Baffinland Iron Mines Corporation

AQUATIC EFFECTS MONITORING PLAN

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Rev 2

Prepared By: Andrew Vermeer
Department: Environment
Title: Environmental Coordinator
Date: April 8, 2016
Signature:

Approved By: Jim Millard
Department: Environment
Title: Environmental Manager
Date: April 8, 2016
Signature:

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06/27/14	0	Jim Millard	Oliver Curran	Part I, Item 2 of Type A Water Licence No. 2AM-MRY1325
10/30/15	1	William Bowden	Jim Millard	Part I, Item 2 of Type A Water Licence N0. 2AM-MRY1325 Amendment No.1
03/31/16	2	Andrew BB Vermeer	Jim Millard JM	CREMP Design Revision recommended by Minnow

Index of Major Changes/Modifications in Revision 2

Item No.	Description of Change	Relevant Section
1	Updated Table 1.2 to include final sediment quality benchmarks established in 2015 and Minnow's recommendations for modifying the CREMP Study Design.	1.0
2	Added Figure 2.1 to show locations of the different Project Sites and updated Figure 2.2 to reflect current ERP operations.	2.1
3	Updated Figure 3.2 and 3.3 as well as Table 3.2 to reflect the 2015 Surveillance Network Program (SNP).	3.4
4	Updated timeline/schedule for MMER requirements.	4.1.5
5	Updated all CREMP Study Design components to reflect the recommendations proposed by Minnow in 2016.	4.2
6	Updated to reflect current status of the Stream Diversion Barrier Study during the Early Revenue Phase (ERP) of the Project.	4.3
7	Updated Table 5.3 to reflect the final sediment quality benchmarks established in 2015.	5.3.3
8	Included Bray Curtis Index in list of metrics used to assess CREMP BMI data.	5.3.5
9	Added Inrisik's report on the establishment of final sediment quality AEMP benchmarks as Appendix D.	Appendix D

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ABBREVIATIONS

Project	the Mary River Project
AANDC	Aboriginal Affairs and Northern Development Canada
AEMP	the Aquatic Effects Monitoring Plan
ANFO	Ammonium Nitrate Fuel Oil
BC MOE	Ministry of the Environment
CanNor	Canadian Northern Economic Development Agency
CCME	Canadian Council of Ministers of the Environment
CES	Critical Effect Size
CREMP	Core Receiving Environmental Monitoring Program
CWQG-PAL	Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life
DFO	Department of Fisheries and Oceans
EC	Environment Canada
EDA	Exploratory Data Analysis
EEM	Environmental Effects Monitoring Program
ERP	Early Revenue Phase
ETMF	Exposure Toxicity Modifying Factors
FEIS	Final Environmental Impact Statement
HADD	Harmful Alternation, Disruption or Destruction of Fish Habitat
INAC	Indian and Northern Affairs Canada
MHTO	Mittimatalik Hunters and Trappers Organization
MMER	Metal Mining Effluent Regulations
NLCA	Nunavut Land Claims Agreement
NSC	North/South Consultants Inc.
NWB	Nunavut Water Board
QIA	Qikiqtani Inuit Association
ROM	Run-of-Mine
SDA	Statistical Data Analysis
SNP	Surveillance Network Program
SSWQO	Site-specific Water Quality Objective
TAP	Technical Advisory Panel
TEMMP	Terrestrial Environment Management and Monitoring Plan
TEWG	Terrestrial Environment Working Group
TOC	Total Organic Carbon
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
VECs	Valued Ecosystem Components
WWTF	Wastewater Treatment Facility

1 INTRODUCTION

This Aquatic Effects Monitoring Plan (AEMP) describes how monitoring of the aquatic environment will be undertaken at the Mary River Project. The AEMP was identified as a follow-up monitoring program in Baffinland`s Final Environmental Impact Statement (FEIS; Baffinland, 2012) and is prescribed by Baffinland`s Type A Water Licence No. 2AM-MRY1325 Amendment No. 1. The AEMP is a monitoring program designed to:

- Detect short-term and long-term effects of the Project's activities on the aquatic environment resulting from the Project;
- Evaluate the accuracy of impact predictions;
- Assess the effectiveness of planned mitigation measures; and
- Identify additional mitigation measures to avert or reduce unforeseen environmental effects.

The AEMP focuses on the key potential impacts to freshwater environment valued ecosystems components (VECs), as identified in the FEIS and the Addendum to the FEIS (FEIS Addendum; Baffinland, 2013a) for the Early Revenue Phase (ERP). The freshwater VECs are:

- Water quantity;
- Water and sediment quality; and
- Freshwater biota and fish habitat.

The AEMP has been structured to serve as an overarching 'umbrella' that conceptually provides an opportunity to integrate results of individual but related aquatic monitoring programs. Table 1.1 describes the organization of the AEMP document.

Table 1.1 AEMP Document Organization

Section	Heading	Description
1	Introduction	The scope of the AEMP, the applicable regulatory requirements for an AEMP, and consultation undertaken during its development.
2	Problem Formulation	An overview of key issues and pathways in which the Project may affect freshwater aquatic valued ecosystem components (VECs). Potential issues and concerns are also presented by project component and water management area.
3	AEMP-Related Programs	A brief description of ongoing monitoring programs that are peripheral to but may inform monitoring as part of the AEMP.
4	AEMP Component Studies	A summary of the various long-term and targeted component studies included under the AEMP umbrella, for which detailed study designs are presented in appendices.
5	Assessment Approach and Management Response	A description of the process used to develop benchmarks for comparison for the various AEMP components (i.e., water, sediment, nutrients, and biota) and the common approach to reviewing and assessing monitoring data and implementing action if necessary.
6	Quality Assurance and Quality Control	An overview of the QA/QC measures to be implemented in the collection of samples and the handling of data, for the various aquatic components.
7	Annual Reporting	A description of the content and frequency of reporting under the AEMP.
8	List of Contributors	Key Baffinland staff and consultants involved in the development of the AEMP.

