Appendix 31-2: 2022 Aquatic Effects Monitoring Program Design Plan

Aquatic Effects Monitoring Program Design Plan

Meliadine Gold Mine

Version 2_NWB

Prepared for:

Agnico Eagle Mines Limited
Meliadine Division
Rankin Inlet, Nunavut X0C 0G0

December 1, 2022

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EXECUTIVE SUMMARY

The Aquatic Effects Monitoring Program (AEMP) is a requirement of the Type A Water Licence (2AM-MEL1631) for the Meliadine Gold Mine (the Mine) issued by the Nunavut Water Board (NWB). The AEMP has been designed to function as an integrated monitoring program, which considers pathways to potential effects of the Mine on the aquatic environment during construction, operations, and closure. The AEMP Design Plan was developed through consultation with communities, stakeholders, and regulatory authorities. This document includes minor updates to Version 1 of the AEMP Design Plan (Golder, 2016) based on the recently updated Water Management Plan for the Mine, findings and recommendations made in successive annual AEMP reports (Golder, 2019; Azimuth 2020, 2021), and findings of the Water Quality Management and Optimization Plan (WQ-MOP; Golder, 2020) that was carried out under terms of the amended Type A Water Licence.

The current study design for the AEMP includes monitoring in Meliadine Lake as well as three lakes close to the Mine, collectively referred to as the Peninsula Lakes. A more complex monitoring program is implemented for Meliadine Lake because it is the final discharge point for surface contact water collected at the Mine. The study considers changes in surface water quality, sediment quality, lower trophic communities, and fish health and tissue chemistry in Meliadine Lake, primarily due to release of surface contact water. The Meliadine Lake study was developed based on the biological monitoring that is required for the Environmental Effects Monitoring (EEM) program under the Metal and Diamond Mining Effluent Regulations (MDMER). The Peninsula Lakes are not impacted by point-source discharges, but based on their proximity to the Mine, changes in surface water quality were predicted due to physical alteration of watersheds and air emissions. Water quality in three Peninsula Lakes is monitored on a regular basis, with biological or other targeted studies to be added if the water quality results suggest mine-related changes have occurred.

To focus the study design and analysis of results in the annual monitoring reports, key questions were developed for each AEMP component. The AEMP Design Plan includes an Adaptive Management Response Framework, which is central to the effective implementation of the AEMP. The Response Framework serves to identify changes to early-warning indicators that can trigger additional investigation, monitoring, or the implementation of additional mitigation.

Version 2 of the AEMP Design Plan includes the following changes:

- Meliadine Mine is no longer a proposed Project, but an operating mine.
- Some of the sampling locations were realigned in response to effluent-related changes and the increased understanding of potential confounding factors in the original design (e.g., substrate variability within and between sampling areas).

- Sampling was discontinued at edge-of-mixing zone stations MEL-13-01 and MEL-13-07 because they overlap with AEMP Near-field stations MEL-01-01 and MEL-01-07. Edge-of-mixing zone station MEL-13-10 was renamed MEL-01-10 and was added the AEMP water quality program. There are now 6 locations sampled during each event at MEL-01. Three stations are located 100 m from the diffuser. The other three stations (MEL-01-06, MEL-01-08, and MEL-01-09) are triangulated around diffuser at a distance of approximately 250 m.
- Phytoplankton was adopted as a core component of the AEMP (phytoplankton was a targeted study in Version 1 of the AEMP Design Plan).
- Updated AEMP Benchmarks and Response Framework Low Action Levels to better reflect site conditions and identify Mine-related effects.
- Integrating commitments and recommendations made by Agnico Eagle through the annual AEMP report review process since the original design plan was developed.

Considerations for the Next Update to the AEMP Design Plan

The Cycle 2 EEM program was conducted in parallel with the 2021 AEMP and the two programs had considerable overlap for the benthic invertebrate and small-bodied fish surveys. There were, however, notable differences in the large-bodied fish surveys conducted for the 2021 AEMP and Cycle 2 EEM. Both programs used Lake Trout as the sentinel species, but the two programs are fundamentally different in their study design. In the case of the AEMP, the study focused on assessing changes in the health metrics in Lake Trout between the baseline period and exposure period. External reference lakes for the Lake Trout study were not included in Version 1 of the Design Plan because, at the time, nearby reference lake(s), with a similar large size and fish assemblage, with good accessibility that meets health and safety needs, had not been identified (Golder, 2016).

A before-after study is less optimal for assessing effluent-related effects on fish because if changes are detected for a given endpoint, for example, condition or relative liver size, there is no way to determine if the change is natural or caused by exposure to effluent. Based on recent EEM studies at the Meadowbank Mine (Portt and Kilgour, 2019), a control-impact study was proposed as the best approach to assess whether Lake Trout in Meliadine Lake are being impacted by exposure to effluent for the Cycle 2 EEM. Environment and Climate Change Canada (ECCC) approved the Cycle 2 EEM control-impact study design for assessing effluent-related effects on Lake Trout in Meliadine Lake (Azimuth and Portt, 2021). The Cycle 2 EEM Interpretive Report was submitted to ECCC in August 2022. We anticipate ECCC will provide comments sometime in mid-2023. A logical timeline for updating the AEMP Design Plan would be after the Water Licence Amendment Process, after receiving comments from ECCC on the Cycle 2 EEM report, and coinciding with the preparation of the Cycle 3 EEM study design. The timeline for submission of an updated AEMP Design Plan is recommended for February 2024 (ahead of the next round of EEM biological monitoring in August 2024).

REVISION HISTORY

Notes/Revisions	Date
Conceptual Aquatic Effects Monitoring Program Design Plan Final preliminary design for submission with the Water Licence application	April 2015
Aquatic Effects Monitoring Program (AEMP) Design Plan (Version 1) Updates based on 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.	June 2016
Conceptual Aquatic Effects Monitoring Program Design Plan - Considerations for the Meliadine Extension (Version 2_NIRB) This document described the overarching principles and objectives that will guide how the Meliadine Extension will be incorporated into the study design for the AEMP.	December 2021
Aquatic Effects Monitoring Program (AEMP) Design Plan (Version 2) – Draft for Discussion The AEMP Design Plan was updated to reflect recent results of the annual AEMPs completed to date from 2016 to 2020, including the results of the Amendment No. 1 monitoring program (2020). Refer to **Section 1.5** for updates that were made to the AEMP.	April 11, 2022
Aquatic Effects Monitoring Program (AEMP) Design Plan (Version 2_NWB) AEMP Design Plan submitted to the NWB to meet requirements of Type A Water Licence Amendment application. Version 2_NWB addressed comments received from regulators regarding the April 2022 Draft for Discussion. Responses to comments received from regulators are provided in **Appendix C**.	December 1, 2022

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GLOSSARY

Term	Definition
Aquatic Effects Monitoring Program	A monitoring program designed to evaluate the effect of mining activities and mitigation on the aquatic environment.
AEMP Design Plan	The "how to manual" that describes the AEMP study design for Meliadine Lake and the Peninsula Lakes.
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.
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.
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)	This is considered as 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.

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

Term	Definition
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.
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
%	percent
≤	less than or equal to
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
cm	centimetre
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
g	gram
GN	Government of Nunavut

Abbreviation	Term
GPS	global positioning coordinates
GSI	gonadosomatic index
ha	hectares
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
K	condition factor
KivIA	Kivalliq Inuit Association
km	kilometres
km^2	square kilometre
K-S test	Kolmogorov-Smirnov test
LC50	median lethal concentration
log_{10}	logarithm base 10
LSI	liver somatic Index
LSM	least squares mean
m	metre
m^2	square metre
m^3	cubic metre
MAC	maximum average concentration
MDMER	Metal and Diamond Mining Effluent Regulations
mg/L	milligram per litre
Mine	Meliadine Gold Mine
µg/L	microgram per litre
µg/g	micrograms per gram
µm	micrometre
µS/cm	microsiemens per centimetre
mL	millilitre
mm	millimetre

Abbreviation	Term
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
SD	standard deviation
SDI	Simpson's diversity index
SE	standard error
SR	studentized residuals
SRSi	soluble reactive silica
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
WAD	weak acid dissociable
WMP	water management plan
WQ-MOP	Water Quality Management and Optimization Plan
WRSF	Waste rock storage facility
ww	wet weight

1 INTRODUCTION

1.1 Background

The Meliadine Gold Mine (Mine) is in the Kivalliq District of Nunavut near the western shore of Hudson Bay, in Northern Canada (**Figure 1-1**). The nearest community is Rankin Inlet (coordinates: 62°48’35’’N; 092°05’58’’W), located approximately 25 km south of the Tiriganiaq deposit (coordinates: 63°01’03’’N, 92°12’03’’W). The mine is located within the Meliadine Lake watershed of the Wilson Water Management Area (Nunavut Water Regulations Schedule 4). Rankin Inlet is an Inuit hamlet on the Kudlulik Peninsula located between Chesterfield Inlet and Arviat. It is the regional centre and the largest community of the Kivalliq region.

1.2 Overview of the AEMP

The Aquatic Effects Monitoring Program (AEMP) is the integrated monitoring program that considers the activities that take place at the mine, and the potential for effects these activities may have on the aquatic environment. The program was developed in two stages. First, a Conceptual AEMP[1] was prepared as part of the Final Environmental Impact Statement (FEIS; Agnico Eagle, 2014) to satisfy guidance[2] issued from 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.*

The Conceptual AEMP (Golder, 2014) defined the principles and objectives of the AEMP and outlined the framework for the AEMP study design presented in Version 1 of the AEMP Design Plan (Golder, 2016).

*The **Conceptual AEMP** provided the philosophy and structure of the AEMP that will be followed throughout the life of the mine, from pre-construction through closure.*

*The **AEMP Design Plan** describes the detailed study design for monitoring mine-related changes in the aquatic environment.*

[1] FEIS Volume 7, Appendix SD 7 3

[2] From FEIS Volume 1, Appendix 1.0-A, Guideline Section # 9.4.16.

The AEMP study design was developed in consultation with the local communities, stakeholders, and regulatory authorities. Aspects of the federal Environmental Effects Monitoring (EEM) program feature heavily in the AEMP study design (see below), as does Inuit Qaujimajatuqangit (IQ) (**Section 4.4**).

Monitoring is conducted in Meliadine Lake as well as three lakes close to the Mine (known as the Peninsula Lakes) that are potentially impacted by non-point source discharges such as dust and hydrological changes associated with construction of the Mine. Meliadine Lake is the final discharge point for effluent – surface contact water – collected at the Mine, and for this reason more resources are devoted to monitoring changes in the aquatic environment. The core elements of the Meliadine Lake study include water quality, sediment quality, benthic invertebrate community, and fish (health and tissue chemistry). The Peninsula Lakes study currently focuses on monitoring changes in water quality.

The AEMP ultimately provides information used to make decisions on how to minimize, mitigate, and/or manage potential effects of the Mine on the aquatic environment. The AEMP is currently focused on monitoring changes related to construction and operations, but the AEMP also considers late operations to closure as well as development of other deposits. The components, stations, parameters, frequency, and overall design are appropriate for operation through closure, although the frequency of monitoring may change as data are collected during the life of the mine. A more thorough description of the Meliadine Lake and Peninsula Lakes study designs are provided in **Section 4**.

Environmental Effects Monitoring (MDMER)

As mentioned above, the AEMP was designed around core components of the federal EEM program, namely fish population and benthic invertebrate community studies. The EEM program is the mechanism used to evaluate the adequacy of the MDMER that govern discharge of mining effluent to receiving environments. Depending on the volume of effluent and concentration in the receiving environment, metal and diamond mines may be required to complete biological studies to verify effluent is not impacting the health of fish or fish habitat, or causing changes in fish tissue chemistry that would negatively impact traditional or recreational fishing. Environment Canada published guidance in 2012 on best practices for designing, implementing, and interpreting data from EEM programs at metal and diamond mines throughout Canada. The Technical Guidance Document (TGD; Environment Canada, 2012) featured prominently in the design of the AEMP. The guiding principles of the EEM program are that the studies are scientifically defensible, cost effective, flexible, and safe.

The Meliadine Lake study and the EEM program share a common objective of ensuring activities at the Mine, namely the discharge of effluent, does not impact the health of aquatic life in Meliadine Lake. To improve efficiency and reduce redundancy, the scope of biological monitoring under the AEMP was harmonized with the EEM where possible and practical. There are however, notable differences between the two programs that precludes a fully integrated aquatic monitoring program. For the AEMP, there are additional study areas for both the small-bodied fish and benthic invertebrate community studies as well as a fish tissue chemistry component that go beyond what is required under EEM based on commitments made during the regulatory approval process. For the EEM program, mines are required to submit a study design to Environment and Climate Change Canada (ECCC) in advance of biological monitoring on a three-year cycle[3]. Depending on input from reviewers with ECCC, the scope of the fish population and benthic invertebrate community studies may deviate from the AEMP study design. Whether the AEMP and EEM are reported in one harmonized report or separately will largely depend on to what extent the two studies differ.

Recommendations, conditions, and commitments made by Agnico Eagle during the environmental assessment (Agnico Eagle, 2014) and the initial Water Licence application (Agnico Eagle, 2015) that are directly relevant to the AEMP are provided in **Appendix A**.

1.3 Applicable Regulations

This AEMP has been designed to comply with existing regulations and follow available guidelines provided by the federal government and the Government of Nunavut. Applicable regulations and guidelines are:

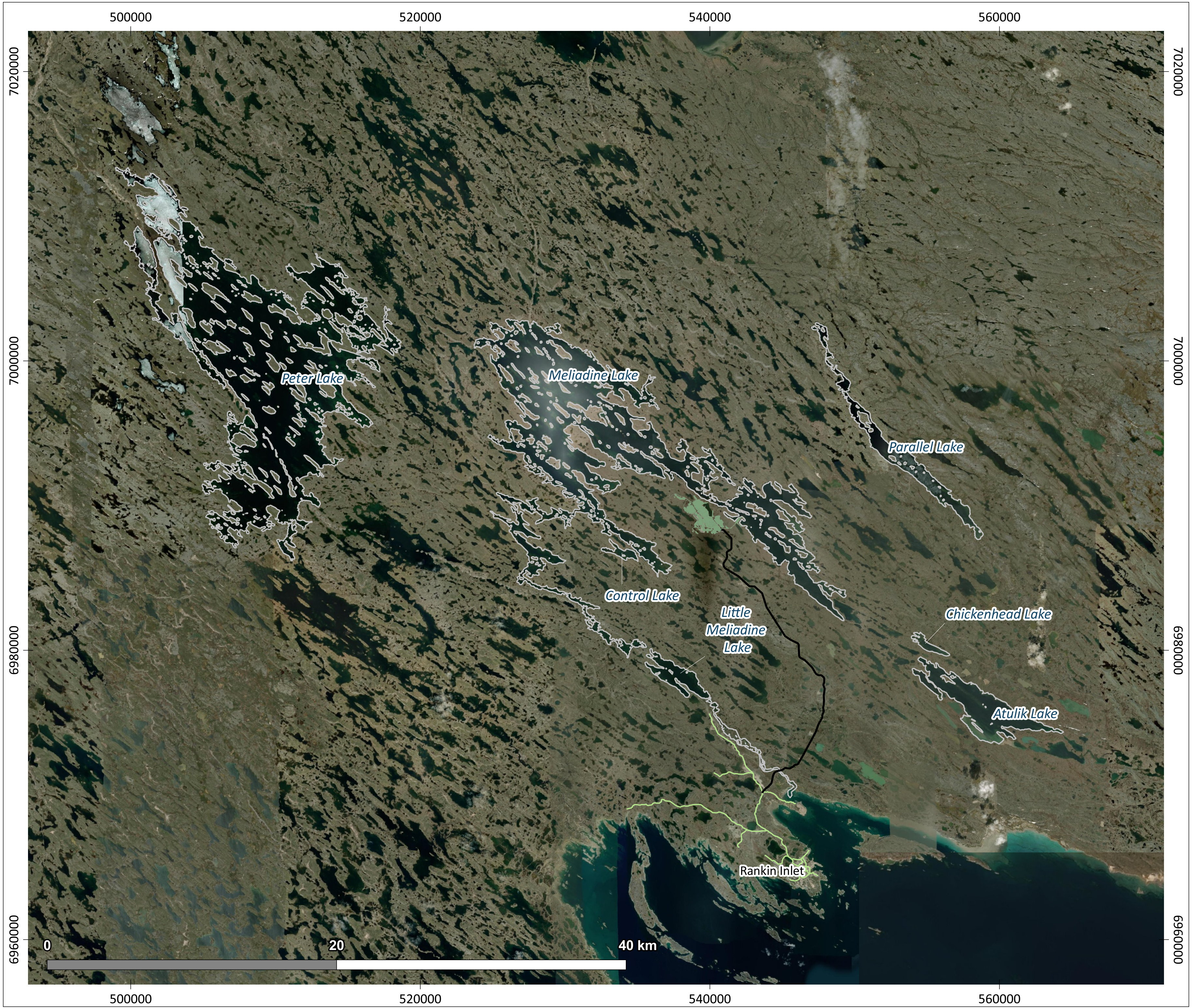
- Fisheries Act (Government of Canada 1985), including the MDMER (Government of Canada 2002)
- Nunavut Environmental Protection Act (Government of Northwest Territories 1988)
- Nunavut Land Claim Agreement Act (Government of Canada 1993)

The AEMP will be updated as necessary based on regulatory requirements.

[3] Meliadine became subject to MDMER in October 2016 with the dewatering of Lake H17.

