MADRID-BOSTON PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

Volume 1 Annex V1-7 Type A Water Licence Applications

Package P4-18

Hope Bay Project Aquatic Effects Monitoring Plan

HOPE BAY PROJECT

MADRID-BOSTON AQUATIC EFFECTS MONITORING PLAN

December 2017

PLAIN LANGUAGE SUMMARY

This Madrid-Boston Aquatic Effects Monitoring Plan (AEMP; the Plan) describes what TMAC will do to monitor for possible project-related effects on freshwater and freshwater life near the Madrid-Boston Project (the Project) and supplements the existing Doris Aquatic Effects Monitoring Plan.

The Plan describes the mitigation measures that will be used to reduce the potential for Project effects to freshwater, and how information will be collected and studies in the freshwater environment to determine if the mining activities are affecting the freshwater environment.

REVISION RECORD

Date	Section	Summary of Changes	Author	Approver
December 2016	Throughout	Initial Plan	Katsky Venter	TMAC
December 2017	Throughout	Update to FEIS	Mike Henry	TMAC
December 2017	All	Review, edit	Dalyce Epp	

GLOSSARY AND ACRONYMS

Term	Definition
AEMP	Aquatic Effects Monitoring Plan
CCME	Canadian Ministers of the Environment
DFO	Department of Fisheries and Oceans
DOE	Department of Environment
ECCC	Environment and Climate Change Canada
GN	Government of Nunavut
HBML	Hope Bay Mining Ltd.
INAC	Indigenous and Northern Affairs Canada
KIA	Kitikmeot Inuit Association
MMER	Metal Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
SSWQO	Site-Specific Water Quality Objective
TIA	Tailings Impoundment Area

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1. INTRODUCTION

This Aquatic Effects Monitoring Plan (AEMP; the Plan) presents the freshwater aquatic monitoring to be conducted for the Madrid-Boston Project (the Project) within the Hope Bay Project development. The Plan focuses on Aimaokatalok Lake where treated mine-related effluents will be discharged, as well as lakes adjacent to proposed infrastructure that have the greatest potential to receive non-point-source inputs such as runoff and dustfall. Potential effects from water withdrawal for mine processes and water loss into the underground mine workings have also been considered. Where possible, monitoring described in this Plan has been aligned with the existing Doris AEMP to retain data comparability and increase program efficiency.

This Plan is being submitted as a part of the *Madrid-Boston Final Environmental Impact Statement* (TMAC 2017), and is anticipated to undergo discussion with interested Parties, including the Nunavut Water Board (NWB), Environment and Climate Change Canada (ECCC), the Nunavut Impact Review Board (NIRB), the Kitikmeot Inuit Association (KIA), Indigenous and Northern Affairs Canada (INAC), and the Department of Fisheries and Oceans Canada (DFO) prior to its finalization and adoption. This Plan considers guidance from the draft Environmental Impact Statement (DEIS) technical meetings in Cambridge Bay, Nunavut (June 2017), guidance outlined in the *Metal Mining Technical Guidance for Environmental Effects Monitoring* (ECCC 2012) and the *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories: Overview Report* (INAC 2009), as well as lessons learned through the implementation of the Doris AEMP (TMAC 2016).

This Plan is intended primarily for use by TMAC and its contractors to ensure appropriate freshwater effects monitoring associated with the Madrid-Boston Project. Monitoring will confirm that conditions of the Metal Mining Effluent Regulations (SOR/2002-222) relative to effects monitoring are met, and minimal potential downstream environmental effects occur. This Plan has been developed in anticipation of receipt of a Type A water licence for the Madrid-Boston Project, and the Plan may be revised on water licence issuance or based on party comments received during the permitting and licencing phases.

1.1. OBJECTIVES

The purpose of this Plan is to assess the potential effects of the Madrid-Boston Project activities on the freshwater environment and comply with requirements set forth in the Project permitting and licencing process. The objectives of the Plan are aligned with the definition of the AEMP as outlined in the Doris Water Licence (2AM-DOH1323).

The main objectives of the Plan are to:

- detect short- and long-term effects in lakes potentially influenced by activities of the Madrid-Boston Project; and
- evaluate the accuracy of the effects assessments made in TMAC's *Madrid-Boston Final Environmental Impact Statement*.

This Plan is designed to address these objectives by measuring the receiving environment in the short-term (on an annual basis) and the long-term (during construction and operation). The sampling design allows for changes in the receiving environment to be detected, which determines whether mitigation measures are being effective and the effects predictions were accurate.

1.2. RELEVANT LEGISLATION AND GUIDANCE

Table 1.2-1 provides a summary of federal and territorial regulations governing this Plan and associated guidelines. Additional regulations and standards govern other TMAC plans that are designed to manage sources of potential compounds to the freshwater environment, including the Hope Bay Project Spill Contingency Plan (Volume 1, Annex V1-7, Package P4-3); the Hope Bay Project Doris-Madrid Water Management Plan (Package P4-7); the Hope Bay Boston Water Management Plan (P4-8); and the Air Quality Monitoring Plan (Volume 8, Annex V8-2).