Section	Heading	Description
9	References	Documents referenced in the report

The AEMP targets flows, water and sediment quality, primary productivity (phytoplankton), benthic community structure and fish (specifically Arctic Char) within the streams and lakes potentially affected by project activities. Development of individual monitoring programs/studies under the umbrella AEMP has allowed for the application of a common platform in terms of study design and sampling protocols.

The following are the component studies that comprise the AEMP:

- **Environmental Effects Monitoring (EEM) Program**, as required under the Metal Mining Effluent Regulations (MMER);
- **Core Receiving Environment Monitoring Program (CREMP)**, which includes monitoring of the core mine site area (water, sediment, benthic invertebrates and fish);
- **Lake Sedimentation Monitoring Program**, evaluating baseline and project-influenced lake sedimentation rates;
- **Dustfall Monitoring Program**, evaluating dustfall rates in proximity to the road, port and mine; and
- **Stream Diversion Barrier Study**, an initial study evaluating potential for fish barriers under natural conditions and due to Project-related stream diversions.

The EEM Program is a legal requirement of metal mines such as the Mary River mine. The Draft EEM Cycle One Study Design has been included under the umbrella of the AEMP and follows a separate but related regulatory function. Baffinland proposes to meet the requirements of the MMER on its own, but report the outcome of EEM monitoring as part of the AEMP.

The CREMP forms the backbone of the AEMP. The CREMP is a detailed aquatics monitoring program intended to complement and expand the scope of an EEM Program required under the MMER. The CREMP is intended to monitor the effects of multiple stressors on the aquatic environment, including the discharge of mine effluents and treated sewage effluent as well as ore dust deposition. The CREMP will include the monitoring of water, sediment, phytoplankton, benthic invertebrates and fish in the mine site area streams and lakes.

Specific effects monitoring (or targeted monitoring) is defined as monitoring conducted to address a specific question or potential impact and/or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Study, Dustfall Monitoring Program, and the Stream Diversion Monitoring Study are such studies.

Stand-alone study designs have been prepared. These are briefly described in Section 4 and are included in the appendices of this report. Table 1.2 lists and provides a description of the stand-alone study designs and related technical support documents.

Monitoring prescribed under the related and water licence prescribed Surveillance Network Program (SNP) focuses on detecting short-term project-related effects. The AEMP is designed to detect project-related impacts at greater temporal and spatial scales that are ecologically relevant (i.e., on a basin spatial scale).

The AEMP is a living document that is expected to be updated periodically throughout the life of the mine to account for the close-out of shorter-term monitoring programs, changes in study designs that are driven by the findings of monitoring or changes to the Project, and new information in the field of aquatic effects monitoring including updated toxicological data.

The AEMP components and the relationship of the AEMP to the Water Licence and other aquatic monitoring activities are shown on

Figure 1-1.

Table 1.2 AEMP Component Studies and Technical Support Documents

Appendix	Document Title	Description
Appendix A	Draft EEM Cycle One Study Design	A draft of the initial (cycle one) study design report, which will be formally submitted to Environment Canada 12 months from the initial date when the Mine became subject to the Metal Mining Effluent Regulations (MMER)
Appendix B	Water and Sediment Quality Review and CREMP Study Design	Presents the water and sediment quality CREMP including a review of the water and sediment quality baseline
Appendix C	Development of Water and Interim Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project	A technical document describing the development of the current water quality benchmarks and interim sediment quality benchmarks for the CREMP in 2014.
Appendix D	Development of the Final Area-Specific Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project	A technical document describing the development of the current sediment quality benchmarks established for the CREMP in 2015.
Appendix E	Core Receiving Environment Monitoring Program: Freshwater Biota	Presents the freshwater biota CREMP including a review of the freshwater biota baseline
Appendix F	2014 Reference Lake Evaluation	Presents work completed on the candidate CREMP reference lakes up to and including the 2014 field program.
Appendix G	Lake Sedimentation Monitoring Program	A targeted study on baseline and project-influenced lake sedimentation rates.
Appendix H	Dustfall Monitoring Program	The dustfall monitoring program contained in the Terrestrial Environment Management and Monitoring Plan (TEMMP; Baffinland, 2014)
Appendix I	Initial Stream Diversion Barrier Study	A targeted study on monitoring the effects of Project-related Stream Diversion

In 2015, Minnow Environmental Inc. (Minnow) was contracted to assist Baffinland in completing the field work and reporting requirements of several of the AEMP component studies, including the CREMP. After completing the CREMP in 2015, Minnow proposed several modifications to the CREMP to provide greater efficiencies to the program and improve the program's ability to achieve its objectives (i.e. to evaluate short and long term effects of the Project on aquatic ecosystems). Minnow's recommendations proposed modifications to the CREMP water quality, sediment quality and benthic community monitoring programs in study lakes and streams as well as modifications to the fish population monitoring program in study lakes. This document has been revised to reflect all of the recommendations proposed by Minnow in 2016.

1.1 WATER LICENCE REQUIREMENTS

The Nunavut Water Board (NWB) issued Type A Water Licence No: 2AM-MRY1325 to Baffinland on June 10, 2013. The licence is valid for 12 years, expiring on June 10, 2025.