Figure 1-1

Study Area for the Meliadine Aquatic Effects Monitoring Program



Aquatic Effects Monitoring Program Design Plan (Version 2)

AZIMUTH

Date:	April 10, 2022
Datum:	NAD 83 UTM Zone 15N
Scale:	1:340,000
Software:	QGIS version 3.16.0-Hannover
Produced by:	E. Franz

REFERENCES:
1. Basemap imagery from Google
2. Mine Plan provided by Agnico Eagle
3. Roads and waterbodies from NRC

Legend

- All weather access road
- Meliadine Mine (2021)

1.4 Objectives and Scope

The AEMP has three main objectives:

- Determine the short- and long-term effects of the Mine on aquatic receiving environments (i.e., Meliadine Lake and the Peninsula Lakes).
- Evaluate the accuracy of predictions made in the Final Environmental Impact Statement (FEIS), including the ***Final Significance Statements*** regarding impact to the aquatic ecosystem.
- Assess the effectiveness of proposed mitigation and management measures by providing input to the Adaptive Management Response Framework (**Section 8**)

Final Significance Statements

Final Significance Statements refer to the attributes of the environment that must be protected during development of the Mine:

- ***water is safe to drink*** *– water is safe for human and wildlife consumption*
- ***fish are safe to eat*** *– fish are safe for human and wildlife consumption*
- ***ecological function is maintained*** *– there is adequate food for fish, and fish are able to survive, grow, and reproduce*

Additional objectives of the AEMP Design Plan are to provide a framework for incorporation of IQ and provide a basis for engagement and to solicit feedback on updates presented in this document.

The core components of the AEMP include monitoring of water quality, sediment quality, plankton (phytoplankton), benthic invertebrate communities, and fish (health and tissue chemistry). The AEMP includes an Adaptive Management Response Framework (Response Framework), which is central to the effective implementation of the AEMP, as it serves to identify changes to early-warning indicators for these components that can trigger additional investigation, monitoring, or the implementation of additional mitigation measures.

1.5 Updates to the AEMP

Version 2 of the AEMP Design Plan was prepared as per Part I, Item 2 of the Type A Amended Water Licence (2AM-MEL1631) issued by the NWB on May 13, 2021 and approved by the Minister of Northern Affairs on June 23, 2021. Revisions to the AEMP Design considered the Water Management Plan (Version 10, Agnico Eagle 2010), recommendations made in successive annual AEMP reports, and relevant information from the recent Amendment No. 1 monitoring program (Water Quality Management and Optimization Plan [WQ-MOP], Golder 2020).

Changes reflected in this version of the AEMP Design Plan are largely editorial and most of the study design elements remain consistent with the original design. Below are some of the changes that were made to the document:

- Meliadine Mine is no longer a proposed Project, but an operating mine.
- Realignment of some sampling locations in response to effluent-related changes and the increased understanding of potential confounding factors in the original design (e.g., substrate variability within and between sampling areas).
- Sampling was discontinued at edge-of-mixing zone stations MEL-13-01 and MEL-13-07 because they overlap with AEMP Near-field stations MEL-01-01 and MEL-01-07. Edge-of-mixing zone station MEL-13-10 was renamed MEL-01-10 and was added the AEMP water quality program. There are now 6 locations sampled during each event at MEL-01. Three stations are located 100 m from the diffuser. The other three stations (MEL-01-06, MEL-01-08, and MEL-01-09) are triangulated around diffuser at a distance of approximately 250 m.
- Phytoplankton was adopted as a core monitoring component of the AEMP.
- Updated AEMP Benchmarks and Response Framework Low Action Levels to better reflect site conditions and identify Mine-related effects.
- Integrating commitments and recommendations made by Agnico Eagle through the annual AEMP report review process since the original design plan was developed.
- Revised and focused data analyses for various AEMP components to directly inform the Response Framework.

2 MINE OVERVIEW

2.1 Site Description

The Mine is comprised of a plant site (mill), an emulsion plant, underground workings, open pits, a permanent camp to house staff, an exploration camp, ore stock piles, waste rock storage facilities (WRSF 1&3), a tailings storage facility (TSF), a water management system comprised of containment ponds, dikes, channels, water treatment plants, discharge locations, and other infrastructure to support mining operations. An All-Weather-Access-Road (AWAR) connects the mine to Rankin Inlet. Flights to and from the Rankin Inlet airport operate most days of the week, transporting personnel and supplies. Bulk shipments of supplies and fuel arrive each summer during the sealift that occurs in July and August. The general layout of the mine site as of 2021 is shown in **Figure 2-1**.

Meliadine started commercial gold production in 2019. The Mine Plan includes one underground mine (Tiriganiaq Underground Mine) and two open pits (Tiriganiaq Open Pit 1 and Tiriganiaq Open Pit 2) for the development of the Tiriganiaq gold deposit. According to the Type A Water Licence Amendment submitted in August 2020, the Mine will be operational through 2027, followed by 10 years of closure activities to 2037 (Agnico Eagle, 2020).

2.2 Waste Rock and Tailings Management

There are three types of mine waste associated with development of the deposit: 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, implemented as per Part F, Item 13 of the Type A Amended Water Licence). The majority of the waste rock produced from underground and open pit mining is stored on site within designated waste rock and overburden storage facilities (WRSF). Other uses of waste rock include use as backfill in the underground workings, construction material (e.g., aggregate production), and cover material for eventual closure of the TSF. The majority of the overburden removed during development of the Tiriganiaq Pits will be disposed of with waste rock within the WRSF, with a portion of the total amount allocated for progressive closure and reclamation activities.

Geochemical testing indicates that the waste rock and overburden from the Tiriganiaq area is non-potentially acid generating and non-metal leaching (Golder, 2020). In short, waste rock is not expected to contribute to low pH conditions or elevated metals concentrations in surface contact water that is eventually collected, treated and discharged to Meliadine Lake.

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 aquatic receiving environments.

2.3 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 of is provided below based on the Water Management Plan in place for the Mine.

2.3.1 Collection, Storage and Treatment

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 Containment Ponds (CPs) through a network of dikes, channels, and culverts. At present, there are five containment ponds in operation (**Table 2-1**). CP3 through CP6 are located adjacent to major infrastructure (**Figure 2-1**). 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).

Table 2-1. Surface Contact Water Management

Source	Initial Collection Location
Industrial Site Pad Ore Stockpile (OP2) Landfill	CP1
WRSF1	CP1, CP4, CP5
WRSF3	CP2* and CP6
Tiriganiaq Pit 1	CP4 unless high salinity measured, in which case Tiri 02.
TSF	CP1 and CP3

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.

2.3.2 Effluent Discharge to Meliadine Lake

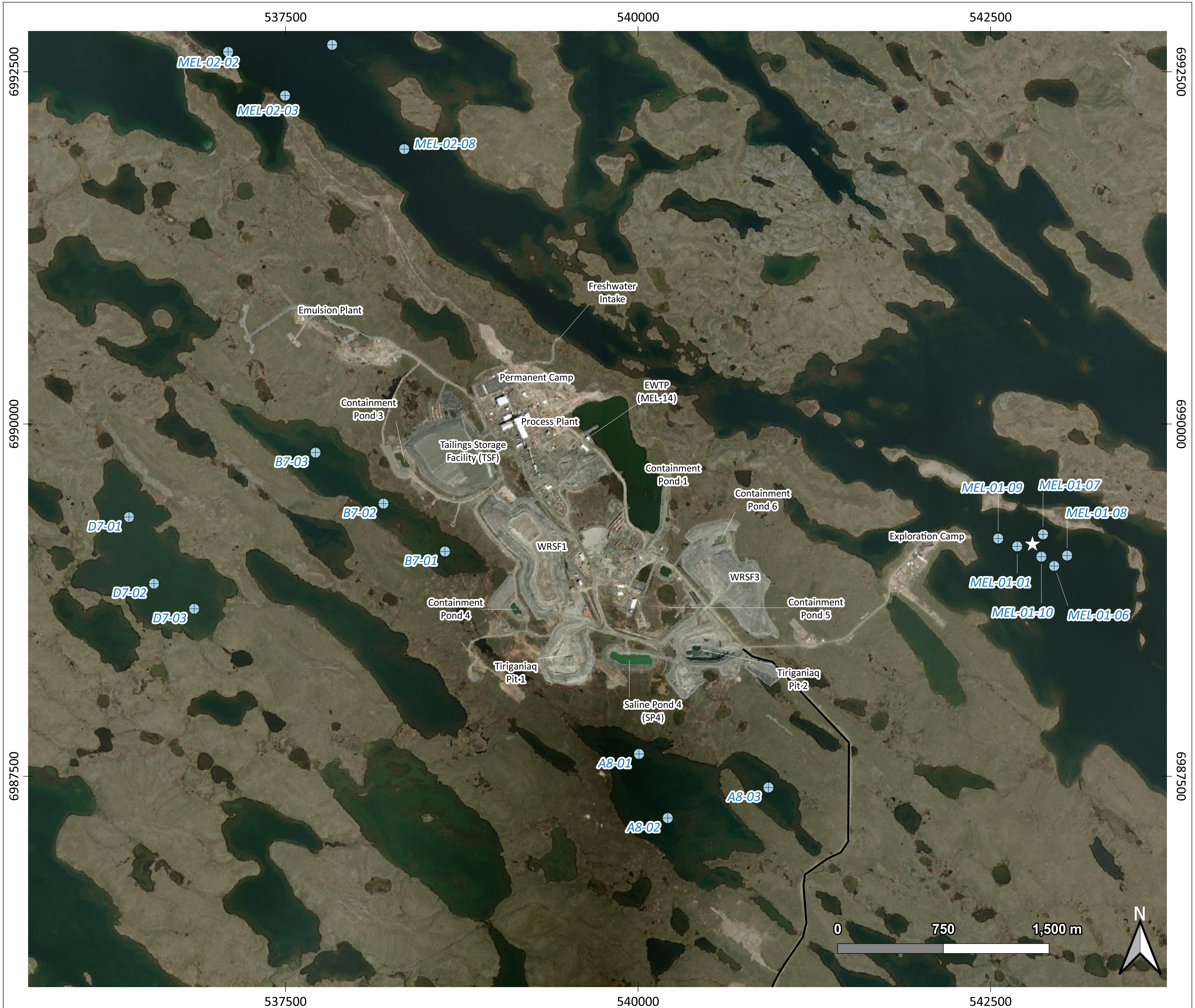
Mine effluent discharged to the receiving environment of Meliadine Lake is permitted under the Type A Amended Water Licence 2AM-MEL1631 (NWB, 2021). Water from CP1 is treated at the EWTP. MEL-14 is the compliance station for effluent chemistry and toxicity testing specified under MDMER and the Water Licence. MEL-13 is the first receiving environment station in Meliadine Lake, located at the surface of the lake directly above the diffuser[4], and is sampled in compliance 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).

[4] The diffuser is located at N 6,989,147.41 and E 542,797.91.

Figure 2-1

Surface Features at the Meliadine Mine (2021)

Aquatic Effects Monitoring Program Design Plan (Version 2)



Date:	April 8, 2022
Datum:	NAD 83 UTM Zone 15N
Scale:	1:35,000
Software:	QGIS version 3.16.0-Hannover
Produced by:	E. Franz

REFERENCES:
1. Basemap imagery from Google
2. Mine Plan provided by Agnico Eagle
3. Roads and waterbodies from NRC

Legend

- All weather access road
- Diffuser
- Water Quality Station

3 CONCEPTUAL SITE MODEL

3.1 Introduction

The conceptual site model is an illustrative approach to describing the interactions of stressors associated with proposed mine activities, exposure pathways, and receptors of potential concern. The intent of the model is to assist in communicating the functions of, and interactions between, ecological components of the study area and potential effects of activities at the Mine. The conceptual site model presented in this section to inform the AEMP Design Plan currently considers the following:

- The Mine Description, including major activities during construction, operation, and closure
- Knowledge of aquatic ecology and the specific aquatic ecosystems in the AEMP study area
- FEIS predictions

The conceptual model focuses on environmental variables related to commitments made by Agnico Eagle and conditions stipulated during the environmental permitting process.

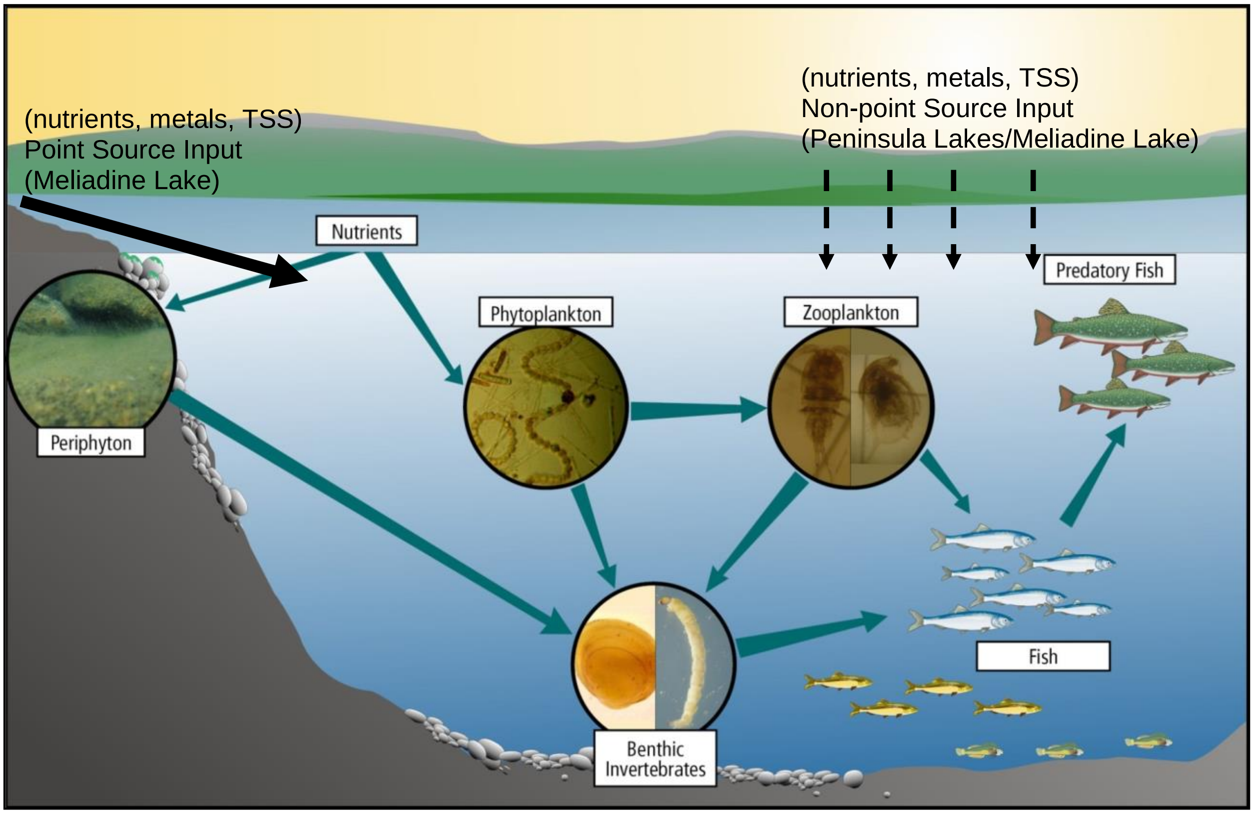
3.2 Aquatic Interactions

Aquatic interactions include biological responses to the physico-chemical conditions in lakes and sediments, as well as biota-biota interactions (**Figure 3-1**). Phytoplankton use nutrients and carbon sources (i.e., internal recycling and renewed external sources) for growth, and are food for benthic invertebrates and zooplankton. Phytoplankton community structure can change due to effluent released by a mine (e.g., increased growth from nutrient enrichment, or decreased growth from direct toxicity). Zooplankton feed directly on phytoplankton, whereas benthic invertebrates feed on decaying organic material that settles to the bottom of waterbodies. Changes in the phytoplankton community can affect the zooplankton and benthic invertebrate communities. Small fish and young fish feed on zooplankton and benthic invertebrates, and larger, predatory fish feed on smaller fish. Species such as Cisco (*Coregonus artedi*), Lake Trout (*Salvelinus namaycush*), and Arctic Char (*Salvelinus alpinus*) occupy top trophic positions in Meliadine Lake. In the Peninsula Lakes, the same species are present, but species assemblages vary among lakes.