Table 1.2-1. Regulations and Guidelines Pertinent to the Aquatic Effects Monitoring Plan

Regulation	Year	Governing Body	Relevance
Nunavut Waters Regulations	2013	NWB	License for mining and milling undertaking to use water and deposit of waste in relation to the construction, operation, closure and reclamation.
Environmental Rights Act	2011	Government of Nunavut (Department of Environment, Environmental Protection division)	Grants all residents the ability to launch an investigation
Guideline	**Year**	**Issued by**	**Relevance**
Canadian Environmental Quality Guidelines	1999 – as amended to date	Canadian Council of Ministers of the Environment (CCME)	Provides guidance on water quality for the protection of aquatic life; both freshwater and marine

1.3. PLAN MANAGEMENT AND EXECUTION

The Plan will be reviewed regularly and updated as necessary. Personnel responsible for implementing and updating the AEMP are identified in Table 1.3-1.

Table 1.3-1. Roles and Responsibilities

Role	Responsibility
VP Environmental Affairs	• Overall responsibility for and implementation of this management plan; • Provide the on-site resources to operate and maintain the monitoring program in accordance with this AEMP; • Provide input on modifications to design and operational procedures to improve operational performance.
Environmental Director	• Review and update this AEMP as required; • Support implementation of this monitoring plan; • Ensure staff conducting monitoring are trained in monitoring and quality assurance and quality control procedures.
Environmental Coordinator / Environmental Consultants	• Conduct sampling and assess whether water quality samples have met applicable regulatory standards and guidelines; • Report issues, irregularities, and non-compliances with sampling program to the Environmental Director; • Ensure sampling gear is safe and operational; • Maintain water quality records and all associated required reporting; • Audit water quality records and all associated required reporting.

2. RATIONALE FOR AEMP DESIGN

This Plan reflects the Madrid-Boston Project documented and assessed in TMAC's *Madrid-Boston Final Environmental Impact Statement*. Monitoring program design, indicators, methodologies, and sampling frequency have been selected based on anticipated or potential effects related to Madrid-Boston development. Monitoring has been aligned with the existing Doris AEMP where possible to retain data comparability and program efficiency. Monitoring has also considered baseline data collection locations, methodologies, and sample collection timing.

The Madrid-Boston Project includes the mining of ore deposits in the Boston and Madrid areas, and continued use of existing Doris Project infrastructure such as the mill, tailings impoundment area (TIA), and ocean discharge pipeline. New infrastructure will include underground mines at Madrid North, Madrid South, and Boston, processing plants at Boston and Madrid North, and a tailings management area for subaerial deposition of dry stack tailings near Boston camp. The Madrid-Boston Project will also result in additional water use demands and groundwater inflow into Madrid North and Madrid South mines. The potential effects of these activities on surface water quantity and quality are discussed below.

2.1. SURFACE WATER QUANTITY

The Madrid-Boston Project has the potential to affect surface water quantities by direct water withdrawal for site and processing (domestic and industrial) activities and through groundwater inflow into the underground mines. Water for industrial purposes will be withdrawn from Doris Lake and Aimaokatalok Lake and water for domestic purposes will be withdrawn from Windy and Aimaokatalok lakes. Three underground mines will be developed as part of the Project: Madrid North, Madrid South, and Boston. Of these, Madrid North and South will mine within a portion of the taliks of Patch and Wolverine lakes in the Doris Watershed. Groundwater within these taliks will be saline and is expected to seep into the underground mines. This inflow will be intercepted and conveyed to the marine environment, with the groundwater being potentially recharged with water from the overlying lakes. This will remove these water quantities from the freshwater watersheds. The Boston mine will remain in permafrost, and will encounter minimal groundwater inflows. Further, water withdrawn for domestic and industrial use from Aimaokatalok Lake will be treated and returned to the lake or its watershed, reducing the potential for effects on water quantity in this lake.

To monitor potential effects of water withdrawal and groundwater removal on the surface water, lake water level monitoring will occur in Wolverine, Patch, Doris, Windy, and Aimaokatalok lakes.

2.2. SURFACE WATER QUALITY

Direct discharge to freshwater from the Madrid-Boston Project will only occur at Aimaokatalok Lake. Treated effluent from the Boston activities will be discharged to Aimaokatalok Lake in compliance with MMER requirements. This discharge represents the primary pathway that the Madrid-Boston Project could affect surface water quality; therefore, the proposed aquatic effects monitoring is focused on this lake.

Indirect inputs that could influence water quality in freshwater waterbodies near development areas may involve dust deposition, tundra discharges, and runoff during the construction and operations phases. Project infrastructure components that may cause indirect inputs to nearby freshwater include:

- Boston, Madrid, and Doris sites;
- fuel storage and fuelling stations;
- quarry crushing;
- road construction and use;
- quarries, waste rock, and ore storage;
- sediment and pollution control ponds;
- explosives storage and use; and
- tailings deposition and storage.

2.3. MITIGATION OF POTENTIAL EFFECTS

TMAC has several management and monitoring plans that prevent or minimize potential effects to the freshwater environment (Table 2.3-1). To date, the water and air management practices outlined in the various plans have been effective in mitigating effects to the freshwater environment surrounding the Doris Mine; no effects to water, sediment, or aquatic life have been detected in any of the waterbodies monitored under the Doris AEMP. Based on this success, similar mitigation measures will be adopted for the Madrid-Boston Project.

The efficacy of the mitigation measures pertaining to aquatic effects will be evaluated through this Plan. These management plans are continuously updated to reflect improvements to mitigation measures identified through the Plan implementation process.