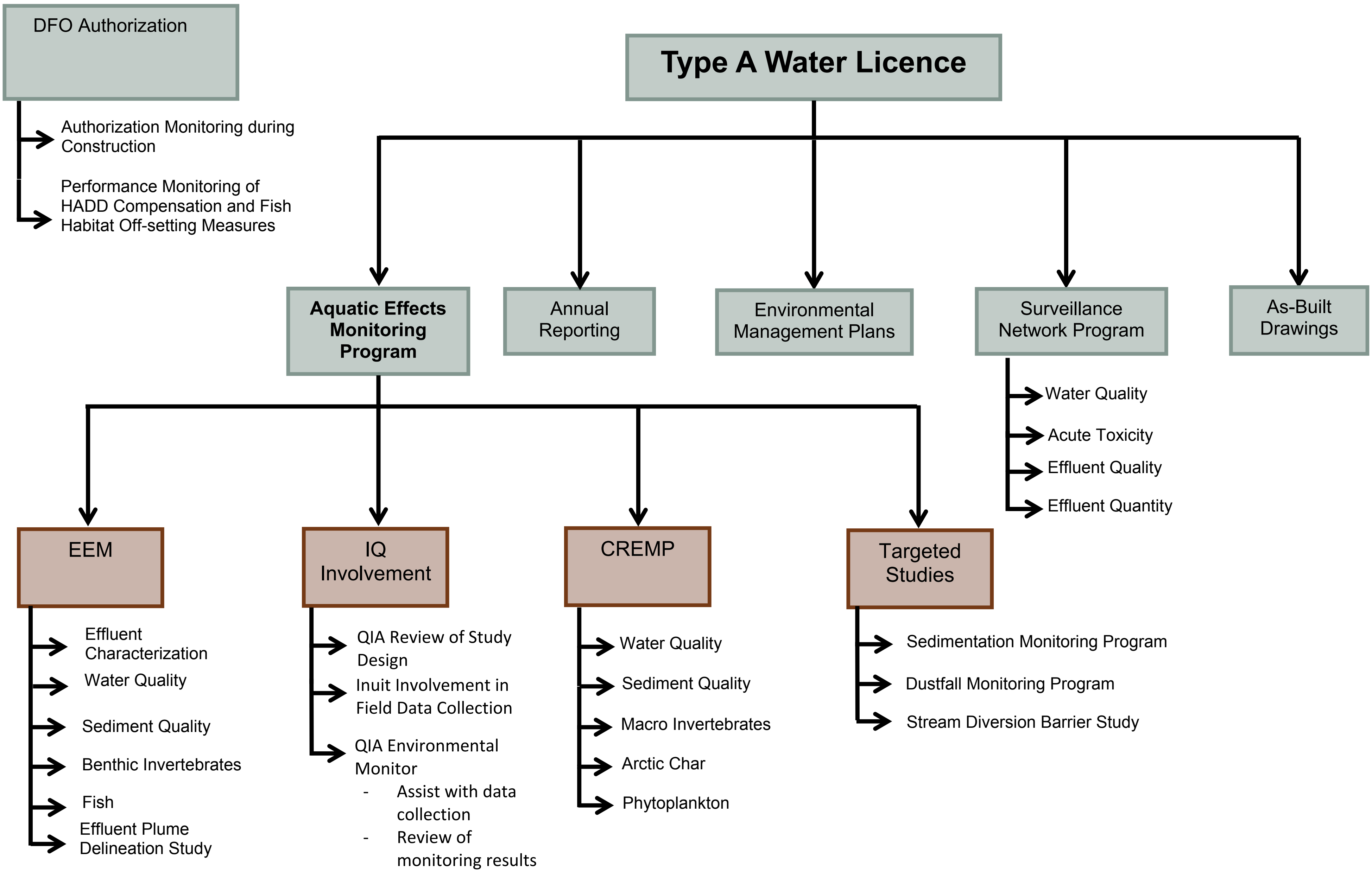
Part I of the licence outlines conditions related to general and aquatic effects monitoring. Part I (1) approved with the issuance of the water licence for the construction phase of the Project an AEMP Framework prepared in February 2013 (Baffinland, 2013b). Part I (1) also required Baffinland, upon further consultation, submit a revised AEMP Framework that considered recommendations received during the final technical review and public hearing during the water licensing process. An Updated AEMP Framework was submitted to the Nunavut Water Board on November 29, 2013 (Baffinland, 2013c).

Part I (2) of the licence requires Baffinland to submit to the board for approval in writing an Aquatic Effects Management Plan (AEMP) at least 60 days prior to commencing the operating phase of the project. This document will be submitted to the NWB in fulfillment of this requirement.

On September 2, 2015 The Nunavut Water Board (NWB) issued the Type A Water Licence No: 2AM-MRY1325 Amendment No.1 to Baffinland. The Amended Licence incorporates the entire scope of the Type “B” Water Licences Nos. 8BC-MRY1314 and 8BC-MRY1416, issued to the Mary River Project for construction and site preparation work; specific elements on the scope of Type “B” Licence No 2BE-MRY1421, issued to the project for Exploration and Bulk Sample Programs; most of the scope of the Amendment No.1 Application, which includes the Early Revenue Phase (ERP) activities and facilities.

On October 30, 2015, a revised version of the AEMP (Rev. 1) was submitted to the NWB for approval. The purpose of this submission was satisfy the condition stated in Part I, Item 2 of the Amended Type A Water Licence requiring Baffinland to submit to the board for approval in writing a revised version of the AEMP 60 days following the issuance of the Amended Licence.