Changes in phytoplankton, zooplankton, and benthic invertebrate densities or species composition can affect the fish community in waterbodies. The broad categories of biological receptors of the aquatic ecosystem for the Mine are as follows:

- Primary producers: phytoplankton and periphyton
- Primary consumers: zooplankton and benthic invertebrates
- Secondary/tertiary consumers: fish

Figure 3-1. Conceptual Representation of Interactions in an Aquatic Ecosystem



TSS = total suspended solids

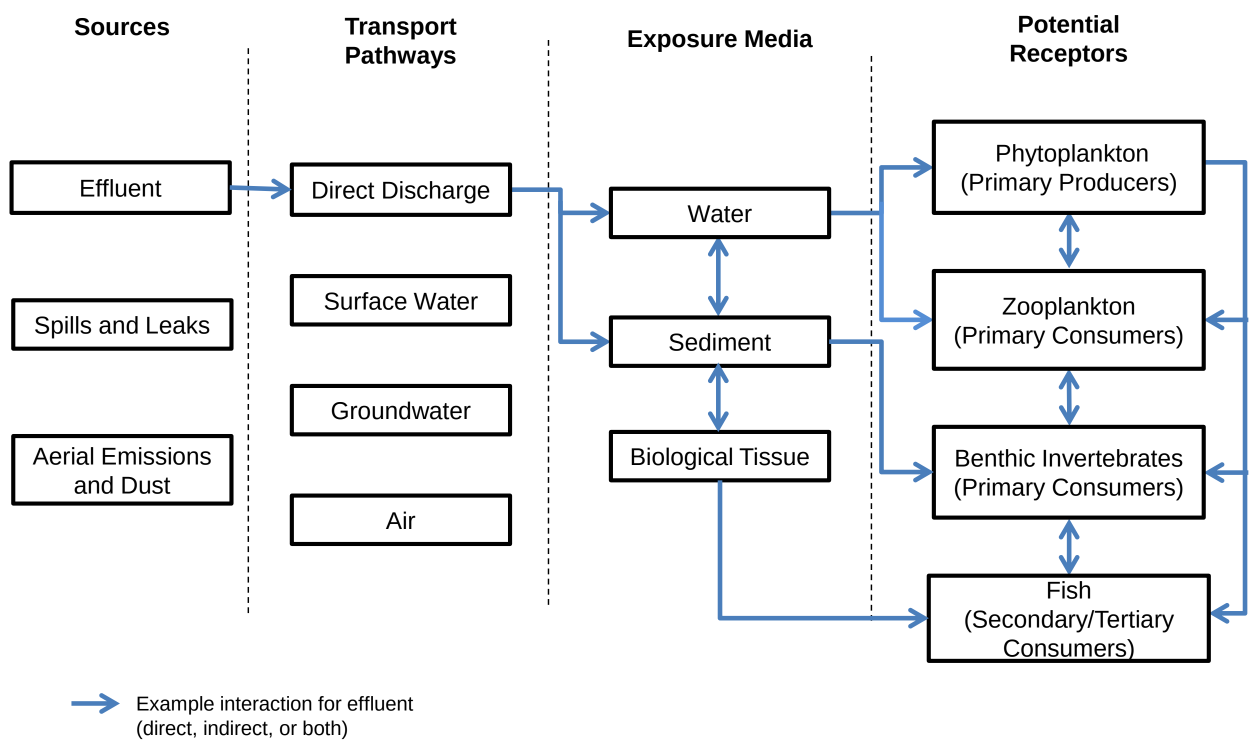
3.3 Stressors of Concern

The sources of potential stressors of concern, with corresponding transport pathways, exposure media, and biological receptors are illustrated in **Figure 3-2**. The main sources of the stressors are treated mine effluent, spills and leaks, and aerial emissions and dust. For purposes of this conceptual figure, effluent includes all mine activities involved in the generation and management of effluent. These stressors are transported to the aquatic environment through direct discharge, surface water, groundwater, and air.

An example of a stressor specific pathway from the release of effluent is illustrated in **Figure 3-2** as the blue line. This is conceptual and not necessarily representative of all constituents. In the example, treated effluent is released directly to Meliadine Lake. The effluent may change the water, sediment, or biological tissue (directly or indirectly), which in turn may influence the biological receptors of concern either directly, indirectly, or both. 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 interactions often include several levels of receptors. For example, discharge of mine-affected water may elevate nutrient concentrations and primary productivity, which in turn may reduce dissolved oxygen concentration and the capacity of a waterbody to support aquatic life (i.e., invertebrates and fish).

The specific chemical stressors of concern will be identified through the monitoring program such that the conceptual site model can be updated and refined to reflect specific stressor chemicals and at a minimum the main pathways to potential effects on the aquatic ecosystem, and how they interact with the potential receptors.

Figure 3-2. Meliadine Lake Study Conceptual Site Model with Exposure Pathways



In the FEIS, changes to water quality from the Mine were predicted to be negligible to low, local in extent, and medium-term (for Meliadine Lake) to permanent (for some peninsula watersheds and drainage paths) in duration (Agnico Eagle 2014a). The Mine was not predicted to adversely impact the continued opportunity for traditional and non-traditional use of fish in the study area, nor the health of aquatic life, or the quality of water for human consumption. To evaluate these predictions, the key pathways considered in the Meliadine Lake study conceptual site model that could cause changes in the aquatic ecosystem, include the release of treated effluent (illustrated in **Figure 3-2**) and release of air emissions (acidifying emissions, dust, and associated metals). The key pathways considered in the

Peninsula Lakes study that could cause changes in the aquatic ecosystem include watershed alteration due to dewatering, diversion of natural drainage paths, construction of new drainage channels, and/or water balance changes, and release of air emissions. 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.

Based on the above, stressors considered in the AEMP and associated pathways to receptors include the following:

- metals that could lead to direct toxicity in fish and other aquatic organisms
- nutrients that could lead to increased productivity, reduced concentrations of dissolved oxygen, and changes to aquatic ecosystem structure

3.4 Impact Hypotheses, Assessment Endpoints, and Measurement Endpoints

The pathways and stressors of the conceptual site model were identified and developed with consideration of the residual effects identified in the FEIS, and the measurement and assessment endpoints (**Table 3-1**). Based on this information, two impact hypotheses are proposed:

- Toxicological Impairment Hypothesis: Toxicity to aquatic organisms may occur due to the release of substances of toxicological concern (primarily trace metals).
- Nutrient Enrichment Hypothesis: Increased productivity may occur due to the release of nutrients (primarily phosphorus and nitrogen).

Assessment and measurement endpoints are terms commonly used in environmental assessments to describe the valued component to be protected (e.g., water quality) and the indicators used to measure potential effects to them (e.g., water chemistry). This terminology is adopted for the AEMP, where the assessment and measurement endpoints are used to focus the components through the collection of appropriate data to address the impact hypotheses. The assessment and measurement endpoints are considered as part of the Response Framework (Section 8) and in the integration of results in the AEMP report (Section 9).

Assessment endpoints identify what is to be protected (e.g., a healthy and sustainable aquatic ecosystem). The assessment endpoints for the AEMP are based on the valued components identified in the FEIS and consider the effect predictions made in the FEIS. *Measurement endpoints* are the quantifiable and measurable metrics included in the AEMP, such as concentrations of metals or nutrients in water, or the density of benthic invertebrates (**Table 3-1**).

Table 3-1. Assessment and Measurement Endpoints Associated with the Aquatic Effects Monitoring Program

Aquatic Component	Assessment Endpoint	Measurement Endpoint	Supporting Evidence
Water Quality	Water and sediment quality support a healthy aquatic ecosystem	Concentrations of metals in: • effluent discharge • surface water • sediments	• Concentrations of toxicity-modifying parameters (e.g., pH, hardness) • Sediment chemistry
		Concentrations of nutrients in: • effluent discharge • surface water • sediments	• Concentrations of other parameters (e.g., chlorophyll *a*)
		Chronic toxicity to standardized aquatic test species	• Water chemistry • Sediment chemistry
Sediment Quality		Concentrations of nutrients and metals in: • surficial sediments	• Water chemistry • Sediment particle size and total organic carbon
Plankton (phytoplankton)	Maintenance of plankton communities	Phytoplankton biomass, density, and taxa richness	• Water chemistry
Benthic Invertebrate Community	Benthic invertebrate communities are characteristic of an oligotrophic subarctic lake	Total invertebrate density and densities of dominant invertebrate groups, Taxonomic richness Benthic community similarity between exposure and reference areas	• Water chemistry • Sediment chemistry • Physical habitat characteristics
Fish Health	Self-sustaining and healthy fish populations compared to baseline and/or reference area populations	Survival • Age • Length-frequency distribution • Length • Weight	• Site characterization • Water chemistry • Sediment chemistry • Benthic invertebrate community • Target species abundance (catch per unit effort) • Fish tissue chemistry
		Growth (Energy Use) • Size-at-age	
		Condition (Energy Storage) • Fish condition • Relative liver size	
Fish Tissue	Fish tissue metal concentrations that are consistent with baseline/reference conditions	Large-bodied fish tissue chemistry	• Water chemistry • Sediment chemistry • Small-bodied fish tissue chemistry • Fish health

4 AEMP STUDY DESIGN

The AEMP was designed around the key aspects of EEM requirements with supplemental components included to fulfil the additional conditions and requirements of the Water Licence and to monitor for potential mine-related effects to the aquatic environment. The core components of the AEMP are:

- water quality
- sediment quality
- phytoplankton community (previously a targeted study)
- benthic invertebrate community
- fish health (small-bodied and large-bodied species)
- fish tissue chemistry

Two distinct programs are proposed within the AEMP: the Meliadine Lake study and the Peninsula Lakes study. The larger Meliadine Lake study includes all the core components listed above and the smaller Peninsula Lakes study is focussed on water quality as an early-warning indicator of potential biological effects. The focus of these two studies remains consistent with the original design plan following the present update.

As per the MDMER, biological studies are only required where there is a point source discharge of effluent. For this reason, the Meliadine Lake study is built around the EEM program requirements and is considered the core of the AEMP. The Peninsula Lakes will not receive effluent and thus do not require an EEM biological program. The Peninsula Lakes study focuses on water quality as the early-warning indicator of potential biological effects. If water quality data suggest that the Mine has affected the Peninsula Lakes beyond FEIS predictions, a supplemental biological program will be designed and implemented. During consultation with Environment Canada, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC; formerly AANDC), and the Rankin Inlet Hunters and Trappers Organization (see Appendix A in Golder [2016]), there was support for the approach of an AEMP with two distinct programs. Support was also expressed for an EEM-based program in Meliadine Lake and a water quality only program in the Peninsula Lakes. The AEMP will continue to integrate IQ (**Section 4.4**) where available.

4.1 Key Questions

Key questions are proposed for each core component to focus approaches adopted to develop study methods, conduct data analyses, and provide interpretation in the annual AEMP report. The key questions for each study are provided in **Table 4-1** by component and have largely remained the same as the original study design.

Table 4-1. Key Questions for the Aquatic Effects Monitoring Program.

Component	Key Questions
Meliadine Lake	
Water Quality	Are concentrations of key parameters in 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 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?
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?
Peninsula Lakes	
Water Quality	Is water quality consistent with predictions in the FEIS and below guidelines to protect aquatic life and human health?
	Has water quality changed over time relative to baseline conditions?

4.2 Meliadine Lake Study Overview

4.2.1 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 Meliadine Lake volume is contributed by lake areas that are less than 2 m in depth, which indicates a considerable reduction in lake volume and overwintering potential during winter (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 and contributes approximately 21% to the entire area of Meliadine Lake. It is separated from the rest of the lake by a shallow and narrow area (up to 2.3 m deep, 100 to 300 m wide, and 800 m long) that features numerous rocky islands and reefs. The east basin may be isolated from the west basin during the winter months, preventing fish passage (Agnico Eagle, 2014).
- The **northwest basin** is the largest basin in Meliadine Lake. At approximately 7,100 ha, this area is approximately 68% of the surface area of the entire Lake.
- The **southwest basin** is 1,135 ha and contributes approximately 11% to the entire lake area. The SE end of the south basin near the outlet to the Meliadine River is generally shallow (less than 4 m deep).

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 NF area compared to the MF and reference areas. The inherent difference among basins is important to consider 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 NF area, 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 MF and reference areas.

4.2.2 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 [NF], mid-field [MF]) and three reference areas to provide spatial context when interpreting potential changes within and between years.

- Near-field (MEL-01) – The NF area (MEL-01) is located in the east basin around the diffuser. Changes in water quality and effects to the biological communities caused by discharge of effluent to Meliadine Lake would be expected to occur at MEL-01 first.
- Mid-field (MEL-02) – The MF 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[5] of Meliadine Lake. Reference Area 2 (MEL-04) is located in 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 Meliadine River.

No changes were made to the monitoring areas for version 2 of the AEMP Design Plan.The location of each monitoring area is shown in **Figure 4-1**. The frequency of sampling by area and monitoring component is presented in **Table 4-2**.

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 FEIS. Furthermore, sending field crews to far off locations to collect biological data is a high-risk activity. To reduce the health and safety risk, but still meet the regulatory needs of the study, reference areas as

[5] Use of east, west and south basins for Meliadine Lake as per Golder (2019).

close to the mine as possible are a preferred alternative. Internal reference areas were considered suitable for the purpose of the AEMP for the following reasons that were outlined in version 1 of the AEMP Design Plan:

- The quantity of effluent will be small relative to the volume of Meliadine Lake (east and south basins estimated at 98,851,000 cubic meters [m^3] and 48,429,000 m^3, respectively).
- The diffuser is approximately 20 km from the outlet to Peter Lake (MEL-04) and 48 km from the outlet to the Meliadine River (MEL-05).
- Concentrations at the edge of the mixing zone (100 m from the diffuser) were predicted to be at or less than FWAL and GCDWQ (FEIS, Volume 7). This prediction has been verified throughout the early operations phase (Azimuth, 2021; Golder, 2020).
- 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 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.
- Arctic Char, Arctic Grayling, Burbot, Cisco, Lake Trout, and Round Whitefish were captured in both Meliadine Lake and the potential reference lakes, but species assemblages were often different than Meliadine Lake.

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 NF, MF, and reference area populations in Meliadine Lake. Unlike small-bodied fish species, large-bodied fish species like Lake Trout have larger home ranges. 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). The large home range of Lake Trout means Lake Trout captured in the northwest basin of Meliadine Lake may have resided in the east basin of the lake where they could have been transiently exposed to effluent. Because there is no true *control* or *reference* area, the Lake Trout study is limited to a *before-after* assessment of changes in health endpoints and tissue chemistry over time. The main limitation with before-after study designs is they cannot determine if a change over time is due to natural factors or if mining activities are the cause. To assess if Lake Trout in Meliadine Lake are being affected by mining activities, two external reference lakes (Peter Lake and Atulik Lake) were included in the large-bodied fish study design for the Cycle 2 EEM study (Azimuth and Portt, 2021). This program was conducted in parallel with the AEMP in 2021 and results will be reported in Q2 2022.

External reference area lakes may be added to the Lake Trout health assessment under the AEMP depending on findings of the Cycle 2 EEM (Azimuth, in prep).

4.2.3 Sampling Design

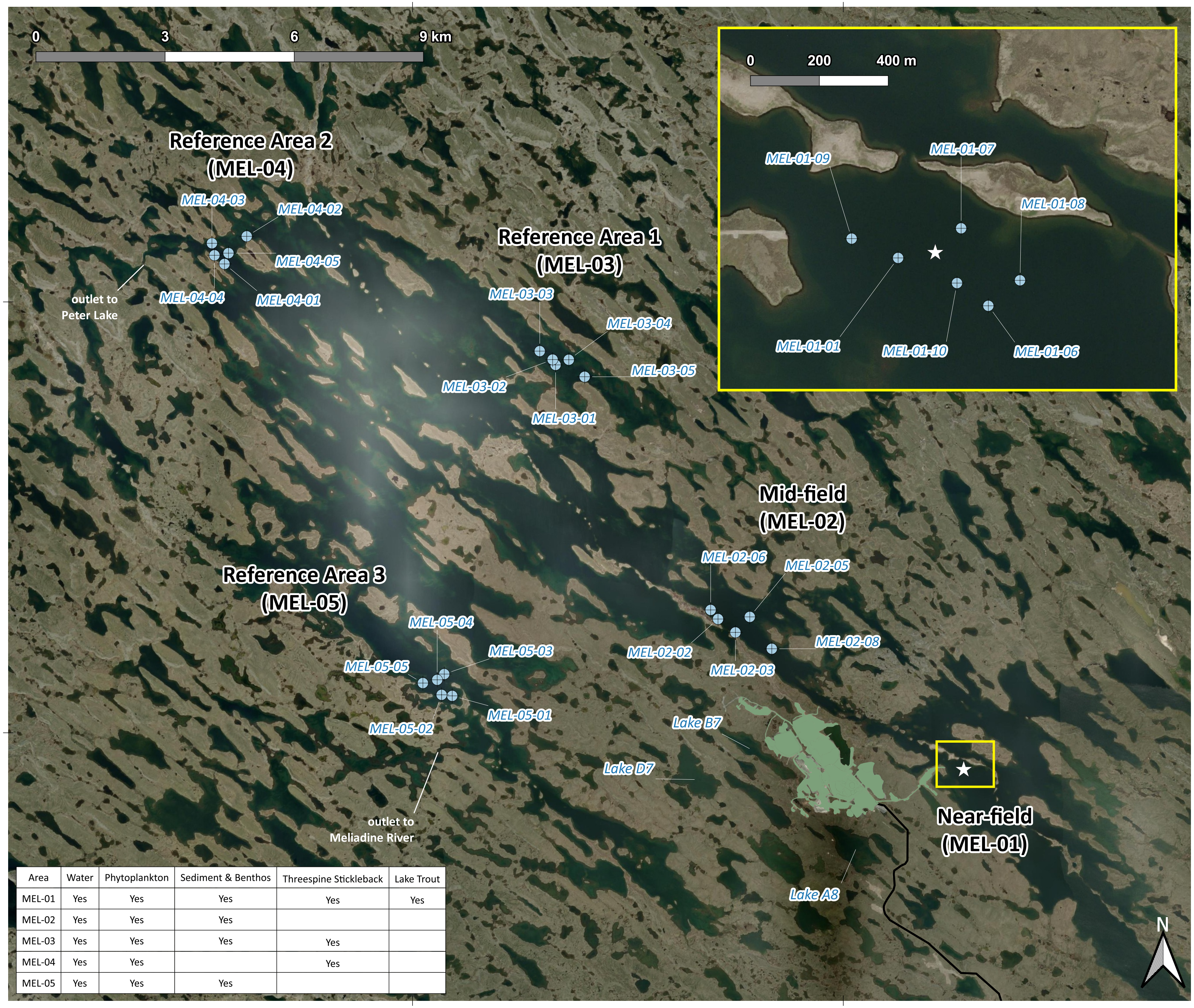
The current scope of the Meliadine Lake study includes monitoring water, sediment, phytoplankton, benthic invertebrates, fish health, and fish tissue chemistry (**Table 4-2**). The AEMP was designed so that water, phytoplankton, sediment, and benthic invertebrate samples were preferentially collected at the same sampling station within each sampling area in Meliadine Lake (**Figure 4-1**). Adequate replication within each area is necessary to provide sufficient statistical power to detect differences among sampling areas. Five stations[6] are sampled in each area as recommended in the TGD (Environment Canada, 2012) except for MEL-01 where six locations are samples around the diffuser. Three NF stations are located at 100 m and another three stations are located at 250 m from the diffuser to verify that water quality meets FEIS predictions at the edge of the mixing zone and determine the spatial extent of changes in water quality.