Table 2.3-1. TMAC Documents and Programs Related to the Aquatic Effects Monitoring Plan

Document Title	Relevance
Hope Bay Project Doris-Madrid Water Management Plan *Hope Bay Project Boston Water Management Plan*	Management of contact water from the site, TIA and underground
Air Quality Management Plan	Management of dust and air-borne emissions
Hope Bay Project Groundwater Management Plan	Management and minimization of groundwater inflow to the mine
Hope Bay Project Waste Rock and Ore Management Plan	Management of waste rock and ore contact water
Doris Project Domestic Wastewater Treatment Management Plan	Management of treated domestic wastewater effluent
Hope Bay Project Spill Contingency Plan	Spill response procedures to minimize spill effects
Hope Bay Project, Phase 2, Doris Tailings Impoundment Area - Operations, Maintenance, and Surveillance Manual *Hope Bay Project, Boston Tailings Management Area - Operations, Maintenance, and Surveillance Manual*	Management of TIA effluent
Quality Assurance and Quality Control Plan	Approved sampling practices
Hope Bay Project Hazardous Waste Management Plan	Describes proper handling, storage and disposal procedures for hazardous wastes
Hope Bay Project Non-Hazardous Waste Management Plan	Describes proper handling, storage and disposal procedures for non-hazardous wastes

Mitigation measures protective of aquatic life implemented at the Hope Bay Project include:

- Sediment control measures for works in or near waterbodies and watercourses, such as use of silt fences or coconut matting at drainage points;
- Minimizing vegetation clearing;
- Implementation of erosion control measures, such as capping of soils exposed during construction activities with rock and capping of the Boston TMA during closure;
- Implementation of blasting restrictions near water outlined in DFO's *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998);
- Treatment of discharges where necessary to ensure compliance with MMER and/or Water Licence discharge criteria;
- Screening of water intakes to prevent impingement or entrainment of fish;

- Construction of stream crossings in a manner that does not interfere with fish passage, constrict channel width, or reduce flows and in accordance with DFO recommendations;
- Reuse of water where possible and practical; and
- Minimization of groundwater inflows.

2.4. POTENTIAL EFFECTS AND AEMP MONITORING COMPONENTS

The management and mitigation measures outlined in the above prevent or reduce the potential for, and scale of, effects to the freshwater environment. However, potential remains for Madrid-Boston activities to affect aquatic habitat through discharge to Aimaokatalok Lake, and dust deposition, runoff, and water drawdown in each AEMP lake. These potential Project contributions have the ability to affect different aquatic components and this, in combination with regulatory requirements and guidance, has determined the aquatic components that will be monitored in this Plan.

2.4.1. Water Quantity

Drawdown of Wolverine, Patch, Doris, and Windy lakes may result directly from the withdrawal of lake water for site and process related purposes, and/or indirectly due to lake water moving into the groundwater as it replaces the talik water that has seeped into the underground mine. Lowered lake levels may affect fish habitat availability. To confirm these effects are not greater than those predicted following mitigation, lake water levels will be monitored in lakes potentially affected by water removal and will be compared to baseline information and EIS predictions.

2.4.2. Water Quality

Treated effluent discharged to Aimaokatalok Lake will meet MMER discharge criteria, and will be confirmed by the sampling prescribed under the MMER. However, if concentrations of particular water quality parameters increase above a certain level as a result of Project contributions, they could affect aquatic life in the lake. Environmental effects monitoring (EEM) related to this discharge will be undertaken in alignment with the MMER EEM guidance (ECCC 2012), including the sampling of water quality four times a year.

Dust deposition and runoff are indirect sources of potential contaminants to Aimaokatalok, Stickleback, Wolverine, Patch, and Doris lakes, and their effects are most likely to be first measured in the lake water. Given this, water quality will be monitored in these lakes and results will be evaluated against CCME guidelines for the protection of aquatic life and approved site-specific water quality objectives, and assessed to determine if concentrations are increasing in the lake due to mine activities.

2.4.3. Phytoplankton Biomass

Discharge, dust deposition, and runoff may contribute nutrients to lakes near Madrid-Boston activities, and if particular nutrients (e.g., nitrogen and phosphorus) naturally limit primary production in these lakes, alteration of water quality could lead to increased primary production. Phytoplankton are the dominant primary producers in lakes, and phytoplankton biomass levels are estimated using the main photosynthetic pigment, chlorophyll *a*. Chlorophyll *a* concentrations will be measured in the potentially affected lakes to evaluate potential mine effects through nutrient inputs.

2.4.4. Benthos

Dust deposition and runoff have the potential to contribute particulate matter and associated compounds to the waterbodies near the Project. This could affect the water and sediment chemistry, and potentially the health of benthic invertebrates (benthos) that are in contact with the water and sediments. As a result, benthos will be monitored to determine if potential changes to water and sediment quality are affecting the benthic biota of lakes near the Project.

2.4.5. Sediment Quality

Discharge, dust deposition, and runoff may contribute particulate matter and associated compounds to the water of lakes near Madrid-Boston activities, and these constituents may settle to the sediments where they could affect aquatic life in the lake if concentrations increase above a certain level. Sediment quality will therefore be monitored in the potentially affected lakes to determine if concentrations are increasing in the lake due to mine activities. All CCME sediment parameters will be evaluated to ensure that mine activities are not affecting freshwater life.

2.4.6. Fish

A fish population study related to effluent discharge is required under MMER if the concentration of effluent in the exposure area is greater than 1% in the area located within 250 m of a final discharge point (Schedule 5, s. 9). Further, MMER require fish tissue monitoring if effluent end-of-pipe total mercury (Hg) concentration exceeds 0.1 µg/L (Schedule 5, s. 9). Should these studies be required, an appropriate monitoring program following sampling recommendations in the *Metal Mining Technical Guidance for Environmental Effects Monitoring* (ECCC 2012) will be developed in the MMER First Study Design.