Figure 1.1 AEMP Components and Relationship to Other Monitoring Programs



1.2 RELEVANT PROJECT CERTIFICATE CONDITIONS

NIRB issued Project Certificate No. 005 to Baffinland on December 28, 2012. On May 28, 2014, NIRB issued an amendment to Baffinland's Project Certificate No. 005 (Amendment No. 1) to allow for the Early Revenue Phase (ERP) of the Project. A number of Project Certificate terms and conditions (PC Conditions) relate to the protection of the aquatic environment, namely #16 through 19 (hydrology and hydrogeology); #20 through 24 (ground and surface waters); and #41 through 48 (freshwater aquatic environment including biota and habitat). PC Conditions not captured directly by permits, licences, authorizations and approvals (including the Type A Water Licence Amendment No. 1) have been incorporated into the various management plans required by the Type A Water Licence Amendment No. 1 and/or the PC No.005.

PC Condition #21 relates specifically to the AEMP, and states the following (from NIRB, 2014):

The Proponent shall ensure that the scope of the Aquatic Effects Monitoring Plan (AEMP) includes, at a minimum:

a. monitoring of non-point sources of discharge, selection of appropriate reference sites, measures to ensure the collection of adequate baseline data and the mechanisms proposed to monitor and treat runoff, and sample sediments; and

b. measures for dustfall monitoring designed as follows:

i. To establish a pre-trucking baseline and collect data during Project operation for comparison;

ii. To facilitate comparison with existing guidelines and potentially with thresholds to be established using studies of Arctic char egg survival and/or other studies recommended by the Terrestrial Environment Working Group (TEWG); and,

iii. To assess the seasonal deposition (rates, quantities) and chemical composition of dust entering aquatic systems along representative distance transects at right angles to the Tote Road and radiating outward from Milne Port and the Mine Site.

The AEMP addresses Part (a) of PC Condition #21. Part (b) overlaps with the current dustfall monitoring program described in the TEMMP (Baffinland, 2014). The existing dustfall monitoring program from the TEMMP is included in Appendix G. Interpretation of the dustfall monitoring data in relation to the aquatic environment forms part of the lake sedimentation targeted study described in Section 4.3.1 and Appendix F.

1.3 CONSULTATION DURING DEVELOPMENT OF THE AEMP

Baffinland would like to acknowledge the participation and contributions of a number of stakeholder agencies in the development of this AEMP:

- Aboriginal Affairs and Northern Development Canada (AANDC);
- Canadian Northern Economic Development Agency (CanNor);
- Department of Fisheries and Oceans Canada (DFO);
- Environment Canada (EC);
- Nunavut Water Board (NWB); and
- Qikiqtani Inuit Association (QIA).

The above organizations were invited and participated in workshops and on-line presentations, and reviewed various iterations of an AEMP Framework document that was circulated. Key consultation activities in the development of this AEMP are listed in Table 1.3.

Table 1.3 Consultation during AEMP Development

Date	Activity
July 6, 2012	Initial AEMP Consultation Meeting by WebEx
November 13, 2012	Conceptual Framework Development Workshop, 1-day workshop held in-person and by WebEx at Hatch Associated Ltd. Offices in Mississauga
December 12, 2012	Draft AEMP Framework filed with NWB and circulated to interested parties
January 14-18, 2013	Technical Meetings on the Type A Water Licence Application, held in Pond Inlet
February 12, 2013	Second AEMP Framework Development Workshop, 1-day workshop held in-person and by WebEx at Hatch Associated Ltd. Offices in Mississauga
February 26, 2013	AEMP Framework filed with NWB and circulated to interested parties
April 23-25, 2013	Final Hearings for the Type A Water Licence Application, held in Pond Inlet
November 15, 2013	Draft Updated AEMP Framework circulated to interested parties
November 21, 2013	WebEx Presentation on Draft Updated AEMP Framework with interested parties
November 29, 2013	Updated AEMP Framework filed with NWB and circulated to interested parties in accordance with Part I, Section 1 of the Type A Water Licence
April 3, 2014	WebEx meeting presenting refined AEMP component study plans to appear in this AEMP document

As mentioned above, Baffinland is grateful for the participation and contributions of the interested parties listed above.

2 PROBLEM FORMULATION

2.1 PROJECT DESCRIPTION

The Project is an iron ore mine with a production rate of 21.5 Mt/a, consisting of the following major components (Figure 2.1):

- Milne Port;
- Mine Site;
- Railway; and
- Steensby Port.

Each development site (excluding the railway) will have all the facilities it needs to operate effectively including maintenance and administrative buildings, warehouses and laydown areas, ore stockpiles and associated runoff management facilities, camps, water supply, wastewater treatment plants, waste management facilities including landfills, power generation, fuel depots, telecommunication facilities, and airstrips.

Baffinland is approved to mine Deposit No. 1 at the Mine Site by open pit mining methods. Since the Mary River iron ore is of a very high-grade, there is no need to have a process plant (or mill) on site, resulting in no tailings being generated. As such, no tailings pond will be required. This is accomplished by crushing and screening of the ore to produce two iron ore products:

- Lump ore – sized between 6.3 mm and 31.5 mm (about golf ball size); and
- Fine ore - sized less than 6.3 mm (about pea size).