Sediment at MEL-01 is predominantly silt and clay in the vicinity of the diffuser. The MF and reference area stations were established in areas with similar depth (8.5 m ± 1.5 m) and similar habitat to avoid the confounding effect of habitat differences when assessing differences in the benthic invertebrate communities among the exposure and reference areas. Sediment and benthic invertebrate samples are preferentially collected at the same location as water and phytoplankton. However, stations will be relocated if the sediment substrate is predominantly sand or if it is difficult to obtain an acceptable sample. A few of the sediment and benthic invertebrate sampling stations were realigned during the August 2021 field program to areas that had higher silt and clay content compared to stations that were sampled in 2018. The coordinates for the water, phytoplankton, sediment, and benthic invertebrate sampling station are provided in **Table 4-4**.

Sampling locations for the small-bodied fish program in the NF area and reference areas MEL-03 and MEL-04 are selected in suitable shoreline habitat for Threespine Stickleback. Lake Trout are sampled from the east basin near the diffuser, recognizing that Lake Trout migrate throughout Meliadine Lake and are therefore only transiently exposed to effluent.

Additional details on the specific components, with respect to sampling and analysis plans, measurement endpoints, data analysis and interpretation are provided in **Section 5**. A summary of the monitoring requirements for the Water Licence and MDMER are provided in **Table 4-5**.

[6] A sixth NF station (MEL-01-10) was added to the study design in 2021.



Area	Water	Phytoplankton	Sediment & Benthos	Threespine Stickleback	Lake Trout
MEL-01	Yes	Yes	Yes	Yes	Yes
MEL-02	Yes	Yes	Yes		
MEL-03	Yes	Yes	Yes	Yes	
MEL-04	Yes	Yes		Yes	
MEL-05	Yes	Yes	Yes		

Figure 4-1

Sampling Areas and Stations for the Meliadine Lake AEMP

Aquatic Effects Monitoring Program Design Plan (Version 2)

AZIMUTH

Date: March 1, 2022
Datum: NAD 83 UTM Zone 15N
Scale: 1:119,000 ; inset =1:15,000
Software: QGIS version 3.16.0-Hannover
Produced by: E. Franz

REFERENCES:
1. Basemap imagery from Google
2. Mine Plan provided by Agnico Eagle
3. Roads and waterbodies from NRC

Legend

- All weather access road
- Meliadine Mine (2021)
- Diffuser
- Sampling Station

Threespine Stickleback are collected from littoral areas in MEL-01, MEL-03 and MEL-04 in the vicinity of the fixed sampling stations. Lake Trout are collected from the area around the diffuser.

Table 4-2. Aquatic Effects Monitoring Program Design Plan for the Meliadine Lake Study.

Area	Component	Program Frequency	Stations per Area	Samples per Station	Parameters	Sample Type	Collection Frequency within Program
MEL-01 Near-field Exposure	Water Quality	Annual	6	1	field measurements, conventional parameters, major ions, nutrients, metals, cyanides	discrete; mid-depth	Winter (Mar or Apr) Open-water (Jul, Aug, Sep)
	Phytoplankton		6	3	chlorophyll-a	composite; from depth-integrated	August
			6	1	phytoplankton taxonomy, biomass, and density		
	Benthic Invertebrates	Every 3 years	5	1	benthic invertebrate taxonomy	composite from 5 grabs	August
	Sediment Quality		5	1	particle size, moisture, total organic carbon, nutrients, metals	composite from up to 5 grabs	August
	Threespine Stickleback (THST) Health Assessment[a]		n/a	30 adult females 30 adult males 20 juveniles	age, length, weight, condition, sex, fecundity, size at age, external and internal health (including gonad and liver weights)	individual fish	August
	Lake Trout (LKTR) Health Assessment[a]		n/a	20 adult females 20 adult males	age, length, weight, condition, sex, fecundity, size at age, external and internal health (including gonad and liver weights)	individual fish	August
	Fish Tissue Chemistry[a]		n/a	~40 (THST	moisture and metals	THST = carcass (viscera removed)	August
				~40 (LKTR)		LKTR = muscle (archive liver and kidney)	
MEL-02 Mid-field Exposure	Water Quality	Annual	5	1	field measurements, conventional parameters, major ions, nutrients, metals, cyanides	discrete; mid-depth	Winter (Mar or Apr) Open-water (Jul, Aug, Sep)
	Phytoplankton		5	3	chlorophyll-a	composite; from depth-integrated	August
			5	1	phytoplankton taxonomy, biomass, and density		
	Benthic Invertebrates	Every 3 years	5	1	benthic invertebrate taxonomy	composite from 5 grabs	August
	Sediment Quality		5	1	particle size, moisture, total organic carbon, nutrients, metals	composite from up to 5 grabs	August

Table 4-2. Aquatic Effects Monitoring Program Design Plan for the Meliadine Lake Study.

Area	Component	Program Frequency	Stations per Area	Samples per Station	Parameters	Sample Type	Collection Frequency within Program
MEL-03 Reference Area 1 (Northeast bay)	Water Quality	Annual	5	1	field measurements, conventional parameters, major ions, nutrients, metals, cyanides	discrete; mid-depth	Open-water (Jul, Aug, Sep)
	Phytoplankton		5	3	chlorophyll *a*	composite; from depth-integrated	August
			5	1	phytoplankton taxonomy and biomass		
	Benthic Invertebrates	Every 3 years	5	1	benthic invertebrate taxonomy	composite from 5 grabs	August
	Sediment Quality		5	1	particle size, moisture, total organic carbon, nutrients, metals	composite from up to 5 grabs	August
	Threespine Stickleback (THST) Health Assessment[a]		n/a	30 adult females 30 adult males 20 juveniles	age, length, weight, condition, sex, fecundity, size at age, external and internal health (including gonad and liver weights)	individual fish	August
	Fish Tissue Chemistry[a]		n/a	~40 (THST)	moisture and metals	THST = carcass (viscera removed)	August
MEL-04 Reference Area 2 (North-west Bay near lake outlet)	Water Quality	Annual	5	1	field measurements, conventional parameters, major ions, nutrients, metals, cyanides	discrete; mid-depth	August
	Phytoplankton		5	3	chlorophyll-a	composite; from depth-integrated	August
			5	1	phytoplankton taxonomy		
	Threespine Stickleback (THST) Health Assessment[a]	Every 3 years	n/a	30 adult females 30 adult males 20 juveniles	age, length, weight, condition, sex, fecundity, size at age, external and internal health (including gonad and liver weights)	individual fish	August
	Fish Tissue Chemistry[a]		n/a	~40 (THST)	moisture and metals	THST = carcass (viscera removed)	
MEL-05 Reference Area 3 (Southwest bay near lake outlet)	Water Quality	Annual	5	1	field measurements, conventional parameters, major ions, nutrients, metals, cyanides	discrete; mid-depth	August
	Phytoplankton		5	3	chlorophyll-a	composite; from depth-integrated	August
			5	1	phytoplankton taxonomy and biomass		
	Benthic Invertebrates	Every 3 years	5	1	benthic invertebrate taxonomy	composite from 5 grabs	August
	Sediment Quality		5	1	particle size, moisture, total organic carbon, nutrients, metals	composite from up to 5 grabs	August

Notes
[a] Sample sizes for the fish health and fish tissue chemistry studies are subject to change depending on results from previous assessments. Sample sizes shown here are from the 2021 AEMP (Azimuth, 2022).

Table 4-3. Summary of Fish Captured in Meliadine Lake and Potential Reference Lakes (1997 to 2013) Using Various Capture Methods

Lake	Meliadine Lake	Potential Reference Lakes				
		Atulik Lake[(a)]	Chickenhead Lake	Control Lake	Little Meliadine Lake	Parallel Lake
Large-bodied Fish						
Arctic Char	473	0	0	0	30	0
Arctic Grayling	199	0	12	2	83	0
Burbot	19	0	1	1	1	0
Cisco	2,503	0	0	0	27	6
Lake Trout	463	0	17	16	83	38
Lake Whitefish	0	0	0	0	0	1
Round Whitefish	114	0	0	42	91	19
Small-bodied Fish						
Ninespine Stickleback	0	0	0	38	18	0
Threespine Stickleback	6,243	0	0	0	0	0
Slimy Sculpin	4	0	0	1	7	0

Notes:
(a) Combined data sources include Golder 2012a, 2012b, Azimuth 2013.

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

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

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

Area	Station ID	Water and Phytoplankton			Sediment and Benthic Invertebrates		
		Depth(m)	Easting	Northing	Depth(m)	Easting	Northing
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	-	-	-
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

Note:
Station locations shown above were from the 2021 AEMP. The exact UTMs may vary slightly year-to-year for the fixed monitoring stations.
Sediment and benthic invertebrate sampling locations are collocated with water and phytoplankton were possible. If habitat differences are present, the stations are relocated to more suitable sampling locations.
Sediment and benthic invertebrate community sampling were discontinued at MEL-04 in 2018 based on differences in habitat in this area of Meliadine Lake (Golder 2019).

Table 4-5. Meliadine Lake Design Plan – Alignment between Water Licence and Metal and Diamond Mining Effluent Regulations.

Core AEMP Component	Description	Frequency	AEMP	MDMER
Water Quality	Physical and chemical characteristics of surface waters	Every year; multiple times per year	Near-field, Mid-field, and three Reference areas	Yes
Effluent Characterization[a]	Characterization of end-of-pipe effluent quality	Every year; multiple times per year	not applicable	Yes
Effluent Plume Characterization[a]	Distribution of the effluent plume and percent effluent concentration in Meliadine Lake	Every three years per EEM schedule	Near-field area	Yes
Phytoplankton	Biomass and composition of the phytoplankton assemblage	Annual	Near-field, Mid-field, and three Reference areas	No
Benthic Invertebrate Community	Structure and composition of the benthic invertebrate assemblage	Every three years per EEM schedule	Near-field, Mid-field, and two Reference areas	Yes Mid-field not included
Sediment Quality[b]	Physical and chemical characteristics of bottom sediments	Every three years per EEM schedule	Near-field, Mid-field, and two Reference areas	Yes Mid-field not included
Small-bodied fish health	Lethal fish health survey with Threespine Stickleback	Every three years per EEM schedule	Near-field area and two Reference areas	Yes
Large-bodied fish health	Lethal fish health survey with Lake Trout	Every three years per EEM schedule	Near-field area	See note [c]
Fish Tissue	Assessment of mercury (large-bodied fish) and other metals (small-bodied fish) in fish tissue	Every three years per EEM schedule	THST = Near-field and two Reference areas LKTR = Near-field area	See note [d])

Notes
(a) Not a core component but a related study with results required for both EEM and AEMP.
(b) Supporting component for EEM but core component for AEMP.
(c) The study design for the Cycle 2 EEM included Lake Trout sampling at two external reference area lakes (Peter Lake and Atulik Lake).
(d) Fish tissue chemistry may be required depending on the concentration of mercury or selenium in effluent.
EEM = Environmental Effects Monitoring; MDMER = Metal and Diamond Mining Effluent Regulations

4.3 Peninsula Lakes Study Overview

4.3.1 Background

Several small watersheds drain to Meliadine Lake from the peninsula between the south and east basins of Meliadine Lake. These peninsula watersheds comprise an extensive network of small lakes, ponds, and interconnecting streams.

During construction and operations, the Peninsula Lakes could be influenced by non-point source discharges (e.g., aerial emissions of dust and metals) and potentially erosion and sedimentation from the alteration of natural drainages. The combined effect of non-point source discharged were predicted to be local and not to extend to Meliadine Lake. Aerial deposition from mine activities were predicted to increase from background levels during pre-production, peak during pit development, and decrease to background levels by closure (Agnico Eagle, 2014). Effects to lakes from non-point source pathways were expected to be negligible to low due to the implementation of environmental design features to control erosion and air emissions. Furthermore, monitoring results from other mines indicate that dust has a negligible impact on surface water quality (Rescan, 2012). A similar outcome is expected for the mine, as indicated by the predictions of negligible to low effects in the FEIS; this prediction will be verified through air quality monitoring and water quality monitoring at Lakes A8, B7, and D7 on the peninsula.

Water quality modeling was completed as part of the 2014 FEIS submission to predict how construction and mining activities would affect water quality in small lakes located in the A, B, and D watersheds on the peninsula[7]. The original Project Certificate No.006 included development of deposits that require dewatering of Lake A8 and nearby Lake A6. Based on the expectation that Lake A8 would be dewatered to make way for development of other deposits south of Tiriganiaq, water quality predictions were developed for the baseline phase (pre-development) and post-closure phases (after the lake is flooded) for Lake A8, but not for constructions and operations. Predictions were not developed for Lake B7 because the original mine plan called for dewatering of Lake B7 for tailings disposal.

For the Type A Water Licence Application, Lake B7, Lake A8, and Lake D7 were removed from the final design because the lakes are underlain by a zone of talik (permanently unfrozen ground) (Agnico Eagle, 2015). Development of previously-approved deposits will expand the footprint of the mine, and will require dewatering of Lake B7 and Lake A8 to support development. New monitoring locations may be established according to strategy described in the Conceptual AEMP Design Plan (Agnico Eagle, 2021).

[7] Refer to Table 7.4-A2 (Inventory of Waterbodies) in Appendix 7.4-A of the FEIS (Agnico Eagle 2014) for lakes that were carried forward for water quality modelling.

4.3.2 Environmental Setting and Sampling Areas

The lakes within the peninsula are generally small (<90 ha in area) and shallow (between 2 and 5 m in maximum depth). They do not freeze to the bottom. They are connected to each other (and to Meliadine Lake) through short stream sections; however, they can often be isolated by limited flow during the summer/fall and frozen stream conditions during the winter.

Three peninsula lakes were selected for water quality monitoring as part of the AEMP: Lake A8, Lake B7, and Lake D7. These are headwater lakes in three different peninsula watersheds and are located close to the mine.

Two of the lakes (Lakes B7 and D7) were previously fished by the Inuit during the winter (pers. comm. Wesley from Rankin Inlet Hunters and Trappers Organization). Some morphological characteristics of these peninsula lakes are provided in Table 4-6.

Table 4-6. Morphological Characteristics of AEMP Peninsula Lakes

Lake	Surface Area (ha)	Volume ($m^3 \times 10^3$)	Depth(m)		Total Shoreline Length (km)
			Mean	Maximum	
A8	89.7	1,419.3	1.6	4.2	7.5
B7	58.1	852.5	1.5	5.1	5.5[a]
D7	72.5	1,183.4	2.8	5.2	5.2

Source: Golder (2012a) Aquatic Baseline Synthesis Report.
[a] Includes shoreline length around two islands.

Under baseline conditions, the Peninsula Lakes were well-oxygenated, with pH values indicative of slightly basic conditions, low sensitivity to acid deposition, and low to moderate ionic strength. Parameter concentrations in the Peninsula Lakes were below relevant guidelines. Sediment samples from the Peninsula Lakes were a mix of sand and fine sediments with concentrations of some metals above CCME interim sediment quality guidelines (ISQG) values (e.g., arsenic, chromium, and copper), which is similar to Meliadine Lake under baseline conditions.

4.3.3 Sampling Design Summary

The Design Plan for Peninsula Lakes is focussed on monitoring water quality. If water quality results suggest mine-related changes have occurred or are occurring that potentially could adversely affect aquatic life, then sediment and biological studies may be considered. Monitoring conducted during construction and operations indicate that concentrations remain below applicable water quality guidelines as predicted. Some parameters have increased above baseline (>10% increase) but concentrations have remained low and been reasonably consistent between July and August sampling events as well as spatially within each lake. Verification monitoring for other Peninsula Lakes and ponds

(B5, E3, G2, H1) is carried out as per the Water Licence requirements where one station per lake (MEL-15 to 18) is sampled on a bi-annual basis during the open water season for water quality.

No changes to the Peninsula Lake Study are proposed at this time.

Table 4-7. Peninsula Lakes Design Plan for Water Licence Requirements

Component	Description	Lake	Frequency	# Stations
Water Quality	Physical and chemical characteristics of surface waters	Lakes A8, B7, and D7	July and August	3 per lake

4.4 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. Agnico Eagle will continue active engagement with communities and Inuit organizations as the Mine proceeds through operations and closure. In addition, feedback will be sought on the reporting of results to the local communities so that it is of relevance and meaning to them. This consultation and engagement should lead to further inclusion of IQ, as it becomes available, in updates to the design and implementation of environmental programs.

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. Elders have previously expressed concerns regarding potential adverse effects due to the operation of the Mine on drinkability of water and fish populations in waterbodies in the entire Meliadine watershed. Therefore, two distinct programs are included in the AEMP: the Meliadine Lake study and the Peninsula Lakes study. In addition, a framework for responding to changes has been identified to allow Agnico Eagle to respond quickly and early to any unexpected changes in Meliadine Lake.

