 12.4
Zirconium	ug/L	0.01	-	-	-	-	-	-	-
Other									
Cyanide (free)	mg/L	0.001	-	0.00035	-	-	-	-	-
Cyanide (Total)	mg/L	0.001	0.001	0.009	0.005	0.2	-	0.00375	0.005
Cyanide (WAD)	mg/L	0.001	-	-	-	-	-	-	-
Ion Ratio (+/-)	%	1	-	-	-	-	-	-	-
Radium-226	Bq/l	0.003	-	-	-	-	-	-	-

Notes
[a] FEIS predictions for the edge of the mixing zone as presented in Agnico Eagle (2014).
[b] The freshwater aquatic life guidelines (FWAL) for cadmium (T), copper (D), lead (D), manganese (D), and zinc (D) are variable depending on modifying factors such as pH, hardness, and DOC. Values shown represent the range of FWAL guidelines calculated for MEL-01 open-water samples in 2021.
[c] Guidelines for Canadian Drinking Water Quality - Health Canada drinking water guidelines (maximum acceptable concentrations).
[d] Site-specific water quality objectives for fluoride, arsenic, and iron.
[e] The AEMP Action Level is 75% of the AEMP Benchmark.
[f] The AEMP Benchmark is the lowest of the FWAL or GCDWQ.

Appendix C:
Response to Comments Received from Regulators on Version 2 of the AEMP Design Plan (Draft for Discussion)

This document presents responses to comments that were received from Environment and Climate Change Canada (ECCC) on the AEMP Design Plan (Draft for Discussion) that was submitted to the Nunavut Water Board with in the 2021 Annual Report. Comments on the AEMP Design Plan and the 2021 AEMP Report were provided to Azimuth Consulting Group Inc (Azimuth) in an email from the Meliadine Environment Department on July 3, 2022. Azimuth provided written responses by email to the Meliadine Environment Department on July 12, 2022. The comments and response specific to the AEMP Design Plan are provided below.

ECCC-3 Definitions for IC25 and QA/QC Blanks

Reference(s)

- Appendix 32-1 AEMP Design Plan
- List of Abbreviations
- Section 5.1.5 Quality Assurance/Quality Control

Comment

IC25 – The ICp is the inhibiting concentration for a specified percent effect, such as a 25% reduction in growth. The definition for IC25 provided should be corrected from “inhibition concentration affecting 25% of tested organisms” to “effluent concentration that causes a 25% inhibitory effect in the sublethal endpoint being measured”. The definition provided is for EC25 rather than IC25.

QA/QC – Errata note: The descriptions of travel and field blanks in the AEMP Design QA/QC section on page 44 have been transposed and should be corrected.

ECCC Recommendations(s)

ECCC recommends revising the definitions as noted, for clarity.

Response

The definition of the IC25 has been updated as requested.

The descriptions of travel and field blanks were corrected.

ECCC-5 Low Action Levels – Phytoplankton Assessment Criteria

Reference(s)

- Appendix 32-1 AEMP Design – Table 8-2 Proposed Low Action Levels for Toxicological Impairment for Meliadine Lake

Comment

The first part of the Phytoplankton Assessment Criteria is "Phytoplankton community metrics at the Near-field area beyond the range of baseline/reference conditions"

For toxicological impairment, most of the metrics would demonstrate a lower value (e.g. density and biomass), but using the descriptive term "beyond" implies higher. This should be clarified by describing the trigger as "below" or "outside" the range of baseline/reference conditions.

Footnote (c) is missing for this table.

ECCC Recommendations(s)

ECCC recommends revision of the assessment criteria statement to specify "below" or "outside" rather than "beyond" the range of baseline/reference conditions and that footnote (c) be completed.

Response

We agree with ECCC's recommendation. We have revised the assessment criteria to state "outside the range of baseline/reference conditions".

Foot note (c) has been updated to correctly cross-reference Table 5-11 that lists the endpoints that are included in the fish health assessment. The reference to tissue chemistry was removed from this footnote because the assessment criteria for "Fish Usability" is discussed in the last row of Table 8-2.

ECCC-6 Proposed Action Levels for Nutrient Enrichment Hypothesis

Reference(s)

- Appendix 32-1 AEMP Design – Table 8-3 Proposed Action Low Action Levels for Nutrient Enrichment for Meliadine Lake

Comment

In order to meet the Low Action Level for Water Quality, the following three conditions are proposed to have to exist:

- Concentrations of TP in the Near-field area above the normal range, supported by temporal trends AND
- A statistically significant relative difference between the Near-field area and Reference for TP AND
- Lake-wide average phosphorus concentration exceeds 75% of AEMP Benchmark

Considering the extent and volume of Meliadine Lake, the third condition would almost certainly never be measured, and to be met would entail an increase of significant magnitude in TP loadings and ensuing concentrations. The AEMP Benchmark has been set at 0.010 mg/L TP to reflect the upper bound of the oligotrophic status, and the Action level trigger would be 0.0075 mg/L TP. A more timely and realistic trigger condition would be on the basis of near-field rather than lake-wide change.

ECCC Recommendations(s)

ECCC recommends amending the third condition by replacing “lake-wide” with “near-field”.

Response

The AEMP Action Level for phosphorus will be applied to the near-field area. However, we want to emphasize that phosphorus concentrations are one of the lines of evidence used to assess nutrient enrichment caused by effluent. Increases in total phosphorus in the East Basin suggests the potential for nutrient enrichment, but any conclusions about the potential for nutrient enrichment need to be supported by more relevant lines of evidence that directly assess phytoplankton productivity, namely total biomass and chlorophyll-a concentrations.