Ore will be stockpiled at the Mine Site and transported either by truck to Milne Port or by railway to Steensby Port. Ore handling facilities at the Mine Site will consist of the open pit, separate ore stockpiles for the trucking and railway operations, and water management facilities to collect runoff from ore stockpiles. Waste rock will be stockpiled in a single stockpile next to the open pit, and up to two ponds will collect runoff from the stockpile. The trucking and railway operations will have separate ore stockpiles and runoff collection ponds but will otherwise share common water management facilities and final discharge points (Figure 2.2).

Mining began in September 2014 with a low-capital trucking operation involving the mining of 3.5 million tonnes per annum (Mt/a) of iron ore being transported year-round by truck to Milne Port, with marine shipping to market during the open water season. Ore handling facilities at Milne Port consist of truck unloading facilities, ore stockpiles and ship-loading facilities at an ore dock. Runoff from the stockpile area at Milne Port will be collected in ponds that will discharge to the marine waters of Milne Inlet. Environment Canada has advised Baffinland that the mine effluent discharge to Milne Inlet will not be subject to the MMER, though the *Fisheries Act* still applies, including Section 36(3) regarding the prohibition of discharges of a deleterious substance in waters frequented by fish (Anne Wilson, pers.comm.) Monitoring of effects to the marine environment is beyond the scope of this AEMP.

Figure 2-1 Project Sites and Location Map

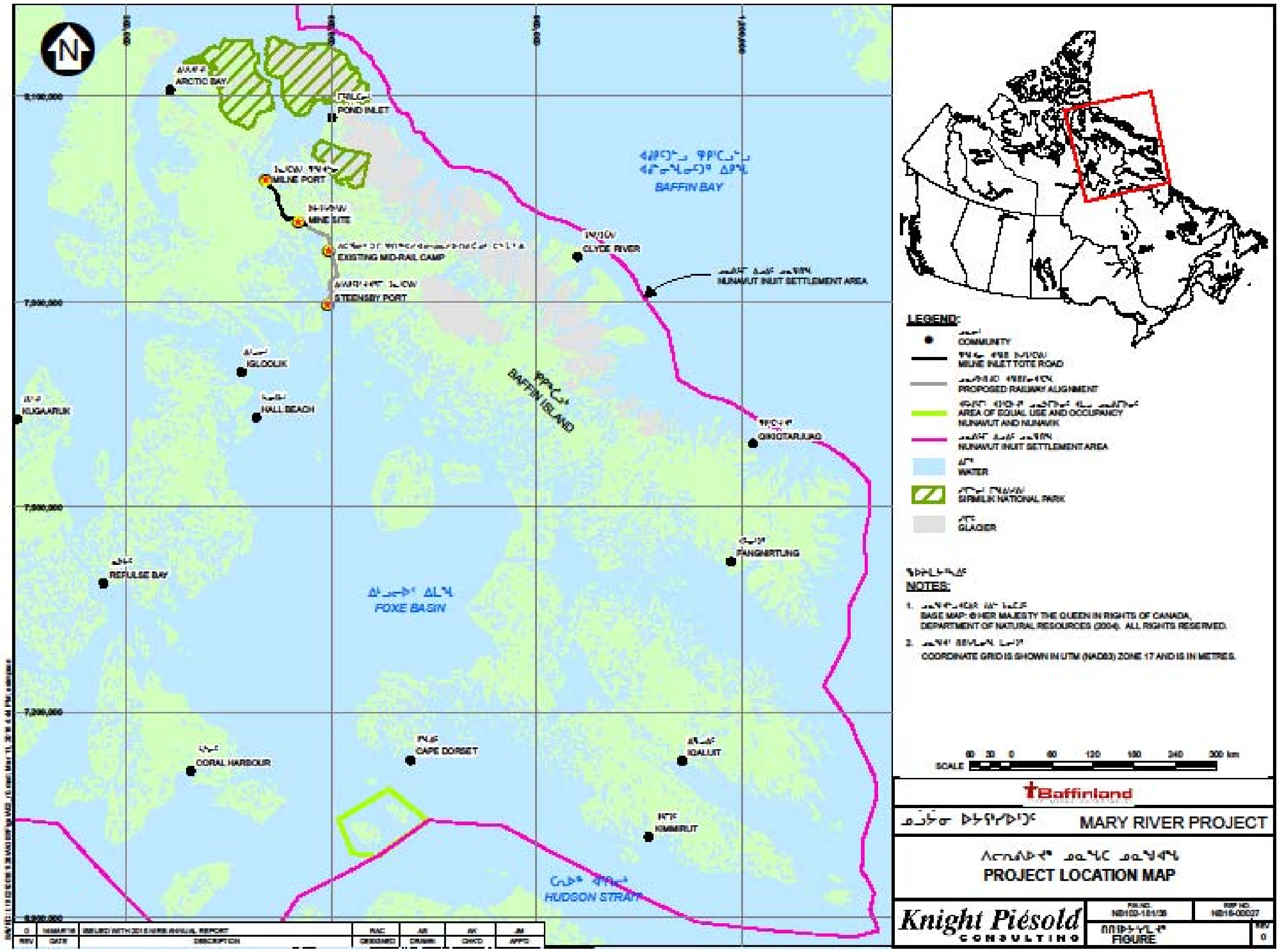
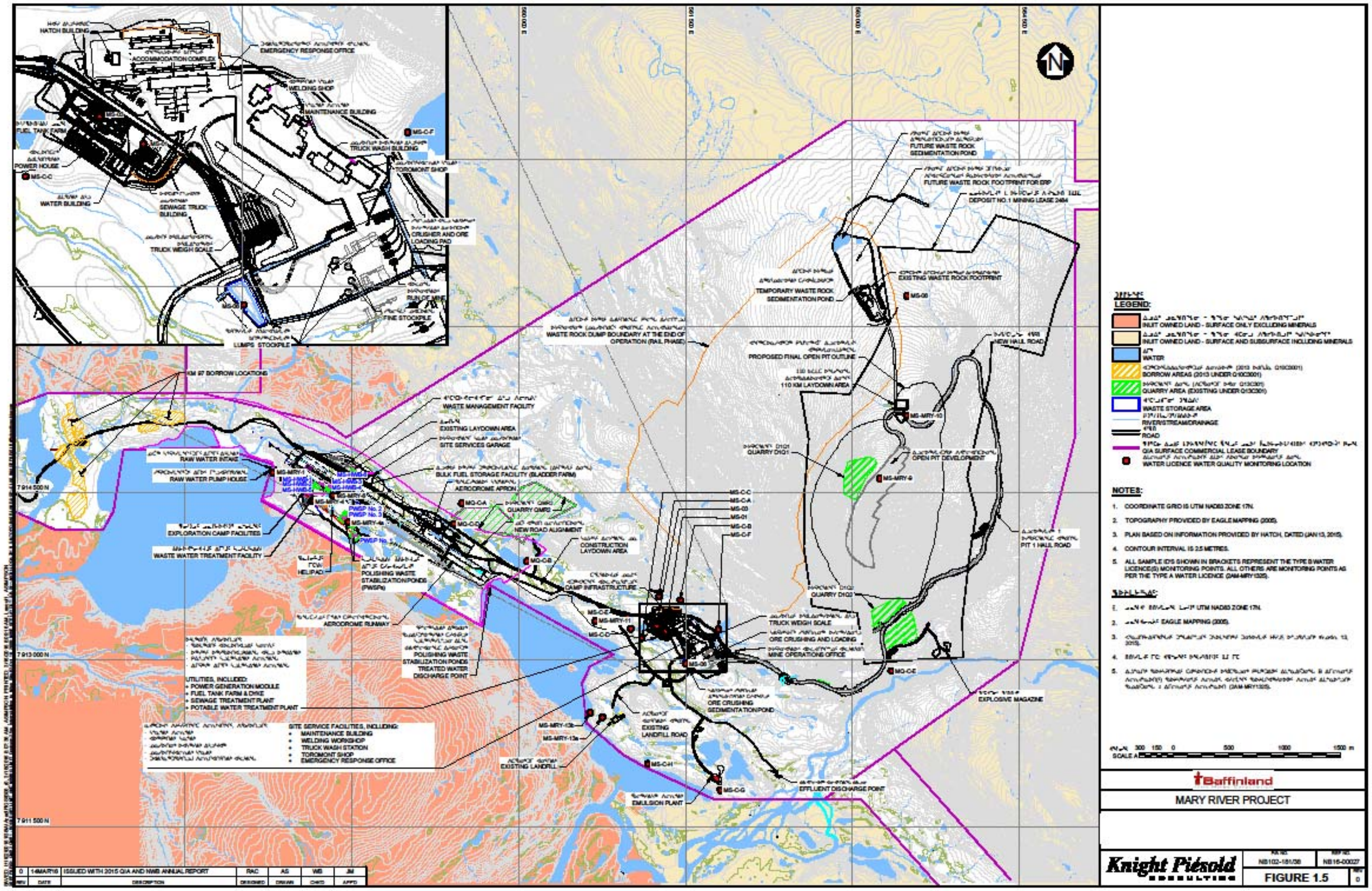