The need for ongoing community consultation is also incorporated in Nunavut Impact Review Board (NIRB) Project Certificate No. 006, TC 103:

"The Proponent is encouraged to consult with the Kangiqliniq Hunters and Trappers Organization and the Kivalliq Socio-Economic Monitoring Committee and to make all reasonable efforts to engage Elders and community members of the Kivalliq communities in order to have community level input into updates to its monitoring plans, programs and mitigative measures. This type of engagement will ensure that these programs and measures have been informed by traditional activities, cultural resources, and land use as such may be implicated or impacted by ongoing Project activities. All plans are to include a feedback mechanism for consulting with residents of the Kivalliq, including the provision of results from the Proponent's wildlife monitoring programs to each community."

5 MELIADINE LAKE STUDY

5.1 Effluent and Water Quality

5.1.1 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 through 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 Final Environmental Impact Statement (FEIS) and less than AEMP Action Levels[8]?*

5.1.2 Study Design and Schedule

Water sample collection in Meliadine Lake will be aligned, where possible, with the collection of phytoplankton samples (i.e., collected at the same time and at the same stations), and with collection of benthic invertebrate and sediment samples (i.e., collected at the same stations but not necessarily at the same time), as described in **Sections 5.2**, **5.3**, and **5.4**, respectively. In addition, effluent quality

[8] AEMP Action Levels refer to 75% of the AEMP Benchmark for a given parameter. The AEMP Benchmarks correspond to the lowest water quality guideline for protection of aquatic life and human health, or site-specific water quality objectives in the case of fluoride, arsenic, and iron. AEMP Action Levels and Benchmarks for the Meliadine Lake AEMP are listed in **Appendix B**.

samples will be collected on the same day, and analyzed for the same parameters, as water quality samples in the Near-field area. The general design for water quality is to collect samples from five stations in each of five areas in Meliadine Lake (i.e., Near-field area, Mid-field area, and three Reference areas) (**Figure 4-1**). Water quality data will be collected to support a control-impact design in the Near-field, Mid-field, and Reference Areas. Station coordinates are provided in **Table 4-4**.

The water quality program will be conducted annually with samples collected at specific times during the year. Samples will be collected at the Near-field and Mid-field stations once during ice cover period (i.e., March/April) and three times during the open-water period (i.e., July, August, and August/September; **Table 5-1**). At the stations in Reference Area 1, samples will also be collected three times during the open-water period, while stations in Reference Areas 2 and 3 will be sampled once a year during the open-water period (i.e., August or September). The timing for the open-water sample collection will coincide with the schedule of effluent discharge and MDMER EEM requirements.

Table 5-1. Meliadine Lake Receiving Water Quality Design Plan Details

Location	Stations per area	Parameter[(a)]	Program Frequency	Collection Frequency within Program
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		once per year[(d)]
Reference Area 3 (MEL-05)	5			

Notes:
(a) Detailed parameter list in **Table 5-3.** 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).

Effluent quality samples will be collected and characterized according to MDMER requirements. Samples for effluent characterization will be collected in the Effluent Water Treatment Plant (EWTP), at the regulated monitoring station and at the last point of control (i.e., MEL-14). This sampling program will include weekly monitoring of water flow and field measurements (pH and temperature), and the collection of effluent water quality samples on a weekly to quarterly basis depending upon the regulated parameters (**Table 5-2**). 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 5-2. Meliadine Lake Effluent Characterization Details: Point of Discharge and Edge of Mixing Zone

Location (Station ID)	Samples per Event	Parameters[a]	Frequency
EWTP (MEL-14)	1	Volume (m^3)	Daily during periods of discharge
	1	Field effluent quality measurements	Weekly during periods of discharge
	1	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
	1	Acute toxicity testing Rainbow Trout & *Daphnia magna*	Once prior to discharge and monthly during discharge
	1	Sublethal toxicity testing on the most sensitive of the test species in the MDMER[c]	Two times per year
Receiving Environment at the Diffuser (MEL-13)	1	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 5-3.**

(b) Further details in the Type A Water Licence Amendment Application (Agnico Eagle, 2020).

(c) 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%.

5.1.3 Field Methods and Laboratory Analysis

Collection of Field Data

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 (e.g., YSI 6-Series 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 include total water depth, station coordinates, date and time of sample collection, sample collection depth, and weather conditions.

Sample Collection and Handling

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 micrometre Millipore filter before being preserved with laboratory-provided preservative. Water samples will be kept refrigerated before shipping and ice-packs will be added to the coolers. 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 5-3**. 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 5-3. 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 $CaCO_3$) + 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 will be discontinued if concentration in effluent is lower than 0.037 Bq/L for 10 consecutive weeks (MDMER; Schedule 5; Part 1, Section 7(d)(ii)).
(d) Un-ionized ammonia is not listed in the Water Licence, but it is included in the list of Prescribed Deleterious Substances in the MDMER.

5.1.4 Data Analysis and Interpretation

Effluent Characterization

Samples collected for effluent characterization (MEL-14)[9] will be compared against the MDMER limits for deleterious substances and Water Licence Limits as reported to meet Type A Water Licence requirements and the MDMER. 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., LC_{50} and IC_{25} results) will be completed by the laboratory and reviewed before reporting in the AEMP.

[9] As described in the Water Management Plan (Agnico Eagle 2020) and the Environmental Monitoring and Protection Plan (Agnico Eagle 2019).

Review of final effluent quality data and water quality data from the edge of the mixing zone will therefore focus on answering the following key questions:

- *Are concentrations of key parameters in effluent (MEL-14) lower than Water Licence limits?*
- *Are concentrations of key parameters at the edge of the mixing zone lower than AEMP Benchmarks?*

Meliadine Lake Receiving Water Quality

Mid-depth field measurements of specific conductivity, pH, temperature, dissolved oxygen, and turbidity will be included in the calculation of descriptive summary statistics described below. Field water column profile data will be plotted to evaluate any changes in water quality with depth.

Water quality data from the lake exposure areas will be evaluated by a multi-step process that involves comparisons to AEMP Benchmarks/Action Levels, FEIS predictions, and the normal range of baseline/reference conditions. This approach serves to focus the analysis on parameters of interest to provide information most relevant for the Action Level Assessment and to evaluate whether effects are occurring due to the Project.

AEMP Benchmarks

The term *AEMP Benchmark* refers to the various water quality guidelines for protection of aquatic life, guidelines for the protection of human drinking water quality, or site-specific water quality objectives (SSWQO) developed for the Project. The AEMP Benchmarks are the effects thresholds protective of aquatic life and human drinking water quality for the project. To provide an added level of protection, the *AEMP Action Level* is set at 75% of the AEMP Benchmark (i.e., the lowest water quality guideline or SSWQO) for each parameter. The AEMP Action Levels are early warning 'triggers' meant to signal changes in water quality that may be of concern prior to exceedances of effect-based thresholds for the protection of aquatic life and human health.

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 AEMP Action Level) for the 2020 AEMP (Azimuth 2021). With the exception of fluoride, arsenic, and iron, which have SSWQO, and antimony which has a lower health-based drinking water quality guideline, the water quality guidelines for protection of aquatic life 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 to 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 protection of aquatic life unless other jurisdictions published more recent guidelines.
- 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 solely on toxicological effects data using the same methods of derivation, where adequate data exists. Parameters with more recent FEQG include vanadium (2016), cobalt (2017), copper (2021), lead (2020), and strontium (2020).
- 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).

Comparisons to FEIS Predictions

Water quality in the NF area MEL-01 in the east basin was evaluated against the following statement:

> *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 of Meliadine Lake. 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*[10] 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, and in 2020, Agnico Eagle commissioned Tetra Tech to complete a multi-year simulation of effluent mixing in the sub-basin of the east basin (termed the *model domain* in Tetra Tech's report) that included the final diffuser design, updated bathymetry in the model domain, and the conservative assumption that

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

effluent discharged to Meliadine Lake would have a maximum average concentration (MAC) of TDS of 3,500 mg/L, equal to the proposed limit in the Water Licence Amendment application. Two multi-year scenarios were modelled, a base case “normal” precipitation scenario, in which TDS concentrations were predicted to increase to 170 mg/L, and a wet-year scenario, in which where TDS concentrations were predicted to increase to 183 mg/L, to provide a more accurate prediction of changes in TDS between 2020 and 2028 (current life-of-mine) for the east basin. Comparisons of observed results to predicted concentrations will include both the original FEIS model and the updated model.

Normal Range Calculations

Water quality parameters will be compared to applicable normal ranges to assess if concentrations measured in Meliadine Lake are outside normal range limits or are within the expected background range. Normal (or background) ranges were calculated by Golder (2019) using reference area data (i.e., from MEL-03, MEL-04 and MEL-05 [also referred to as Reference Areas 1, 2, and 3]) collected from 2015 to 2018, and baseline data collected from the Near-field and Mid-field areas during the same time-period.

Methods used to define normal ranges for water quality and other AEMP components by Golder (2019) followed the methods of Barrett et al. (2015); however, Golder (2019) noted that the normal ranges were subject to refinement in future reports as additional appropriate data became available. Since then, an alternative approach has been used to calculate normal ranges for water quality in Meliadine Lake (i.e., the ‘revised 90th percentile method’; Azimuth [2020]). These normal ranges may be subject to future refinement with future reference area data to continue to capture natural variability within the study area.

Normal Range Comparisons and Identification of Parameters of Interest

The first step of the screening process involves the calculation of seasonal descriptive statistics for all water quality parameters from data collected from each exposure and reference area; i.e., mean, median, minimum, maximum, standard deviation (SD) and standard error (SE) values. Seasonal statistics and individual concentrations will be compared to AEMP Benchmarks, and the appropriate normal range. Parameters with mean/median concentrations that exceed the normal range will be further evaluated in the statistical analysis as parameters of interest. Parameters with mean/median concentrations below their normal range will not be evaluated further because those concentrations are within the expected range for background conditions without the Project.

Analysis of Parameters of Interest

Spatial patterns and visual temporal trends to determine if:

- parameters are increasing over time
- parameters are increasing above AEMP Action Levels

- there are differences between the exposure (Near-field and Mid-field areas) and reference areas
- if concentrations are diverging over time between areas.

A control-impact design will be employed to compare differences between the exposure and reference areas using visual time series and spatial plots and statistical analyses as required. Spatial and temporal changes in water quality focus on the open-water season because reference data are not collected during the ice-cover season due to safety concerns (Golder 2016). Parameters of interest from both seasons will be included in a visual assessment of spatial patterns within Meliadine Lake and a visual assessment of temporal trends with respect to changing concentrations of these parameters over time. The results of the lake water quality assessment will feed directly into the Action Level Assessment described in **Section 8**.

5.1.5 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 are not met.

A summary of QA/QC procedures specific for the water quality component are provided below. These procedures are undertaken to confirm that the water quality data collected are representative of known quality, properly documented, and scientifically defensible.

Field Collection

Samples will be collected by qualified field staff trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. 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 and 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[11] 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.
  - 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 measurement 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:

[11] Canadian Association for Laboratory Accreditation

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

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[12] 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.

[12] 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.

5.2 Phytoplankton

Phytoplankton and zooplankton monitoring were included as targeted studies in Version 1 of the *AEMP Design Plan* (Golder, 2016). 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[13] (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 included as a core monitoring component of the Meliadine Lake AEMP. Zooplankton was not retained in the AEMP for Meliadine Lake due to high variability in the zooplankton dataset (Golder, 2018).

5.2.1 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
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to phytoplankton communities in Meliadine Lake

5.2.2 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

[13] 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.

5.2.3 Field Methods and Laboratory Analysis

At each sampling station, Secchi depth, total water depth, and limnology profiles will be measured prior to the collection of the plankton samples (**Section 5.1** for details). After these measurements are taken, then 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 then 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 will be collected in 250 millilitres (mL) amber bottles and preserved with approximately 4 mL of acidified Lugol's solution. Samples will be stored in the dark, either refrigerated or at ambient temperatures. Samples will be submitted to Plankton R Us, Winnipeg, Manitoba, for taxonomic identification to the lowest taxonomic level, and abundance and biomass estimates.

The subsamples for chlorophyll *a* will be placed in an amber bottle. The collected water sample will be filtered onto 47-millimetre (mm) glass fibre type C filters (nominal pore size: 1.2 µm) using a glass filter tower and vacuum pump. The chlorophyll filtration will be done under low light conditions in the laboratory to prevent photo-shock in the algal cells. 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 will then be wrapped in aluminum foil, to prevent light penetration, and frozen. Frozen filters should be submitted to the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta, for spectrophotometric analysis of chlorophyll *a*.

5.2.4 Data Analysis and Interpretation

Phytoplankton effects endpoints (i.e., density, biomass, and community composition) will be evaluated, using both statistical (quantitative) and visual (qualitative) methods, to determine whether changes in the phytoplankton community have occurred. Appropriate statistical analyses will be conducted to evaluate potential differences in phytoplankton community structure between the Near-field area, Mid-field area, and the three within-lake reference areas. Temporal trends in phytoplankton metrics between sampling years will also be assessed. If changes in the phytoplankton community are observed, an evaluation of the statistical and visual results will be used to determine whether the observed changes are within FEIS predictions.

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. 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 NF, MF, and reference area communities should follow the same pattern of change each year. If, however, the phytoplankton community at the NF and MF areas diverges 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 NF and MF 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 involved adding nMDS scores for NF (MEL-01) and MF (MEL-02) areas for each year. The 90th, 95th and 99th percentile probability ellipses provide a concise way of visualizing whether the phytoplankton community at the NF and MF areas 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)
- 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 5-4**).
- CCME (2004) – A total phosphorus-specific scheme using trigger ranges (**Table 5-5**).
- Carlson (1977) – Independent index scores for TP, chlorophyll-a and Secchi depth (**Table 5-6**), calculated as follows:

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

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

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

Table 5-4. 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 5-5. 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 5-6. 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

5.2.5 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.

5.3 Benthic Invertebrate Community

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).

5.3.1 Objectives

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

- 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
- 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

5.3.2 Study Design and Schedule

The benthic invertebrate community study is a control-impact design with monitoring the Near-field area, a Mid-field area and two within-lake reference areas (MEL-03 and MEL-05). The design is intended to facilitate the characterization of spatial and temporal variation in benthic invertebrate communities, to fulfil both EEM/MDMER and AEMP requirements.

5.3.3 Field Methods and Laboratory Analysis

Sampling Locations and Frequency

Benthic invertebrate sampling in Meliadine Lake will be undertaken in four study areas: two within-lake Reference areas, one Mid-field area, and one Near-field area. For a given year, five replicate stations will be sampled within each area (total of 20 stations) with one composite sample taken at each station. Station locations sampled in the 2018 survey by Golder (2019) (**Table 4-4**) will be adopted by the updated AEMP Design Plan. These stations underwent optimization based on data collected during a Sediment Reconnaissance Survey (July 2018) to further minimize variability in substrate and habitat characteristics within and between sampling areas, to the extent possible. Variability in sediment substrates within the AEMP study area was identified by Golder (2018) to be a potential confounding factor in monitoring of benthic invertebrate communities.

Sampling will be scheduled to occur in late summer (August) to be consistent with previous sampling in Meliadine Lake and other monitoring programs in Nunavut. August is targeted for benthic sampling because invertebrate communities tend to be the most diverse and stable in late summer/early fall, near the end of the open-water season.

Sampling Methods

Benthic invertebrate samples will be collected within a water depth range of approximately 7 to 10 m and comparable substrate types will be sampled to reduce habitat-related variability in the biological data. Samples will be collected using a standard grab sampler from a boat anchored at each sampling station. A Sediment Reconnaissance Survey previously carried out at the reference and exposure areas in 2018 by Golder (2019) evaluated the success rate of grab samplers Ekman and Ponar grab samplers. The Ponar grab was selected to provide better penetration and recovery of substrates encountered in the sampling areas, leading to the successful use of a Petite Ponar in the 2018 survey (15.24 × 15.24 centimetre [cm]; bottom sampling area of 0.0232 m^2).

One composite sample comprising of five individual grabs will be taken at each station. Grab samples will be sieved through a 500 µm mesh screen and material retained in the mesh will be placed into a single pre-labelled container, thus creating a single composite sample consisting of five grabs for each station. Samples will be preserved in 10% neutral buffered formalin. A second internal waterproof label will be inserted into each sample bottle and the sample bottle lids will be sealed prior to shipping.

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.

Sediment grab samples will also be collected at each benthic invertebrate sampling station for analysis of sediment chemistry (e.g., metals, nutrients, and carbon content) and particle size distribution as described in Section 5.4. The following supporting data will be collected at each benthic invertebrate sampling station:

- station location (Universal Transverse Mercator [UTM] coordinates)
- water depth
- weather conditions
- habitat description (e.g., water clarity and colour) and near-bottom field water quality measurements (e.g., pH, dissolved oxygen, water temperature, conductivity) prior to disturbing the sediments
- observations of the sediments for colour, consistency, odour
- benthic sample-related information (sampler used, sieve mesh size, sampler fullness, preservative)
- presence of aquatic vegetation and alga
- photographs of the sampling areas and representative samples

Laboratory

Preserved benthic invertebrate samples will be shipped to a qualified taxonomist for processing, enumeration, and identification to the lowest taxonomic level (typically genus), using current literature and nomenclature. Samples will be processed according to TGD (Environment Canada 2012) guidance and subsequent updates, if any. Organisms that cannot be identified to the desired taxonomic level (e.g., immature, or damaged specimens) will be reported as a separate category at the lowest level of taxonomic resolution possible. This will typically be the family level, which is the level recommended in the TGD.