3. MONITORING

This chapter describes the study area, monitoring schedule, sampling methods, analysis, and the quality assurance and quality control (QA/QC) procedures used to fulfil the objectives outlined in Section 1.1.

3.1. STUDY DESIGN

3.1.1. Study Area

Aquatic effects monitoring will focus on Aimaokatalok, Stickleback, Wolverine, Patch, Windy and Doris lakes (Figures 3.1-1a and 3.1-1b). These are the waterbodies adjacent to or downstream of most of the Project infrastructure and activities, and the associated taliks in which mining will occur.

Monitoring of Doris Lake will be aligned with the existing and approved Doris AEMP, as the nature of potential effects to this lake remain the same as those considered in the development of the Doris AEMP. Doris Lake monitoring, along with monitoring at Stickleback, Wolverine, and Patch lakes will provide information needed to assess potential non-point source aquatic effects related to the Project, including Project-related water drawdown. Windy Lake will be monitored specifically for potential effects related to water drawdown (i.e., lake water level).

Monitoring in Aimaokatalok Lake will focus on both point-source aquatic effects, monitored in alignment with the EEM guidance and MMER requirements, as well as potential non-point source effects.

Monitoring will also occur in parallel at a reference lake. This will provide information on regional changes that may be occurring in the aquatic environment. The reference lake used in the Doris AEMP, Reference Lake B, will also serve as the reference lake in this AEMP. Reference Lake B has been sampled continuously since 2010.

3.1.2. Monitoring Sites

Monitoring will be conducted at sampling locations illustrated in Figures 3.1-1a and 3.1-1b. Hydrometric monitoring stations will be installed in each lake, preferably at accessible locations near exposed bedrock (for survey purposes) and deeper water (to allow year-round under-ice data collection). Water, sediment, and biological sampling locations were selected over deep basins to characterize point-source effects and/or align with historical sampling locations.

Monitoring will include the collection of physical limnology, water quality, sediment quality, and ice thickness, as well as phytoplankton biomass (as chlorophyll *a*) and benthic invertebrates. Fish will be monitored under MMER.

3.1.3. Monitoring Schedule

Aquatic effects monitoring components have been selected to address the potential mine effects as described above. Similarly, scheduling of monitoring has been tailored to address the mine development and operation sequence, and is tied to periods during which Project effects may occur. Table 3.1-1 outlines the mine-specific monitoring triggers (such as water level changes, non-point-source inputs, and/or direct discharge) that will initiate and drive the monitoring schedule.

During Madrid North construction and operations, Madrid North-associated activities have the potential to affect Windy Lake (due to potable water use), Patch Lake (due to groundwater inflows and proximity) and Doris Lake (due to water use and upstream water loss to groundwater inflows from Patch Lake). As a result, these lakes will be monitored during Madrid North construction and operations.

During Madrid South construction and operations, Madrid South activities have the greatest potential to affect Wolverine Lake (due to groundwater inflows and proximity), Patch Lake (due to groundwater inflows and proximity), Doris Lake (due to water use and upstream water loss to groundwater inflows from Patch Lake) and Windy Lake (due to potable water use). As a result, these lakes will be monitored during Madrid North construction and operations.