Figure 2-2 Mine Site Layout



At some point in the future when the iron ore market and economic conditions for financing capital-intensive projects improves, an 18 Mt/a railway operation will be constructed. This will involve the construction and operation of a 149-km railway to Steensby Port. Steensby Port, once constructed, will be equipped with a railway car dumper and associated conveying equipment, an ore stockpile, and ship-loading facilities to load ore onto ice-breaking ore carriers.

Shipping of ore from Steensby Port will take place year-round. Runoff from the ore stockpile at Steensby Port will be collected and discharged to the marine waters in Steensby Inlet. Environment Canada similarly advised that the mine effluent discharge to marine waters from the ore stockpile at Steensby Port would not be subject to the MMER but would otherwise be subject to the *Fisheries Act*.

For the 18 Mt/a operation, a number of proven mitigation measures have been proposed to reduce potential effects on water quality, freshwater fish, fish habitat, and other aquatic organisms. At each of the ore handling locations, crushers and screens will be installed inside buildings, and conveyors will be covered and equipped with wind ventilation hoods to reduce wind exposure and the potential for dust generation. Where practicable, ventilation ducts will be routed to dust collectors which will limit dust emissions. For the 3.5 Mt/a ERP operation, crushers and conveyors will not be fully enclosed. Specific management plans detail the many ways that water will be protected (Baffinland, 2012).

The operational life of the Project, based on current ore reserves and a production rate of 21.5 Mt/a, is 21 years. The Closure of the facilities is expected to be carried out over a three to five year period and post-closure monitoring will follow for an additional five years. If closure objectives are not met, post closure would extend beyond five years.

2.1.1 Water Management Facilities and Final Discharge Points

A total of four ponds will collect runoff from stockpiles and the open pit at the mine site:

- West Pond – will collect runoff from the west side of the waste rock stockpile;
- East Pond – will collect runoff from the east side of the waste rock stockpile;
- ROM Pond – will collect runoff from the ROM stockpile; and
- Ore Stockpile Pond – will collect runoff from the ore stockpiles. Initially this will be one smaller pond for the ERP, and eventually a second pond will be constructed to support the rail phase.