5.3.4 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 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.

Prior to data analysis, data from individual grab samples (field sub-samples taken to assess within station variation) will be pooled so all replicate stations will be represented by one set of taxon abundances.

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 will be calculated as a component of the data analysis as recommended by Environment Canada (2012) and consistent with AEMP programs for other northern mines (**Table 5-7**).

Table 5-7: 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 MMTGD (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

- Total density (N/m^2) and taxa richness 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,
pi = the proportion of the i^{th} 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), and
S = the total number of taxa at the station (i.e., taxa richness).

- 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,
Yi1 = count for taxon i at site 1,
Yi2 = count for taxon i at site 2, and
n = the total number of taxa at the two sites.

Normal Range of Baseline and Reference Conditions

Version 1 of the AEMP Design Plan (Golder, 2016) developed provisional normal ranges using reference and baseline data to help provide context for interpreting the results of key benthic invertebrate community metrics. Normal ranges were updated in the 2018 AEMP (Golder, 2019) but were quite broad. This was particularly evident for total density where the lower bound of the normal range was 128 organisms/m^2 and the upper bound was 1,938 organisms/m^2 (Golder, 2019). A more comprehensive evaluation approach to estimating the normal range of baseline and reference conditions for benthic invertebrate community metrics will be explored prior to the next study planned for 2024.

Statistical Analysis

Statistical analyses will be conducted to evaluate potential differences between the Near-field, Mid-field, and Reference Areas 1 and 3. The data analysis approach has been designed to address the key question for benthic invertebrates and to be consistent with the TGD. 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 MMTGD.

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 (Environment Canada 2012). 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.

5.3.5 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 MMTGD.

Samples will be collected following standard sampling protocols by qualified personnel using appropriate sampling equipment. Samples will be analyzed by qualified taxonomists using techniques consistent with the MMTGD. 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.

5.4 Sediment Quality

The sediment chemistry component of the AEMP is conducted on a 3-year cycle to provide supporting data for the benthic invertebrate community monitoring program. On its own, sediment chemistry data are not used as a basis for triggering management actions through the Response Framework.

5.4.1 Objectives

The sediment quality program was designed to meet the Type A Water Licence requirements, MDMER sediment quality monitoring requirements for EEM, and to provide supporting information to the benthic invertebrate component. The specific objectives 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)
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to sediment quality in Meliadine Lake

In the AEMP Design Plan, sediment quality is intended to be a supporting component of the AEMP, in that sediment quality, on its own, will not be used as a basis for triggering response actions through the Response Framework. Rather, sediment data will be used to support the benthic invertebrate community component that will be used as a basis for triggering response actions.

These objectives are addressed through the following key questions:

- *Are concentrations of key parameters in Meliadine Lake below applicable sediment quality guidelines?*
- *Are concentrations of key parameters in the exposure areas increasing over time relative to the reference areas or baseline?*

If mining-related changes in concentrations of key parameters in lake sediment are identified, the next key question is:

- *Are the changes in sediment chemistry adversely affecting the benthic invertebrate community?*

5.4.2 Study Design and Schedule

Sediment sampling stations are co-located with the benthic invertebrate stations, with alignment with the sampling of other components, where possible. Samples will be collected at the same time as the benthic samples to provide supporting information for the assessment of benthic invertebrate communities and evaluate Project effects on lake sediments. Samples will be collected from four areas within Meliadine Lake: Near-field and Mid-field exposure areas, and Reference Areas 1 and 3, and to match the benthic invertebrate component in subsequent AEMP years. Sampling during late summer/fall (August) is proposed, and five replicate stations will be sampled within each area. Sampling station locations within each lake area have been selected to be of similar water depth and substrate type, and at least 20 m apart, at a targeted depth range between 7 and 10 m. Sampling station locations sampled in 2018 by Golder (2019) are proposed in this AEMP Design Plan update for sampling going forward (**Table 4-4**).

5.4.3 Field Methods and Laboratory Analysis

Bottom sediment samples will be collected within each area during the benthic invertebrate program in accordance with the MMTGD, as well as the specific handling requirements of the accredited laboratory. Samples will be collected using a petite Ponar from five stations per area, within the targeted depth range to the extent possible. Surficial sediment will be collected from the top 5 cm of the grab, and material from up to five grabs will be combined and homogenized into a composite sample in the field to collect sufficient sediment to meet analytical requirements. Physical descriptions of the sediment samples will be recorded, and photographs of representative samples taken.

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 5.3.3**.

Samples will be collected in containers provided by an accredited analytical laboratory, with sample processing undertaken according to laboratory instructions and best practices. Ice-packs will be added to the coolers to keep the samples as cool as possible during shipping, and samples will be shipped to the analytical laboratory as soon as possible after sample collection and processing. The suite of parameters to be analyzed in the samples is listed in **Table 5-8**. Sediment quality samples will be analyzed by an accredited laboratory at detection limits lower than applicable sediment quality guidelines.

Table 5-8. Sediment Quality Parameters

Group	Parameters
Particle Size[a] and Moisture	gravel, sand, silt, clay, moisture
Nutrients and Carbon	total phosphorus, total nitrogen, total organic carbon
Metals[b]	aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, uranium, vanadium, zinc

Notes:
[a] PSA-3 Sieve-SK/PSA-pipet+Gravel-SK [sieve+pipette]) as recommended by the MMTGD (Environment Canada 2012).
[b] The term metals as used includes metalloids (i.e., arsenic).

5.4.4 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.

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 from the 2018 AEMP pooled all reference and baseline data collected in Meliadine Lake, rather defining the normal range for each basin (Golder, 2019). Metals in sediment are often highly variable in lakes close to mineralized areas. Furthermore, high spatial heterogeneity in the concentrations of some metals in Meliadine Lake makes it challenging to establish a relevant normal range for assessing temporal changes.

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. The reference areas are primarily important for understanding if sediment chemistry is changing naturally. Therefore, rather than calculating normal ranges for concentrations of parameters in sediment, potential increases in sediment concentrations over time in the near-field and mid-field areas that are not observed in the reference areas will be assessed using plots and statistics, as appropriate.

5.4.5 Quality Assurance and Quality Control

Field Collection

Similar sample collection procedures are implemented to ensure high-quality data from the sediment sampling program as outlined for water sampling (e.g., use of standardized field datasheets, sample naming conventions, etc.).

Laboratory QA/QC

Laboratory QA/QC procedures for sediment are described above for water in **Section 5.1.5**.

Field QA/QC

Field QA consisted 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 field duplicates at a frequency of at least 10%. The DQOs for field duplicates were 1.5-times the laboratory RPDs or between field duplicate results of less than 3-times the DL (i.e., 1.5x the difference objective for laboratory duplicates).

5.5 Fish Health

The fish health component of the AEMP includes lethal studies on one small-bodied fish species and one large-bodied fish species conducted every three years coinciding with the timing of the EEM program. Threespine Stickleback (*Gasterosteus aculeatus*) were selected as the small-bodied fish species for the AEMP and the EEM due to their relatively high abundance in Meliadine Lake, their early age-of-maturity, and their relatively small home range. Lake Trout (*Salvelinus namaycush*) were selected as the large-bodied fish species for the AEMP due to their importance to the community members of Rankin Inlet and because of their relatively high abundance and catch-per-unit-effort in Meliadine Lake (Golder, 2016).

The FEIS (Agnico Eagle, 2014) predicted that nutrients in effluent discharge 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 by the edge of the mixing zone around the diffuser. The FEIS predicted low risk of effects the health of Lake Trout and other large-bodied fish species such as Arctic Char and Arctic Grayling from development of the Mine. Furthermore, no major changes were predicted for traditional and non-traditional use of fish in Meliadine Lake relative to natural changes in the fish population.

5.5.1 Objectives

The objectives of the fish health component are as follows:

- Determine whether Mine effluent has an effect on the survival, energy use (growth and reproduction), and energy storage (condition)of fish 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.
- Provide data to inform adaptive management intended to reduce or eliminate Mine-related effects to fish health in Meliadine Lake.

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

- *Are activities at the mine causing changes in Meliadine Lake that are impacting the health of fish?*

Details regarding the study design for Threespine Stickleback and Lake Trout described below were adapted from the most recent Cycle 2 EEM study design that was completed in advance of the 2021 field program (Azimuth and Portt, 2021).

5.5.2 Threespine Stickleback Study

Study Design and Timing

The small-bodied survey uses a Control-Impact (CI) design with Threespine Stickleback collected from the Near-field (NF) exposure area (MEL-01) and Reference Area 1 (MEL-03) and Reference Area 2 (MEL-04) (**Figure 4-1**). The NF area in 2021 was located along the south shoreline of the esker nearest to the effluent diffuser and within the 1% effluent plume. Reference area sampling locations are selected based on habitat considerations (e.g., depth, substrate, lake morphometry) to maximize catch-per-unit-effort (CPUE) and to achieve sample size requirements.

The Threespine Stickleback survey is conducted every three years in August, which is consistent with the timing of the Cycle 1 EEM (2018) and baseline data collection (2015, 2017). This is also consistent with the recommendations of Barrett and Munkittrick (2010).

Parasitism and Sample Size Considerations

Threespine Stickleback were the most abundant fish species captured in Meliadine Lake during baseline monitoring. Previous monitoring studies suggest that the majority (~72%) of Threespine Stickleback captured in Meliadine Lake are parasitized by *Schistocephalus solidus*, a parasite which has been shown to influence a variety of fish health indices, including EEM monitoring endpoints:

- Altered feeding habits (Barber and Huntingford 1995; Wright et al. 2006),
- Reduced body condition (Bagamian et al. 2004),
- Reduced fecundity (i.e., clutch size, egg mass, and clutch mass; Schultz et al. 2006; Heins et al. 2010),
- Reduced breeding activity in males (i.e., courtship, nesting, nuptial colouration, and kidney development; Rushbrook and Barber 2006), and
- Increased size-at-maturity (Golder 2018a).

Based on lethal sampling during baseline monitoring (2015 and 2017), the Cycle 1 EEM (2018), and the 2021 AEMP, the rate of parasitism by *S. solidus* in Threespine Stickleback in Meliadine Lake is high, but the percentage of parasitized individuals captured varies temporally and spatially within the lake (**Table 5-9**).

Table 5-9. Total catch (n) of Threespine Stickleback at each station in Meliadine Lake by year, and the percentage of catch that was parasitized.

Year	MEL-01 (Near-field)		MEL-03 (REF1)		MEL-04 (REF2)	
	n	% Parasitized	n	% Parasitized	n	% Parasitized
2015	95	84%	-	-	-	-
2017	-	-	97	80%	63	65%
2018	126	62%	90	71%	-	-
2021	429	75%	907	85%	497	71%

Data from lethally sampled Threespine Stickleback from the Cycle 1 EEM study were used to compare the total weight versus total length relationship ($\log_{10}$ transformed) of parasitized and non-parasitized Threespine Stickleback. Analysis of covariance (ANCOVA) shows that fish with parasites are significantly heavier than unparasitized fish when adjusted for length (Azimuth and Portt 2021). Parasitized fish were, when adjusted for length, 16% heavier than non-parasitized fish. In a non-lethal study, length and weight would be collected from live fish, and the presence and extent of internal parasitism would remain unknown. The significantly higher weight of parasitized fish along with the spatial variation in the percentage of parasitized fish captured in Meliadine Lake (**Table 5-9**), indicates that parasitism could confound a non-lethal study.

A lethal study of Threespine Stickleback is also potentially confounded by parasitism. Therefore, the small-bodied fish study for the 2021 AEMP and Cycle 2 EEM targeted non-parasitized Threespine Stickleback because of the potential confounding effect of parasitism on the endpoints used to assess the health of the population.

As separate study was conducted as part of the Cycle 2 EEM that looked specifically at parasitized fish. Given the high proportion of parasitized fish, fewer fish would need to be sacrificed if the program focused on assessing the health of parasitized fish.

As stated above, the current study design for the AEMP and EEM focuses on non-parasitized fish. The Cycle 1 EEM / AEMP in 2018 indicated sample sizes of 30 mature males and 20 mature females per site provides adequate statistical power to detect effects equal to the critical effect sizes for weight adjusted for length, and liver weight adjusted for body weight (**Table 5-10**). If the parasitism rate is 80%, the total number of fish that would be sacrificed is five times the required sample size.

Predicted sample sizes required to detect a difference equal to the critical effect size for gonad weight versus body weight for both females (n = 63) and males (n = 94) suggest this endpoint cannot be practically assessed. The Technical Advisory Panel that reviewed the Cycle 2 EEM agreed with this assessment, and reproductive endpoints were not included in the study design for both the EEM and AEMP studies in 2021.

Ageing data from Cycle 1 EEM indicate that Threespine Stickleback in Meliadine Lake are short lived, with the majority of adults between age 2 and age 4. ANCOVA on ranks was used to analyze the Cycle 1 data (Golder 2019), however, with few age categories present and few fish per age category, alternate methods are more suitable (refer to Environment Canada 2012. pp 8-54-8-55).

Table 5-10. Threespine Stickleback sample sizes required to detect a critical effect with a power of 0.9 for all fish (parasitized and non-parasitized) and non-parasitized fish, based on the results of the Cycle 1 EEM study (Golder 2019).

Sex	Parameter	Dependent Variable	Covariate	Critical Effect Size	Sample Size Required to Detect Critical Effect With a Power of 0.90	
					All Fish (parasitized and non-parasitized)	Non-parasitized Fish
Female	Total length†	Total length	-	25%	8	4
	Condition	Body weight	Total length	10%	19	20
	Relative liver size	Liver weight	Body weight	25%	26	5
	Relative gonad size	Gonad weight	Body weight	25%	47	63
	Weight-at-age	Body weight	Age	25%	79	18
Male	Total length†	Total length	-	25%	4	3
	Condition	Body weight	Total length	10%	22	105*(21)
	Relative liver size	Liver weight	Body weight	25%	25	30
	Relative gonad size	Gonad weight	Body weight	25%	85	94
	Weight-at-age	Body weight	Age	25%	62	111*(35)

† Threespine Stickelback are short-lived in freshwater, so length was used as a surrogate for age (EC 2012).

* Assumptions of normality and equality of variance were not met with untransformed or $\log_{10}$ transformed data, and therefore, Golder (2019) used a rank ANCOVA results to determine sample size requirements. Re-analyzing using $\log_{10}$ transformed data, and assuming violation of asssumptions for the ANCOVA do not lead to misinterpretation, results suggest sample sizes of 21 for condition and 35 for weight-at-age would detect a critical effect with a power of 0.9.

Collection Methods

Use of unbaited gee-style minnow traps (1/4" square mesh; 9" x 16") has been an effective method for capturing Threespine Stickleback from shoreline areas in the NF exposure area and reference 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 will be released.

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.

Threespine Stickleback Measurements

Individual fish retained for the lethal survey will undergo an external and internal examination. Features of the fish that do not appear normal, for example wounds, tumours, parasites, fin fraying, gill parasites or lesions, will be reported in detail, and if necessary, submitted for further analysis (i.e., histopathology). Where possible, information on maturity, sex, and overall health will be recorded and this information will be verified during the internal examination. External examinations will be conducted following the recommendations outlined in Chapter 3 of the MMTGD.

Following the external examination, the fish will be sacrificed by a sharp blow to the back of the head and cervical dislocation (i.e., cutting the spinal cord immediately behind the head) followed by an internal examination. The following information will be determined for each Threespine Stickleback that is part of the lethal sampling:

- total length in mm, to the nearest mm;
- total weight in g, to the nearest 0.001 g;
- presence of external deformities, lesions, tumors, or parasites;
- liver weight in grams, to the nearest 0.0001 g;
- sex, gonad condition and gonad weight in grams, to the nearest 0.0001 g;
- fecundity and mean egg weight for mature females that will spawn in the current year; and
- presence of internal deformities, lesions, tumors, or parasites.

Following removal of the viscera, carcass weight is recorded (± 0.0001g) and the specimen is labelled and frozen for future aging (using otoliths) and possible tissue chemistry analysis. Otoliths will be collected and placed in envelopes labelled with the sampling area, date, species, and specimen number. Age will be estimated based on the number and annuli counted in whole otoliths 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.

Threespine Stickleback are multiple spawners, and both spawning and resting individuals have been captured during August sampling in previous years (Golder, 2019; Golder 2016b). Females are classified as mature if eggs could be identified at 3.0 times magnification. Fecundity (number of eggs within the ovaries) is determined by counting all eggs for ripe females, distinguished by the presence of larger yellow eggs which could be readily separated. Males are identified by the presence of lobular testes. Individuals with opaque testicles are classified as mature, while individuals with translucent testicles were immature. Indistinguishable gonads are characterized as sex unknown.

Initial Data QA/QC

Data will be entered into a spreadsheet 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 as part of the lethal fish health surveys will be summarized by area and presented in summary tables.

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:

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

Hepato-somatic index (HIS) will be calculated using the formula:

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

Summary Statistics

Summary statistics (sample size, mean, median, minimum, maximum, standard deviation, standard error) will be generated for length, weight, and condition for all Threespine Stickleback from each sample area. The same summary statistics for length, weight, condition, age, liver weight, HSI, gonad weight, and GSI will be calculated for mature males and mature females separately for each sample area. Proportions of fish with abnormalities or parasites will also be determined.