Figure 3.1-1a
AEMP Monitoring Sites, Northern Hope Bay Belt

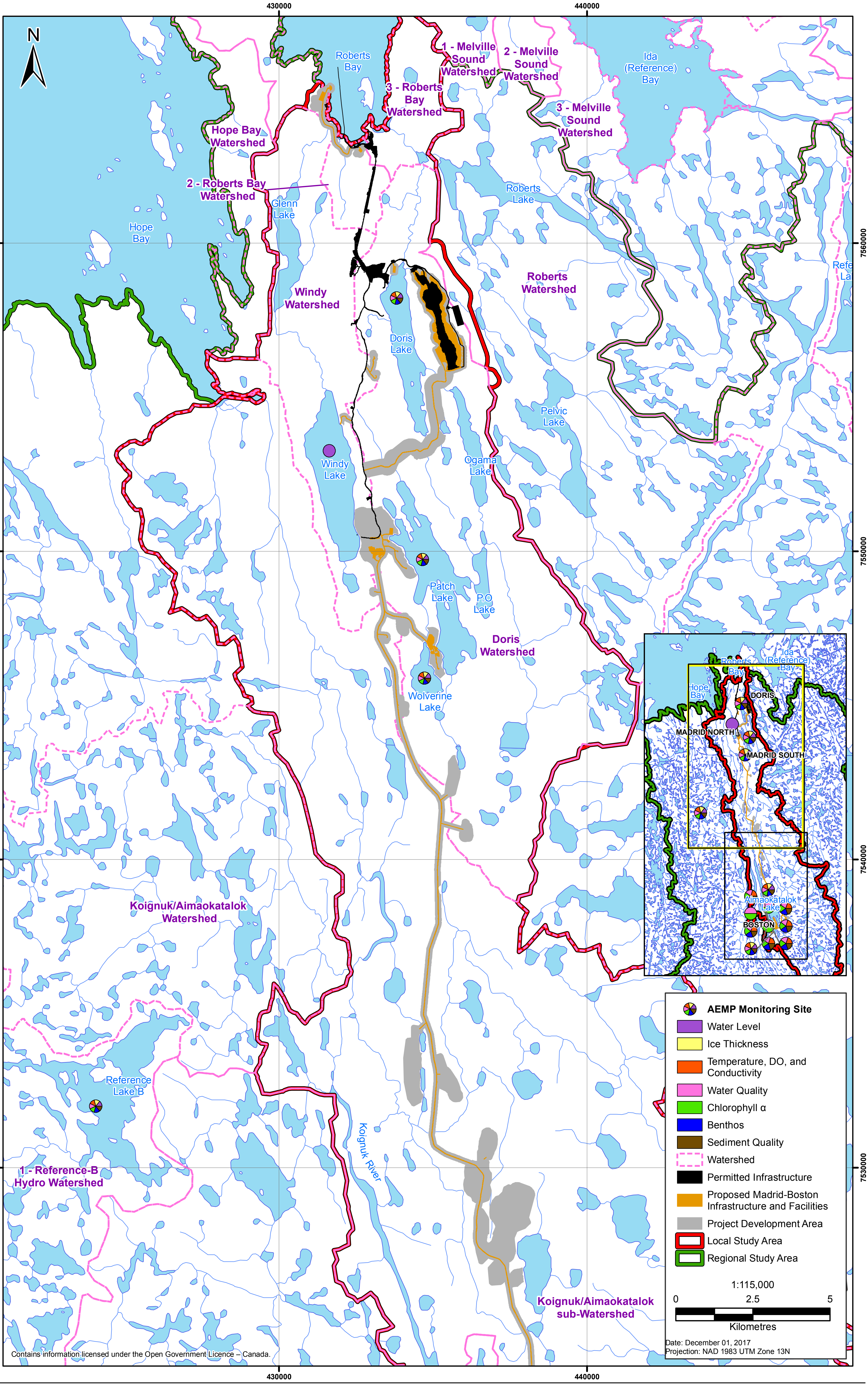

Figure 3.1-1b
AEMP Monitoring Sites, Southern Hope Bay Belt

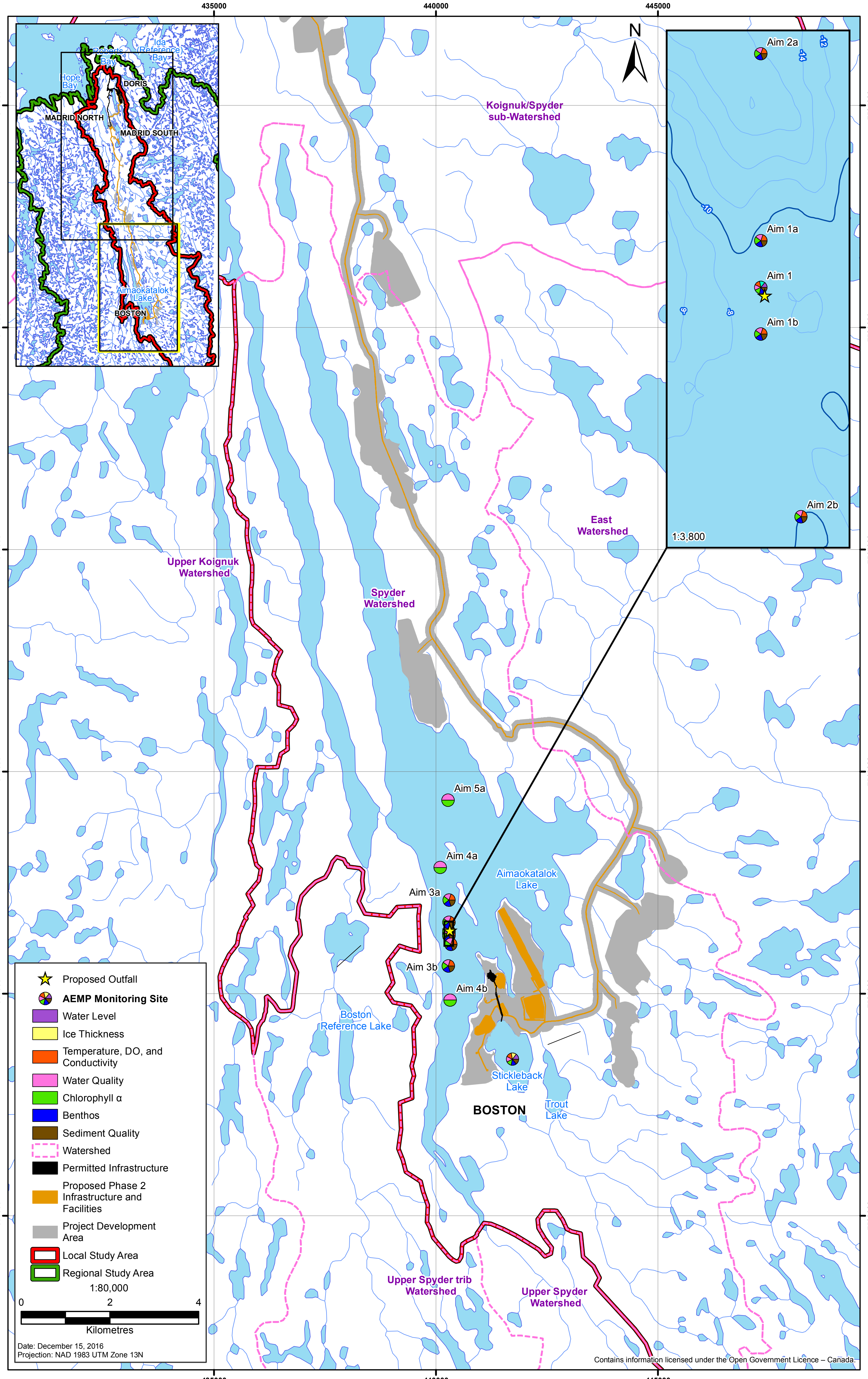

Table 3.1-1. Monitoring Location Descriptions and Monitoring Triggers

Watershed	Station	Description	Monitoring Trigger	Reason
Windy Watershed	Windy Lake	Deep basin representative of lake	Madrid North Construction and Operations	Direct potable water withdrawal (increased accommodation at Doris)
			Madrid South Construction and Operations	Direct potable water withdrawal (increased accommodation at Doris)
Doris Watershed	Wolverine Lake	Deep basin representative of lake	Madrid South Construction and Operations	Groundwater inflows; Indirect inputs due to proximity
	Patch Lake	Deep area in center of lake representative of lake	Madrid North Construction and Operations	Groundwater inflows; Indirect inputs due to proximity
			Madrid South Construction and Operations	Groundwater inflows; Indirect inputs due to proximity
	Doris Lake	Deep basin representative of lake	Madrid North Construction and Operations	Direct water withdrawal; upstream loss from groundwater mine inflows Indirect inputs due to proximity
			Madrid South Construction and Operations	Direct Water withdrawal; upstream loss from groundwater mine inflows
			Boston Operations	Direct Water withdrawal
Aimaokatalok Watershed	Stickleback Lake	Deep basin representative of lake	Boston Construction and Operations	Indirect inputs due to proximity
	Aimaokatalok 1	Proposed diffuser location, near to Project activities	Boston Construction and Operations until replaced by MMER-EEM program	Indirect inputs due to proximity
	Aimaokatalok 1a	MMER EEM sampling location 50 m north of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 1b	MMER EEM sampling location 50 m south of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 2a	MMER EEM sampling location 250 m north of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity

Watershed	Station	Description	Monitoring Trigger	Reason
Aimaokatalok *(cont'd)*	Aimaokatalok 2b	MMER EEM sampling location 250 m south of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 3a	MMER EEM sampling location 750 m north of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 3b	MMER EEM sampling location 750 m south of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 4a	MMER EEM sampling location ~ 1.5 km north of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 4b	MMER EEM sampling location ~ 1.5 km south of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
	Aimaokatalok 5a	MMER EEM sampling location ~ 3 km north of diffuser, ~10-15 m depth	Discharge to Aimaokatalok Lake - MMER	Direct inputs (MMER discharge); Indirect inputs due to proximity
Reference	Reference Lake B	Deep basin representative of lake	Doris, Madrid, and Boston Construction and Operations	none