Monitoring of the waste rock stockpile (MS-08) runoff in an interim settling pond commenced during the summer of 2015 and coincided with the early development of the waste rock stockpile. A construction of a permanent settling/sedimentation pond commenced during 2015. It was designed for collecting runoff from the waste rock stockpile and will be completed during 2016. Currently, the pit has not developed sufficiently to the point that there is a sump with active discharge. A suitable monitoring location and analytical schedule will be established once this has occurred.

Mine effluent will be discharged to two watercourses (Figure 2.2):

- Mary River (early in the Mine life); and
- Camp Lake Tributary 1 (later in the Mine life).

There will be three final discharge points that will discharge mine effluent to the Mary River as follows:

- East Pond discharge collecting stormwater from the east side of the waste rock stockpile;
- Run-of-mine (ROM) stockpile discharge; and

- Ore stockpile discharges (trucking and rail phases) at the rail load-out area

There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

2.1.2 Stream Diversions

The development of the open pit, a waste rock stockpile, and associated water management facilities (ditches, berms and settling ponds) will divert and redirect runoff away from certain watercourses during the operational phase of the Mary River Project (Baffinland, 2012). Five tributary streams are anticipated to be affected by diversions in the Mine Area (Figure 2.3).

The reduced production rate associated with the ERP will result in a considerably smaller mining footprint (open pit and waste rock stockpile) than associated with the future rail phase. As such, Project-related stream diversions will be negligible during the ERP.

A discussion of the Project's effects on the freshwater VECs follows.

2.2 WATER QUANTITY

Article 20 Inuit Water Rights of the Nunavut Land Claims Agreement (NLCA) formally recognizes the importance of water quantity and flow to the Inuit. Under the NLCA, Inuit require compensation if a project or activity will substantially affect the quantity of water flowing through Inuit-Owned Lands. Therefore, water quantity has been identified as a VEC. The water quantity VEC can be defined as the spatial and temporal variability of the volume of water within the RSA that may be subject to alteration by Project activities.

Conditions applying to water use and management have been outlined in Part E of the Water Licence (NWB, 2013). These conditions will be adhered to throughout applicable timeframe of this licence. The current limits on water use in the Type A Water Licence Amendment No.1 are 1,888 m^3/day and 689,000 m^3/year total water use from all sources during the construction phase, and 967 m^3/day or 353,000 m^3/year during the operation phase, for total domestic camp and industrial water use from all sources.

<u>Key Issues and Pathways for Water Quantities</u>

Key issues identified for freshwater quantity are listed below:

- Water Withdrawal;
- Water Diversion (stream diversion or changes to flow patterns in a specific watershed); and
- Runoff or effluent discharge.

<u>Key Indicators and Benchmarks</u>

The key indicators for water quantity are listed below:

- Water withdrawn for consumption (measured in cubic metres – m^3); and
- Streamflow increase or decrease (measured as a percent change of mean).

The benchmarks are the water quantities authorized under the Type A Water Licence Amendment No.1.

<u>Diversions, Drainage Flows (Runoff) and Effluent Discharges</u>

Diversions, drainage flows and effluent discharges are mainly impacted at the Mine Site and have potential effects on fish habitat due to reduction or increase in flows that result from the site development. This is discussed in Section 4.3.3.

2.3 WATER AND SEDIMENT QUALITY VEC

Key Issues and Pathways

Key issues considered for the surface water and sediment quality VEC are summarized in Table 2.1.