Data Analysis and Interpretation

Data assessment and interpretation will be conducted following the guidelines presented in the MMTGD (Environment Canada 2012). The objective of the fish health survey is to determine whether the health of the fish population exposed to effluent discharged to the east basin of Meliadine Lake is affected relative to fish populations at the reference areas. The following endpoints will be analyzed to determine fish health:

- Survival (e.g., age)
- Energy use (e.g., size-at-age)
- Energy storage (e.g., condition; relative liver size)

Survival is a measure of the difference in the mean age of all fish (separated by species and sex) between the exposure and reference areas. A healthy population should exhibit variability in age.

Energy Use is a measure of the ability of the fish population to utilize resources in their environment to grow and reproduce. It is also an indicator as to whether a population is growing and reproducing normally and successfully.

Energy Storage is a measure of the energy reserves of the fish population. Condition and relative liver size provide valuable information on food quality and availability to the fish population. A healthy fish will demonstrate a greater body weight to length ratio and have a liver weight that is proportional to its body size. Stressors from the environment, whether they are natural or anthropogenic, can affect the condition of a fish population and alter the relative liver size (e.g., enlarged liver as a result of contaminant depuration processes or increased lipid processing as a result of eutrophication).

Fish health endpoints related to the above responses will be statistically compared to identify whether an *effect* has occurred on the fish population at Meliadine Lake per the MMTGD. *Effects*, under EEM, are defined as a statistically significant differences in measurement endpoints between an area exposed to effluent and a reference area. Fish health response effect indicators, measurement endpoints, dependent variables and covariates (as appropriate), and statistical procedures that are applicable to the fish health component of the AEMP are provided in **Table 5-11**.

Monitoring endpoints are assessed separately for mature males and mature females except for length-frequency distributions, which includes data from all individuals (regardless of sex and maturity). Reproductive endpoints, including relative gonad size, and relative fecundity (# of eggs/female) are not assessed for the EEM or the AEMP. As mentioned above, Threespine Stickleback spawn multiple times during the summer, and mature individuals are in various stages of reproductive development, which confounds comparisons of reproductive endpoints across areas. Reviewers of the Cycle 2 EEM study design agreed with this assessment.

Size-at-age is assessed using one-factor ANOVAs for the strongest age classes, rather than using an analysis of covariance (ANCOVA) across all ages. Threespine Stickleback are short lived, and therefore assessing size-at-age using an ANCOVA can provide misleading results (Environment Canada, 2012).

Table 5-11. Statistical procedures used for various monitoring endpoints to compare Threespine Stickleback populations between exposure and reference areas.

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:

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

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

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

5.5.3 Lake Trout Study

Study Design and Timing

The large-bodied survey uses a *before-after* study design with Lake Trout collected from Meliadine Lake during the operational phase compared to samples collected during the pre-operational phase. As mentioned in **Section 4.2.2**, external reference areas for Lake Trout program were ruled out during the baseline phase based on the fisheries data available at the time as well as factoring in health and safety and logistical constraints associated with conducting a fisheries survey in August at remote reference areas.

Lake Trout Spawning and Sample Size Considerations

A thorough assessment of the Lake Trout study was completed in the Cycle 2 EEM Study Design (Azimuth and Portt, 2021). Based on the results for the baseline Lake Trout data collected in Meliadine Lake and 2015, the Cycle 2 EEM study design concluded that it was not feasible to collect a sufficient number of adult Lake Trout that would spawn in the current year to address reproductive effects indicators for female or male fish. In 2015, only 5 of the 32 mature females (16%; **Table 5-12**) would have spawned meaning that on average, female Lake Trout spawn once every six years. The recommended sample size to assess reproductive endpoints for EEM is 20 females and 20 males. Approximately 120 mature female Lake Trout would need to be collected at each sample area in order to achieve the target sample size to assess reproductive endpoints. Such a study would be impractical and unacceptable from the standpoint of impact on the Lake Trout population in Meliadine Lake.

For males, a higher percentage of individuals spawn each year (45%; **Table 5-13**). These results suggest that in Meliadine Lake, on average, mature male Lake Trout spawn every second year. Therefore, it is estimated that approximately 40 adult male Lake Trout would need to be collected at each sample area in order to achieve the recommended minimum sample size of 20 that would be required for an adult fish study that examines reproductive endpoints. Assuming an equal sex ratio, the lethal sampling of 80 fish would be required obtain 20 males spawning in the current year. It is expected that attempting such a study would negatively impact the adult population and may still result in a statistical power that is insufficient.

Table 5-12. Count, relative percent, GSI range, and fork length range sorted by reproductive stage for female Lake Trout captured in Meliadine Lake in 2015.

Reproductive Stage	n	Spawn in Current Year	Percentage of Total	GSI Range (% body weight)	Fork Length Range (mm)
Late Stage Development	5	Yes	16%	11.4-17.8	541-803
Early Stage Development	21	No	66%	0.23-1.49	487-740
Resting	5	No	16%	0.10-0.19	606-915
Reabsorbing	1	No	3%	0.774	808

Table 5-13. Count, relative percent, GSI range, and fork length range sorted by reproductive stage for male Lake Trout captured in Meliadine Lake in 2015.

Reproductive Stage	n	Spawn in Current Year	Percentage of Total	GSI Range (% body weight)	Fork Length Range (mm)
Late Stage Development	13	Yes	45%	1.90-4.15	530-773
Early Stage Development	16	No	55%	0.04-0.48	398-768

In light of the fact that reproductive endpoints cannot be practically assessed, the Cycle 2 EEM study design recommended 25 Lake Trout be collected for the purpose of the EEM.

Collection Methods

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. 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.

Index gill nets comprised of six panels of stretched mesh (sizes 106, 201, 76, 51, 38, and 25 mm) were used for the 2021 AEMP study. Each panel of gill net is 1.8 m (6 feet) deep by 22.7 m (25 yards) long. The total length of a six-panel gang is 136.4 m (150 yards).

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.

Lake Trout Measurements

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 mounded 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.

Data Analysis and Interpretation

Data assessment and interpretation will be conducted according to the approach outlined above for Threespine Stickleback.

Lake Trout monitoring endpoints assess the survival, energy use, and energy storage of individuals captured in the exposure area during the baseline period (2015) compared to individuals captured in the exposure area during the operational period. A summary of the monitoring endpoints is provided in **Table 5-14**. Except for length-frequency distributions, which includes data from all individuals (regardless of sex), monitoring endpoints are assessed separately for males and females (regardless of maturity). Reproductive endpoints, including relative gonad size, and relative fecundity (# of eggs/female) are not assessed in the AEMP or the EEM because of the low percentage of female and male Lake Trout that spawn each year.

Table 5-14. Statistical procedures used for various monitoring endpoints to compare Lake Trout populations between baseline (2015) and operational (2021) sampling periods.

Effect Indicator	Endpoint	Dependent Variable	Covariate	Statistical Procedure	Critical Effect Size
Survival	Age	-	-	t-test	25%
Growth (Energy Use)	Length-frequency distribution	-	-	KS Test	-
	Fork Length	-	-	t-test	-
	Total Weight	-	-	t-test	-
	Size-at-age	Total Weight	-	ANCOVA	25%
		Fork Length	-	ANCOVA	25%
Condition (Energy Storage)	Condition	Total Weight	Fork Length	ANCOVA	10%
	Relative Liver Size	Liver Weight	Fork Length	ANCOVA	25%
Reproduction (Energy Use)	Relative Gonad Size	Gonad Weight	Total Weight	ANCOVA	25%
		Gonad Weight	Fork Length	ANCOVA	25%

The percent difference in means (t-test) and least-square means (ANCOVA) between the operational period (2021) and the baseline period (2015) was calculated as:

$$\%\ Difference = \frac{\bar{x}_{operational} - \bar{x}_{baseline}}{\bar{x}_{baseline}}$$

When log-transformed data were analyzed, the least-mean square values used were antilogs of the calculated values. The percent difference was compared to the critical effect size for each endpoint, where applicable. A critical effect size is a threshold above which an effect may be indicative of a higher risk to the environment (Environment Canada, 2012).

5.5.4 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.

5.6 Fish Tissue Chemistry

Lake Trout tissue chemistry is included in the AEMP 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. The study is conducted in parallel with the Lake Trout health assessment and involves analysis of metals in muscle, liver, and kidney. Data from the muscle samples (i.e., fillets) are used primarily to support decisions regarding changes to the useability of the fishery. Liver and kidney samples are used to help support findings from the Lake Trout health assessment if adverse effects to survival, energy use, and/or energy storage are identified that are consistent with toxicological impairment.

Small-bodied fish species like Threespine Stickleback are well-suited for directly assessing exposure to contaminants in aquatic environments because they have a relatively small home range, and are therefore more consistently exposed to point-source discharges than large-bodied pelagic species like Lake Trout, Arctic Char, and Round Whitefish. In this respect, Threespine Stickleback provide an early indication of potential changes in fish tissue chemistry at Meliadine Lake.

5.6.1 Objectives

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

- Determine whether Mine effluent has an effect on metal[14] 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.
- 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?*

[14] Includes non-metals (e.g., selenium) and metalloids (e.g., arsenic).

5.6.2 Study Design and Schedule

Fish tissue chemistry will be analyzed from Threespine Stickleback carcasses and Lake Trout muscle, liver, and kidney tissues collected during the fish health survey. As such, timing of sampling will follow the late August and early September fish health surveys. Threespine Stickleback will be sampled to provide an early indicator of potential changes in fish tissue chemistry at Meliadine Lake, and Lake Trout will be used to document concentrations in species of fish likely to be eaten by people (i.e., community members). Tissue chemistry data will be collected from these species every three years.

5.6.3 Field Methods and Laboratory Analysis

Fish tissue samples will be collected from Threespine Stickleback and Lake Trout captured during the fish health survey. Threespine Stickleback carcasses will be retained from lethally sampled fish. Subsamples of muscle, liver and kidney tissue will be collected from lethally sampled Lake Trout. 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. If small-bodied fish carcasses or large-bodied tissue samples of sufficient size are not available to meet the minimum sample weight recommended by the lab, fish of similar size and the same sex (i.e., male or female) will be composited. Tissues will be submitted to an appropriate laboratory for analysis of moisture content and metals, including mercury.

5.6.4 Data Analysis and Interpretation

Prior to performing statistical analyses on the fish tissue chemistry data, values reported below the analytical detection limit (DL) will be reviewed. If tissue metals concentrations are above the DL in more than 50% of the samples, concentrations in the exposure and reference areas will be compared to determine if there are statistically significant differences. Metals concentrations will be analyzed using an ANOVA, with the exception of mercury and selenium which will be analyzed using an ANCOVA. The covariate (i.e., length or weight) with the strongest regression relationship (i.e., smallest Akaike information criterion [AIC] or *P*-value) will be used as the covariate for the ANCOVA analysis. If more than 50% of samples are below the DL for a given parameter, that parameter will not be considered further in the analysis.

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.

For fish tissue, an effect on fish usability is defined as total mercury concentrations that exceed 0.5 mg/kg wet weight as measured in an exposure area, and that are statistically different and greater than mercury concentrations measured from a reference area (Government of Canada 2002). Large Lake Trout often exceed the 0.5 mg/kg wet weight consumption limit in northern lakes because of the tendency for mercury to biomagnifying in higher trophic level predator fish. Because mercury is not a site-related contaminant of concern, the important point of comparison is whether mercury concentrations are increasing over time, not whether the absolute concentration exceeds the 0.5 mg/kg consumption advisory limit from Health Canada (2007). Effects endpoints will be considered statistically different between exposure and reference areas at $\alpha = 0.1$, and target sample sizes of at least eight fish per group are expected to achieve sufficient power (i.e., >0.9). Sample sizes and achieved power will be re-assessed as part of the regular reporting requirements.

5.6.5 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 5.1.5**). A review of the data entry will involve checking a minimum of 10% of the data for completeness, data entry errors, transcription errors, and invalid data. This checking will be done by a second, independent individual. If an error is found, all data will undergo a zero tolerance (i.e., every datum checked) QA check. All statistical 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.

6 PENINSULA LAKES STUDY

6.1 Water Quality

6.1.1 Objectives

Water quality monitoring is the core component of the Peninsula Lakes study. The Peninsula Lakes will not receive direct discharge from the mine and are therefore not required to be monitored under MDMER. The primary objectives of the water quality component for the Peninsula Lakes study are as follows:

- Characterize and interpret water quality in the selected monitoring lakes for purposes of identifying effects related to the mine
- Verify and update the FEIS predictions and other submissions to the NWB, as applicable, relating to water quality.
- Assess efficacy of impact mitigation strategies to minimize the water quality effects of the mine.
- Provide data to inform management intended to reduce or eliminate Mine-related effects to water quality in the Peninsula Lakes.
- Recommend any necessary and appropriate changes to the water quality component of the AEMP for future years.

These objectives are addressed through the following key questions:

- *Is water quality consistent with predictions outlined in the FEIS and less than AEMP Action Levels?*
- *Has water quality changed over time, relative to baseline conditions?*

6.1.2 Study Design and Schedule

Three lakes have been monitored under the Peninsula Lakes program since 2015; that is, one lake from each of watershed A (Lake A8), watershed B (Lake B7), and watershed D (Lake D7) (**Figure 2-1**). Water quality samples will continue to be collected in July and August from three stations per lake with a target water depth of approximately 1.5 to 2.5 m.

6.1.3 Field Methods and Laboratory Analysis

Field data and water samples for laboratory analysis will be collected at each water quality station, with samples analyzed for the same set of parameters as the Meliadine Lake study (**Table 5-3**). Collection of field data will include physico-chemical measurements of the water column profile (i.e., pH, temperature, dissolved oxygen, and conductivity) and recording of incidental information such as station coordinates, total water depth, sample collection depth, Secchi depth, and photographs. In-situ physico-chemical measurements will be taken near the surface, at 0.5 m below the surface, and every 0.5 m thereafter throughout the water column, ending at approximately 0.5 m above the lake-bed. Secchi depth was measured using a Secchi disk at each station. Discrete water samples will be collected at each sampling station from a depth of approximately 1 m using a Kemmerer sampler (or similar).

Samples will be processed and shipped to the analytical laboratory as described in **Section 5.1.3**. Quality control samples (duplicate and blanks) will be collected at randomly selected stations to represent at least 10% of all samples collected.

6.1.4 Data Analysis and Interpretation

Analysis and interpretation of the Peninsula Lakes water quality data will focus on answering the key questions by comparison to AEMP Benchmarks, water quality predictions in the FEIS, and normal ranges for each of the lakes. In addition, a qualitative assessment of time series plots for water quality parameters measured in Peninsula Lakes A8, B7, and D7 will be conducted to identify changes in concentration or increasing trends relative to baseline conditions (i.e., 2015 to 2017).

Descriptive statistics will be calculated (i.e., sample size, mean, median, minimum, maximum, and standard deviation). These statistics and individual concentrations will be compared to AEMP Benchmarks, and FEIS predictions. Field measurements will be included in the calculation of descriptive summary statistics, and field profile data will be plotted to evaluate changes in water quality with depth.

Water quality parameters will be compared to applicable normal ranges to assess if the concentrations measured in the three lakes were outside the normal range limits or were within the expected background concentration range (as described in **Section 5.1.4** for Meliadine Lake). Data will be evaluated for a sub-set of parameters of interest (identified as described in **Section 5.1.4**) to provide a visual assessment of temporal trends with respect to changing concentrations over time in the three lakes.

6.1.5 Quality Assurance and Quality Control

QA/QC procedures will be consistent with those described for water quality monitoring in Meliadine Lake (**Section 5.1.5**).

6.2 Biological Monitoring in the Peninsula Lakes

The Peninsula Lakes will not receive direct discharge from the mine and are therefore not required to be monitored under MDMER. Biological studies will be included in future monitoring cycles if results of the water quality program indicate that the small lakes on the peninsula may be affected by mining activities.

7 SPECIAL STUDIES

Special studies will occur as needed to support the AEMP. Special studies include, plume delineation studies, development of monitoring methods, further investigation of monitoring findings, or focused surveys to fill data gaps.

8 RESPONSE FRAMEWORK

The AEMP Response Framework links monitoring results to management actions, with the purpose of maintaining the assessment endpoints within acceptable ranges. It is a systematic approach for evaluating AEMP results and responding appropriately, such that potential unexpected effects are identified and mitigation is undertaken to reduce or reverse them, thereby preventing the occurrence of 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. Through this and subsequent iterations of the AEMP design plan document, the Action Levels and management responses will be further developed or amended.

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 AEMP component measurement endpoints, for one or both of the impact hypotheses, 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:

- **Benchmark**: For purposes of the AEMP, a benchmark is a generic term used to refer to a set of numerical standards that are appropriate for the Project and are used for screening of monitoring results (Appendix C). Benchmarks may be derived from generic aquatic life guidelines (e.g., CCME or Federal Environmental Quality Guidelines), generic drinking water guidelines, or site-specific water quality guidelines. Benchmarks are set at a level to be protective of aquatic life or drinking water quality.
- **Action Levels**: Low, Moderate, and High Action Levels are pre-defined levels of environmental change, often but not exclusively 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 that effects are measurable but well 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 type of action taken will depend upon the type of effect observed. Examples of response actions are provided in **Table 8-1**.