During Boston construction and operations, Stickleback Lake and Aimaokatalok Lake Station 1 (Aim 1) will be sampled for non-point source effects and water level. Following the initiation of discharge to Aimaokatalok Lake, sampling of Aim 1 will be replaced by sampling a larger group of locations in Aimaokatalok Lake arrayed in a gradient transect design focused on monitoring for mine discharge effects.

The monitoring schedule, sampling frequency, and sampling instrumentation for each of the Plan's environmental monitoring components are outlined in Table 3.1-2.

The water level in monitored lakes will be continuously recorded and downloaded annually at all sites. Ice thickness will be measured in at each monitoring lake in April. Water quality and phytoplankton biomass (as chlorophyll *a*) samples as well as physical profiles of temperature, dissolved oxygen, and conductivity will be collected twice a year to represent both winter (April sampling) and summer (August sampling) conditions. At Aimaokatalok Lake, additional MMER-related water quality sampling will occur in July and September to conform to MMER requirements. Benthic invertebrate and sediment quality sampling will be conducted every three years during August. Sampling will be conducted on a similar schedule in Reference Lake B for all environmental components, except water level, which will not be monitored in the lake.

Table 3.1-2. Monitoring Schedule, Sampling Frequency, and Sampling Device

Monitoring Parameter	Frequency*	Sampling Device
Water level	Continuous recording (download annually)	Transducer and data logger
Ice thickness	Annually (April)	Manual measurement
Temperature, dissolved oxygen and conductivity	2× per year (April, August)	Temperature-DO-conductivity meter
Water Quality (Physical, nutrients, total metals)	2× per year (April, August)	Discrete sampler
Phytoplankton Biomass (as chl *a*)	2× per year (April, August)	Discrete sampler
Benthic Invertebrates	once every 3 years (August)	Ekman Grab (500 µm sieve)
Sediment Quality	once every 3 years (August)	Ekman Grab

Monitoring frequency outlined in this table applies to periods during which monitoring is triggered as outlined in Table 3.1-1.
**For MMER EEM-related monitoring locations (as identified in Table 3.1-1), water quality sampling will also occur in July and September, and will follow requirements of the MMER at a minimum even if this deviates from this table.*

This Plan has been developed with a focus on Construction and Operations phases. During the Closure and Temporary Closure (i.e., care and maintenance) phases, sampling will continue as prescribed under the MMER at sites related to MMER EEM discharge sampling in Aimaokatalok Lake (as identified in Table 3.1-1). Water level monitoring will also continue as long as combined winter water withdrawal and groundwater inflows are greater than 10% of lake volume. Due to the reduction of site activities, other sampling addressing non-point-source inputs will be suspended during Closure and Temporary Closure unless effects have been detected in the immediately preceding years.

3.2. MONITORING COMPONENTS

3.2.1. Water Level and Ice Thickness

<u>Methods</u>

Lake water levels will be measured continuously throughout the year at lakes depicted in Figure 3.1-1. A pressure transducer paired with a data logger will be installed in each lake at a depth suitable to avoid ice damage and to allow data to be collected throughout the year. Data will be recorded in 10-minute intervals and will be downloaded annually.

Ice thickness monitoring will occur once each year in April concurrent with water sampling. The measurement will be taken through an augured hole and the ice thickness recorded using a metred rod. Lake-bottom depth will also be measured using a depth sounder or a weighted and metred line.

Effects Analysis

Water level data will be examined to determine if water level reductions during effect years at Doris and Windy watershed lakes are within those predicted.

Quality Assurance and Quality Control (QA/QC)

The collection and analysis of water level data will follow procedures outlined in the 2014 Hydrology Report (ERM Rescan 2014). A number of field- and desk-based procedures will be used to assess the reliability of data collected from the hydrometric station. Field QA/QC procedures will include following accepted water level surveying procedures and using stable benchmarks (such as bedrock).

Field crews will be trained to employ consistent methods for measuring ice thickness to ensure comparability of data.

3.2.2. Water Quality

Methods

Water quality sampling will be conducted in April and August of each year at all sites. Samples will be collected at the surface (1 m depth; 1 m below the ice in winter) and at depth (2 m from sediments) using an acid-cleaned discrete sampling device (e.g., GO-FLO or Niskin).

All water samples will be collected using laboratory-approved clean sampling bottles, with personnel wearing powder-free nitrile gloves. Samples will be preserved with the appropriate chemicals and properly labelled and stored. All samples will be sent to an accredited analytical laboratory within the appropriate holding times, and at a minimum, will be analyzed for the water quality parameters outlined in Table 3.2-1 (except temperature and dissolved oxygen). Other parameters not listed in the table (e.g., calcium, sodium, conductivity, total dissolved solids, sulphate, and other metals) will also be analyzed and will be reported in the appendices of the annual AEMP report.

Water quality samples collected from MMER EEM sites (as identified in Table 3.1-1) will also be analyzed for any additional parameters that may be required under the MMER (e.g., cyanide and Radium 226), and will additionally be sampled in July and September to address the MMER EEM requirements.

Dissolved oxygen, temperature, and conductivity profiles will be conducted during each water quality survey using a calibrated temperature-conductivity-dissolved oxygen meter. Each open-water profile will extend from the surface to approximately 1 m above the sediment surface, with values recorded every 1 m. Under-ice profiling will begin just below the base of the ice layer (approximately 2 m) and will extend to 1 m above the sediments. All data will be recorded onto field sheets with the applicable meta-data such as date, time, personnel, weather, calibration data, and ice thickness measurements.

Table 3.2-1. Freshwater Water Quality Parameters

Physico-chemical	Total Metals
pH [a, b, e]	Aluminum (Al) [a, c]
Alkalinity [b, e]	Arsenic (As) [a, d]
Hardness [b, e]	Boron (B) [a]
Chloride [a]	Cadmium (Cd) [a, c]
Salinity [e]	Chromium (Cr) [a]
Conductivity [e]	Copper (Cu) [a, d]
Total Suspended Solids [a, d]	Iron (Fe) [a, c]
Turbidity [a]	Lead (Pb) [a, d]
Temperature [a, b, e]	Mercury (Hg) [a, c]
Dissolved Oxygen [a, e]	Molybdenum (Mo) [a, c]
Water Depth	Nickel (Ni) [a, d]
Nutrients	Selenium (Se) [a, c]
Ammonia [a, c]	Silver (Ag) [a]
Nitrate [a, c]	Thallium (Tl) [a]
Nitrite [a]	Uranium (U) [a]
Total Phosphorus [a]	Zinc (Zn) [a, d]
Orthophosphate	

[a] *Parameters with CCME water quality guidelines for the protection of aquatic life.*
[b] *Co-factors for the determination of site-specific environmental quality benchmarks.*
[c] *subject to EEM Effluent Characterization Study (Schedule 5 s.4(1a-h))*
[d] *MMER deleterious effluent substance (Schedule 4 - Column 1)*
[e] *subject to EEM Water Quality Monitoring Study (Schedule 5 s. 7(1b-c))*

Analysis of Effects

For non MMER EEM-related sites, water quality parameters with CCME guidelines will be evaluated for potential effects using a before-after-control-impact (BACI) design. ‘Before’ data will be that collected at a site prior to potential effects. For Doris Lake, ‘before’ data will be data collected prior to 2016, as defined in the Doris AEMP. For other lakes identified as potentially affected by Madrid North development, ‘before’ data will be data collected prior to mining at Madrid North. For Wolverine Lake (which may be affected by Madrid South development), ‘before‘data will be data collected prior to Madrid South portal/mine development. For Boston non-MMER sampling in Aimaokatalok and Stickleback lakes, ‘before’ data will be that collected prior to the initiation of mining. Data collected following these project milestones will serve as the ‘after’ data.

Reference Lake B will be the ‘control’ component of this monitoring, and other monitoring sites will be the ‘impact’ components for analyses purposes. The interaction between the ‘before-after’ and ‘control-impact’ terms is the BACI effect of interest. Potential effects will be assessed at a significance level of 0.05.