Figure 8-1. Overview of the Aquatic Effects Monitoring Program Response Framework

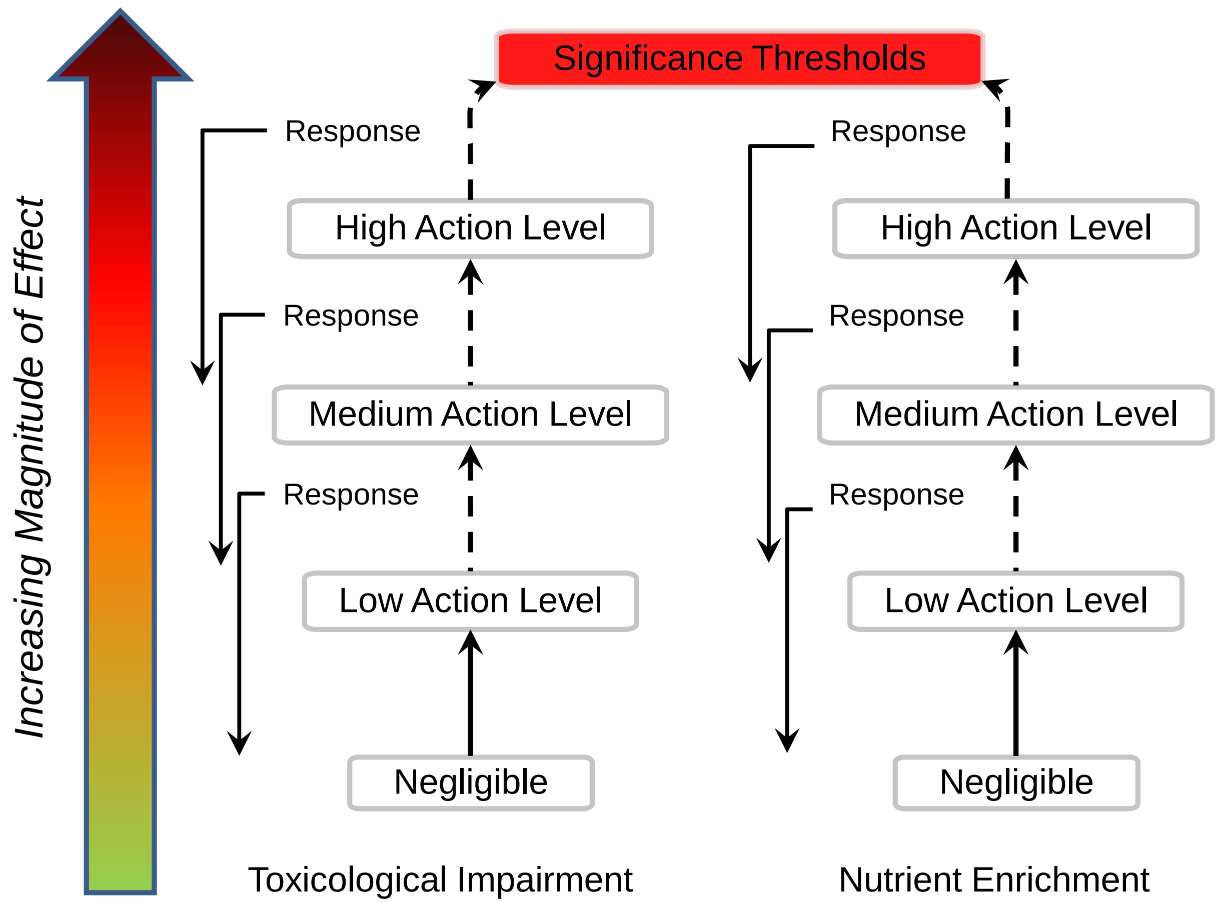


Table 8-1. Examples of Action Levels and Responses

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.

8.1 Significance Thresholds

Significance Thresholds are centered 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 and are considered the "no-go" condition for the Mine. The proposed Significance Thresholds are focused on key "values" that are to be protected, which include the following:

- water is safe to drink – water is safe for human and wildlife consumption
- fish are safe to eat – fish are safe for human and wildlife consumption
- the ecological function is maintained – there is adequate food for fish, and fish are able to survive, grow, and reproduce

The Significance Thresholds (and related Action Levels) rely upon measurement endpoints to determine if a valued component is changing due to Mine activities. Agnico Eagle will continue consultation work with the KivIA and the Inuit community to review results of the AEMP and to incorporate IQ for evaluation of cultural perception of significance of changes.

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):
  - Safety of fish for consumption will be considered through the use of risk assessment tools with consideration of measured fish tissue parameters should a Moderate Action Level be exceeded. Prior to such a trigger, however, the significant threshold is assessed against Health Canada guidelines (Health Canada, 2015). A significance threshold is not considered exceeded if one fish sample is above the Health Canada mercury guideline because the potential for toxicity is based on a sufficient dose (i.e., consumption of more than one fish). Further, concentrations of mercury in the region are already above the commercial food inspection guidelines in some large piscivorous fish; this is largely due to local geology and/or atmospheric deposition and is unrelated to the operation of the Mine.
- Ecological Function is not maintained:
  - Inadequate food for fish, or
  - Fish are unable to survive, grow, or reproduce, or
  - Sustained absence of a fish species.

8.2 Action Levels

The proposed Action Levels for Meliadine Lake are designed to provide an early warning indication of potential adverse effects to plankton and benthos (i.e., food for fish), to fish health, and to the maintenance of ecological function (including water quality and sediment quality). The proposed Low Action Levels (**Table 8-2** and **Table 8-3**) are designed such that changes of sufficient magnitude to trigger a Low Action Level 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 provide further adaptive management guidance to the Mine to avoid reaching the Significance Thresholds.

The type of management response taken after reaching an Action Level will depend on the type and magnitude of effect observed, and cannot be defined *a priori*; examples of management responses are provided in **Table 8-1**. At this time, no formal Action Levels have been developed for the Peninsula Lakes for the annual water quality monitoring program.

8.2.1 Toxicological Impairment Hypothesis

The Mine has the potential to result in toxicological impairment and thus the proposed Low Action Levels (**Table 8-2**) are designed to provide time to respond before significant adverse effects occur.

Table 8-2. Proposed Low Action Levels for Toxicological Impairment for Meliadine Lake

Component	Assessment	Assessment Criteria
Water	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[(d)]
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 5-11** for the fish health endpoints.

(d) The CES for fish health endpoints are 10% for relative body weight, 25% for relative liver weight and 25% for age-related endpoints.

8.2.2 Nutrient Enrichment Hypothesis

The proposed mine will have the potential to result in nutrient enrichment through the treated effluent discharge to Meliadine Lake. The proposed Low Action Levels (Table 8-3) are designed to provide time to respond before significant adverse changes occur.

Table 8-3. Proposed Action Low Action Levels for Nutrient Enrichment for Meliadine Lake [(a)]

Water Quality	Plankton	Benthic Community	Fish Health
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 Average phosphorus concentration in the Near-field area that exceeds 75% of AEMP Benchmark	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	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	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[(d)]

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) The fish health effect indicators considered under the Action Level assessment include relative body weight, relative liver weight.

(d) Critical effect sizes are differences of 10% for relative body weight, 25% for relative liver weight and 100% for fish tissue chemistry parameters.

CES = Critical effect size

8.3 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.

9 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).

10 REFERENCES

AENV (Alberta Environment). 2006. Aquatic Ecosystems Field Sampling Protocols. Edmonton, AB, Canada.

Agnico Eagle 2020. Type A Water Licence 2AM-MEL-1631 Amendment. August 2020.

Agnico Eagle. 2019. Meliadine Gold Project Environmental Management and Protection Plan (EMPP). January 2019. Version 8.

Agnico Eagle. 2015. Meliadine Gold Project – Type A Water Licence Main Application Document. April 2015. Version 1.

Agnico Eagle. 2014. Meliadine Gold Mine, Nunavut. Final Environmental Impact Statement. Submitted to the Nunavut Impact Review Board. April 2014.

Azimuth and Portt. 2021. Environmental Effects Monitoring Cycle 2 Study Design – Meliadine Gold Project. Report prepared by Azimuth Consulting Group and C. Portt & Associates. July 5, 2021.

Azimuth. 2021. Aquatic Effects Monitoring Program 2020 Annual Report. Meliadine Gold Mine. Prepared for Agnico Eagle Mines Limited, Meliadine Division, Rankin Inlet, Nunavut. March 2021.

Azimuth. 2020. Aquatic Effects Monitoring Program 2019 Annual Report. Meliadine Gold Project. Prepared for Agnico Eagle Mines Limited, Meliadine Division, Rankin Inlet, Nunavut. March 2020.

Azimuth (Azimuth Consulting Group). 2013. Meliadine – AEMP Development, Phase 1. Submitted to Agnico Eagle Mines Limited Rouyn-Noranda, QC.

Barrett TJ, Munkittrick KR. 2010. Seasonal reproductive patterns and recommended sampling times for sentinel fish species used in environmental effects monitoring programs in Canada. Environmental Reviews, 18: 115-135.

Barrett TJ, Tingley MA, Munkittrick KR, Lowell RB. 2010. Dealing with heterogeneous regression slopes in analysis of covariance: new methodology applied to environmental effects monitoring fish survey data. Environmental Monitoring and Assessment, 166:279-291.

Barrett TJ, Hille KA, Sharpe RL, Harris KA, Machtans HM, Chapman PM. 2015. Quantifying natural variability as a method to detect environmental change: definitions of the normal range for a single observation and the mean of m observations. Environmental Toxicology and Chemistry. 34: 1185-95.

British Columbia Ministry of Environment (BC ENV). 2019. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture - Summary Report. Water Protection & Sustainability Branch, BC Ministry of Environment & Climate Change Strategy. August 2019.

Carlson RE. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22: 361-369.

CCME. 2004. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater System. In: Canadian Environmental Quality Guidelines, 2004. Winnipeg, MB, Canada.

CCME. 2002. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life – Summary Table Update 2002.

CCME. 1999 (with updates to 2019). Canadian Environmental Quality Guidelines for the Protection of Aquatic Life – Summary Table. Available at: http://st-ts.ccme.ca/.

Chapman PM, Mann GS. 1999. Sediment quality values (SQVs) and ecological risk assessment (ERA). Marine Pollution Bulletin 38: 339-344.

Clarke KR. 1993. Non-parametric multivariate analyses of changes in community structure. Aust. J. Ecol. 18:117-143.

Coad BW, Waszczuk H, Labignan I. 1995. Encyclopedia of Canadian Fishes. Canadian Museum of Nature, Ottawa and Canadian Sportfishing Productions, Waterdown, ON.

De Beers. 2010. 2009 Annual Report in Support of the Aquatic Effects Monitoring Program Water Licence (MV2001L2-0002), Snap Lake Mine. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NT, Canada.

Environment and Climate Change Canada. 2022. Canadian Environmental Protection Act, 1999, Federal Environmental Quality Guidelines, Environment and Climate Change Canada.

Environment Canada. 2020. Canadian Environmental Protection Act, 1999, Federal Environmental Quality Guidelines, Lead. Environment Canada. July 2020.

Environment Canada. 2017. Canadian Environmental Protection Act, 1999, Federal Environmental Quality Guidelines, Cobalt. Environment Canada. May 2017.

Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. Ottawa, ON, Canada.

Environment Canada. 2004. Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems. Ecosystem Health: Science-based Solutions Report No. 1-8. National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada, pp. 114.

Findlay DL, Kling HJ. 2001. Protocols for Measuring Biodiversity: Phytoplankton in Freshwater. Department of Fisheries and Oceans. Freshwater Institute, Winnipeg, MB.

Golder. 2020. Water Quality Management and Optimization Plan Progress Update Rev4, Phase 3: Meliadine Mine Effluent Discharge Benchmarks for Total Dissolved Solids. Submitted to Agnico Eagle Mines Limited. November 13, 2020. Ref. No. 19132390-751-RPT-Rev1

Golder 2019. Cycle 1 Environmental Effects Monitoring Report and 2018 Aquatic Effects Monitoring Program Annual Report. Submitted to Agnico Eagle Mines Ltd. March 2019

Golder Associates Ltd. 2018. Aquatic Effects Monitoring Program – 2017 Annual Report. Submitted to Agnico Eagle Mines Limited – Meliadine Project. March 26, 2018.

Golder. 2016. Meliadine Gold Project, Nunavut. Aquatic Effects Monitoring Program (AEMP) Design Plan 6513-REP-03 Version 1. Submitted to Agnico Eagle Mines Limited Rouyn-Noranda, QC.

Golder (Golder Associates Ltd.). 2012a. SD 7-1 Aquatics Baseline Synthesis Report, 1994 to 2009 - Meliadine Gold Mine, Nunavut. Submitted to Agnico Eagle Mines Limited Rouyn-Noranda, QC.

Golder. 2012b. SD 7-2 2011 Aquatic Baseline Studies - Meliadine Gold Mine, Nunavut. Submitted to Agnico Eagle Mines Limited Rouyn-Noranda, QC.

Government of Canada. 2022. Metal and Diamond Mining Effluent Regulations. SOR/2002-222. Current to March 7, 2022. Last amended on February 21, 2022.

Government of Canada. 1993. Nunavut Land Claims Agreement Act. S.C. c. 29. Current to 17 November 2020. Last amended on 21 May 2004. https://laws-lois.justice.gc.ca/eng/acts/N-28.7/.

Government of Canada. 1985. Fisheries Act. R.S.C., c. F-14. Current to 17 November 2020. Last amended on 28

Government of Northwest Territories. 1988. Environmental Protection Act. Current to 24 July 2013. Last version 10 March 2011. https://www.canlii.org/en/nu/laws/stat/rsnwt-nu-1988-c-e-7/latest/rsnwt-nu-1988-c-e-7.html.

Health Canada 2020. Guidelines for Canadian Drinking Water Quality—Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

Health Canada. 2015. Health Canada's Maximum Levels for Chemical Contaminants in Foods. Available at: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/maximum-levels-chemical-contaminants-foods.html. Retrieved 8 January 2021

Koenings JP, Edmundson JA. 1991. Secchi disk and photometer estimates of light regimes in Alaskan lakes: Effects of yellow color and turbidity. Limnol Oceanogr 36: 91-105.

McPhail JD, Lindsey CC. 1970. Freshwater fishes of Northwestern Canada and Alaska. Bulletin 173. F. R. B. o. Canada. Ottawa, ON, Canada.

McPhail JD. 2007. The Freshwater fishes of British Columbia. Edmonton, AB, The University of Alberta Press.

NIRB (Nunavut Impact Review Board). 2014. Final Hearing Report. Meliadine Gold Mine. Agnico Eagle Mines Limited. NIRB File No. 11MN034. October 2014.

NIRB (Nunavut Impact Review Board). 2007. Guide to Terminology and Definitions. Updated August 2007. http://ftp.nirb.ca/04-GUIDES/.

Paterson M. 2002. Ecological Monitoring and Assessment Network Protocols for Measuring Biodiversity: Zooplankton in Fresh Waters. Department of Fisheries and Oceans. Freshwater Institute, Winnipeg, MB.

Portt and Kilgour. 2019. Environmental Effects Monitoring: Whale Tail Pit First Biological Monitoring Study Design. C. Portt and Associates and Kilgour and Associates Ltd. July 26, 2019.

Rescan (Rescan Environmental Services Ltd.). 2012. Ekati Diamond Mine: 2012 Aquatic Effects Monitoring Program Re-evaluation. Prepared for BHP Billiton Canada Inc., Yellowknife, Northwest Territories, Canada.

Resh, V. H., and Rosenberg, D. M. 1993. Freshwater biomonitoring and benthic macroinvertebrates (No. 504.4 FRE). Chapman and Hall.

Reynoldson, T. B., and Metcalfe-Smith, J. L. 1992. An overview of the assessment of aquatic ecosystem health using benthic invertebrates. Aquatic Ecosystem Health, 1(1), 295–308.

Tetra Tech. 2020. Meliadine Leak Updated 3-D Modelling of the Discharge Assessment. Presented to Agnico Eagle Mines Limited. November 2020.

Vollenweider RA. 1970. Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication. OECD, Paris. Tech. Rpt. DA 5/SCI/68.27. 250 pp.

Wetzel RG. 2001. Limnology 3rd edition. Elsevier Science Academic Press, New York, NY, USA.

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 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 4.4
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 5.1 Peninsula Lakes: Section 6
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 5.1

Commitment Number and Source	Recommendation / Condition / Commitment Details	Reference
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 5.6
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 as an early warning to potential far downstream effects. Section 4.2 and Section 5.1
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 8
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 5.2
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 5.6 Peninsula Lakes fish tissue chemistry may be completed as a targeted study if changes in water quality suggest fish are at risk.
FEIS GN-1	Agnico Eagle has committed to monitoring water quality during different seasons of the year including under-ice and early spring.	Section 5.1
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.	Section 5.1,
EC-9 and EC-10	Updated the reference area sampling frequencies	Completed in V1 of the AEMP Design Plan. See Table 4-3, Section 5.1.2, and Table 5-1
KIA-WL-16	List of parameters to be analyzed and the minimum acceptable detection limits.	Water quality parameters and detection limits from the 2021 AEMP are listed in Appendix B

Commitment Number and Source	Recommendation / Condition / Commitment Details	Reference
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 5.1.2 and Table 5-1 Peninsula Lakes: Section 6.1.2
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 5.2 Action Levels: Section 8.2
EC-12	Clarification on selection of sampling location for fish based on information request from ECCC	Section 4.2.2 Cycle 2 EEM Study Design (Azimuth and Portt, 2021)

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 (2021 AEMP)

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP.

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	-	-	-	-	-	-

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP.

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
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	-	-	-	-	-	-	-

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP.

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
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	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP.

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
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	-	-	-	-	-	-	-

Table B-1. Water Quality Screening Values for the Meliadine Lake AEMP.

Parameter	Units	DL	Normal Range	FEIS[a]	FWAL[b]	GCDWQ[c]	SSWQO[d]	AEMP Action Level[e]	AEMP Benchmark[f]
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.