For the MMER EEM-related monitoring, which has a replicated gradient sampling design, analysis will evaluate spatial trends in effects relative to the point of discharge. This analysis will consider ‘before’ conditions, which will be represented by data collected prior to initiation of mine discharge to Aimaokatalok Lake. Monitoring parameters analyzed will include water quality parameters with CCME guidelines as well as those listed under the MMER.

Those parameters without MMER or CCME guidelines, such as water hardness, sodium, and sulphate, will be reported in appendices with summary information, and the data used where necessary to support the evaluation of effects.

Quality Assurance and Quality Control (QA/QC)

Quality assurance measures will include Environmental staff being trained to carry out the sampling as well as QA/QC procedures such as using certified laboratories for analyses, and using lab-approved clean bottles, high quality preservatives, and distilled water. On-site quality control measures will include the use of chain-of-custody (CoCs) forms to track shipped samples and collecting travel blanks, field blanks, and replicate samples to assess potential sources of contamination and variability in the sampling program. The travel and field blanks are designed to identify sources of contamination during the collection and transportation of water samples, while replicate samples identify potential *in situ* variability within the sampling environment.

Rigorous quality assurance and control measures will be followed at the analytical laboratory, and will include identifying holding time exceedances and using split samples and spiked samples (using certified standards) to track laboratory precision and process recoverability.

3.2.3. Phytoplankton Biomass (as chlorophyll *a*)

Methods

Triplicate samples will be collected for phytoplankton biomass (as chloropyll *a*) from 1-m depth using a discrete sampling device. Each replicate sample will be collected in a foil-wrapped bottle and filtered onto a 0.45 µm filter. The volume of water filtered will be recorded, the filter frozen, and samples sent to a laboratory for analysis of chlorophyll *a*.

Analysis of Effects

Potential changes in phytoplankton biomass will be evaluated using a BACI analysis similar to that described for Water Quality, with chlorophyll *a* as the response variable.

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for chlorophyll *a* sampling will include collecting the water in a foil-wrapped bottle (to prevent further photosynthesis), keeping the filtered sample frozen at all times prior to analysis, collecting replicate samples, and using CoC forms to track sample shipment.

3.2.4. Benthos

Methods

Benthos will be collected using an Ekman grab sampler, with each sample being comprised of a composite of three subsamples. Each composited sample will be sieved to 500 µm, preserved with formalin, and sent to a taxonomist for identification and enumeration. Five replicate samples will be collected from Wolverine, Stickleback, Patch, and Doris lakes and Aimaokatalok Stn 1. A single sample will be collected from each of the MMER EEM-related monitoring locations in Aimaokatalok Lake, which target effects monitoring specific to MMER-related discharge.

Analysis of Effects

Potential changes in benthos will be evaluated using a BACI analysis, with benthos metrics for effects evaluation including total density, richness, and diversity (both Simpson's and Bray-Curtis).

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for benthos sampling will include the collection of subsamples and replicates to account for within-site variability and the use of CoC forms to track samples.

A re-sorting of randomly selected sample residues will be conducted by the taxonomist on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting will be that more than 90% of the total number of organisms will be recovered from the initial sort. The number of organisms initially recovered from the sample will be expressed as a percentage of the total number after the re-sort (total of initial and re-sort count). Any sample not meeting the 90% removal criterion will be re-sorted a third time.

3.2.5. Sediment Quality

Methods

Surficial sediment quality samples will be collected using an Ekman grab sampler. Samples will be collected concurrently with the benthos samples. Each sediment sample will be carefully transferred onto a plastic tray, and the top 2 to 3 cm of sediment will be removed and homogenized in a plastic bowl using a plastic spoon and placed into two containers: one for particle size, and one for sediment chemistry. All samples will be kept cool and sent to an accredited analytical laboratory within the appropriate holding times. Five replicate samples will be collected as described from Wolverine, Stickleback, Patch, and Doris lakes and Aimaokatalok Stn 1. A single sample will be collected from each of the MMER EEM-related monitoring locations in Aimaokatalok Lake, which target effects monitoring specific to MMER-related discharge.

Samples will be analyzed for the sediment quality parameters outlined in Table 3.2-2. Additional metal parameters that are part of the laboratory analytical outputs will be reported in the appendices of the annual AEMP report.

Analysis of Effects

Sediment quality parameters will be evaluated for potential Project-related effects using a BACI analysis outlined in the water quality section.

Table 3.2-2. Freshwater Sediment Quality Parameters

Physical and Nutrients	Total Metals
% Moisture	Arsenic (As) [a]
pH	Cadmium (Cd) [a]
Particle size[b]	Chromium (Cr) [a]
Total nitrogen	Copper (Cu) [a]
Total organic carbon[b]	Lead (Pb) [a]
	Mercury (Hg) [a]
	Zinc (Zn) [a]

[a] *Parameters with CCME sediment quality guidelines for the protection of aquatic life (CCME 2015).*
[b] *required for EEM benthic invertebrate survey*

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for sediment quality sampling will include the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples. Rigorous quality assurance and control measures will be followed at the analytical laboratory, and will include identifying holding time exceedances and using split samples and spiked samples (using certified standards) to track laboratory precision and process recoverability.

4. REPORTING

The results of the monitoring and analysis described within this Plan will be reported annually to the NWB during construction and operations and as required by the MMER to ECCC. If adverse trends are detected, the results will be communicated to TMAC management and further investigation will be undertaken if required.

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