Figure 2-3 Mine Site Tributaries and Effluent Discharge Locations

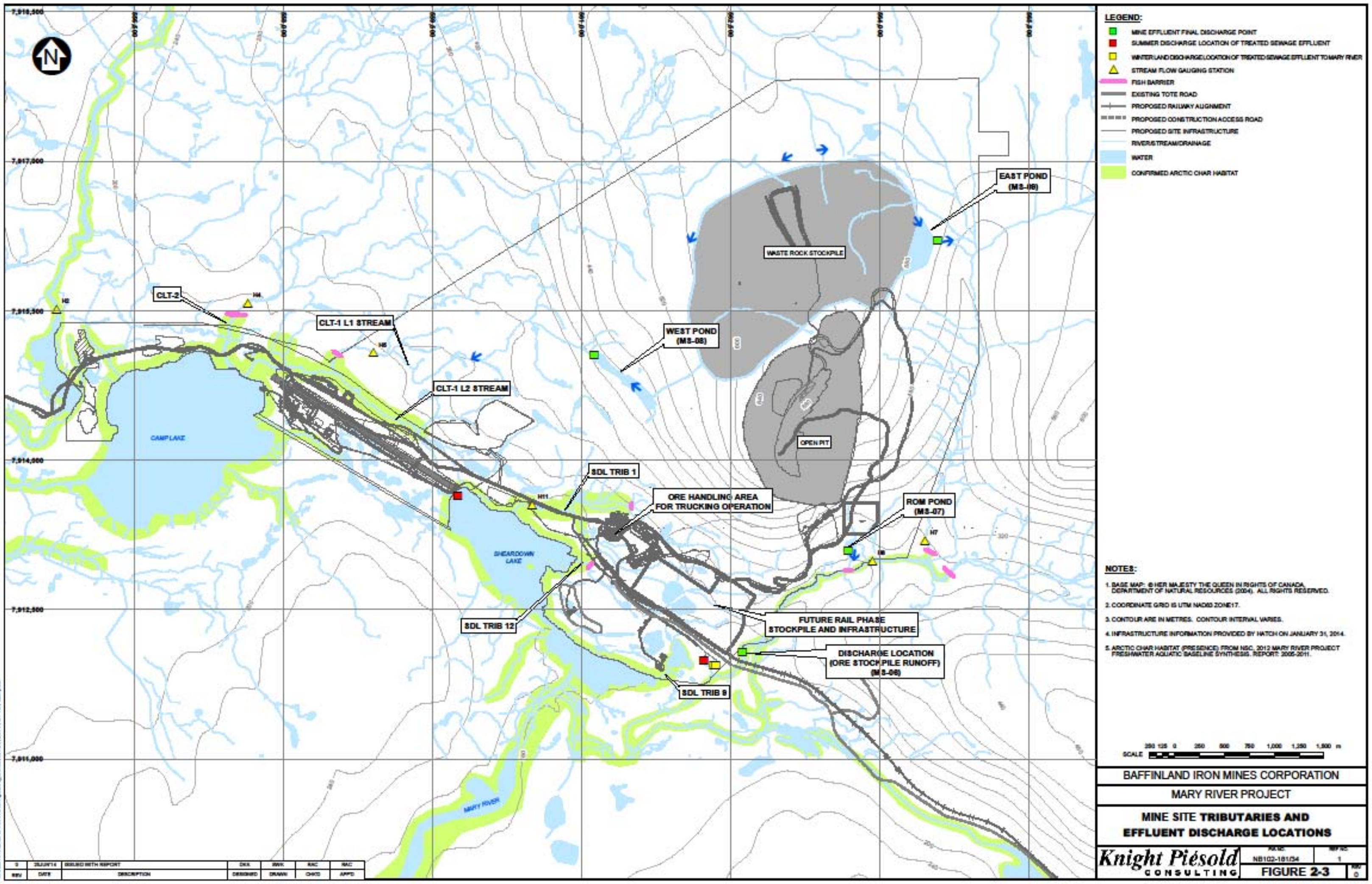


Table 2.1 Key Issues for Water and Sediment Quality at the Mine Site

PATHWAY	KEY ISSUES	LOCATION	PROJECT PHASES
Surface runoff	Uncontrolled runoff at construction site Erosion and sediment entrainment Site drainage control Spills and contamination Drainage from quarry sites	All	Construction Operation Closure
Discharges from secondary containment	Fuel depots/storage - contact water may be contaminated with hydrocarbon/petroleum products	Milne Port, Mine Site, Railway construction, Steensby Port, Quarry sites	Construction Operation Closure
Discharge of brine used for drilling in permafrost	Salinity of the discharge	Railway tunnels	Construction
Pooling water in landfarm	Pooling water maybe contaminated with hydrocarbon/petroleum product and may require treatment prior to discharge	Milne Port Mine Site Steensby Port	Construction Operation Closure
Pooling water in landfill	Pooling water maybe contaminated with metals, hydrocarbon/petroleum product and may require treatment prior to discharge	Mine Site Steensby Port	Construction Operation Closure
Treated sewage effluent discharges	Effectiveness of treatment - pH, flows, Biological oxygen demand (BOD), Faecal Coliform (FC), TSS, nutrient, metals, oil and grease	Sheardown Lake Mary River outfall	Construction Operation Closure
Treated oily water treatment plant discharge	Effectiveness of treatment - pH, flows, TSS, metals, oil and grease	Mary River outfall	Construction Operation Closure
Dustfall	TSS in runoff, sediment deposition on stream and lake bottoms	Mine Site	Construction Operation Closure
Run of mine ore stockpile contact water	Metals, TSS, blasting residue (ammonia, nitrate)	Mary River	Operation
Ore stockpile contact water	Metals, TSS, blasting residue (ammonia, nitrate)	Mary River	Operation
Mine pit dewatering	Metals, TSS, blasting residue (ammonia)	Camp Lake Tributary	Operation
Waste rock stockpile runoff – west pond	ARD, metals, TSS, blasting residue (ammonia)	Camp Lake Tributary	Operation Closure Post-closure
Waste rock stockpile runoff – east pond	ARD, metals, TSS, blasting residue (ammonia)	Mary River	Operation Closure Post-closure
Mine pit water	ARD, metals	Open pit	Post-closure

2.4 FRESHWATER AQUATIC BIOTA AND HABITAT

Key Issues and Pathways

Arctic Char (*Salvelinus alpinus*) are the primary freshwater biota of interest regarding potential effects of the Project on the aquatic environment. Potential linkages between the Project components/activities and Arctic Char are presented on Figure 2-4. These linkage pathways can be categorised into three key issues as follows:

- Key Issue #1: Potential effects on the health and condition of Arctic Char;
- Key Issue #2: Potential effects on Arctic Char habitat; and
- Key Issue #3: Potential effects on direct mortality of Arctic Char.

2.4.1 Potential Effects on the Health and Condition of Arctic Char

Project-related changes in water and/or sediment quality have the potential to affect the health and condition of Arctic Char. The major pathways of effects are based on the residual effects identified in the water and sediment quality assessment. Linkages considered for potential effects include three general categories:

- Point source discharges (treated sewage effluent, waste rock stockpile runoff, ore stockpile runoff, mine pit water, run of mine stockpile runoff, and exploration drilling runoff);
- Aqueous non-point sources (NPS; including effects related to sediment and erosion, release of blasting residues, general site runoff, development of quarries and borrow pits); and
- Dust emissions and introduction to surface waters.

Effects considered under this key issue relate to sub-lethal effects of Project-related changes in water and/or sediment quality on fish health and condition.

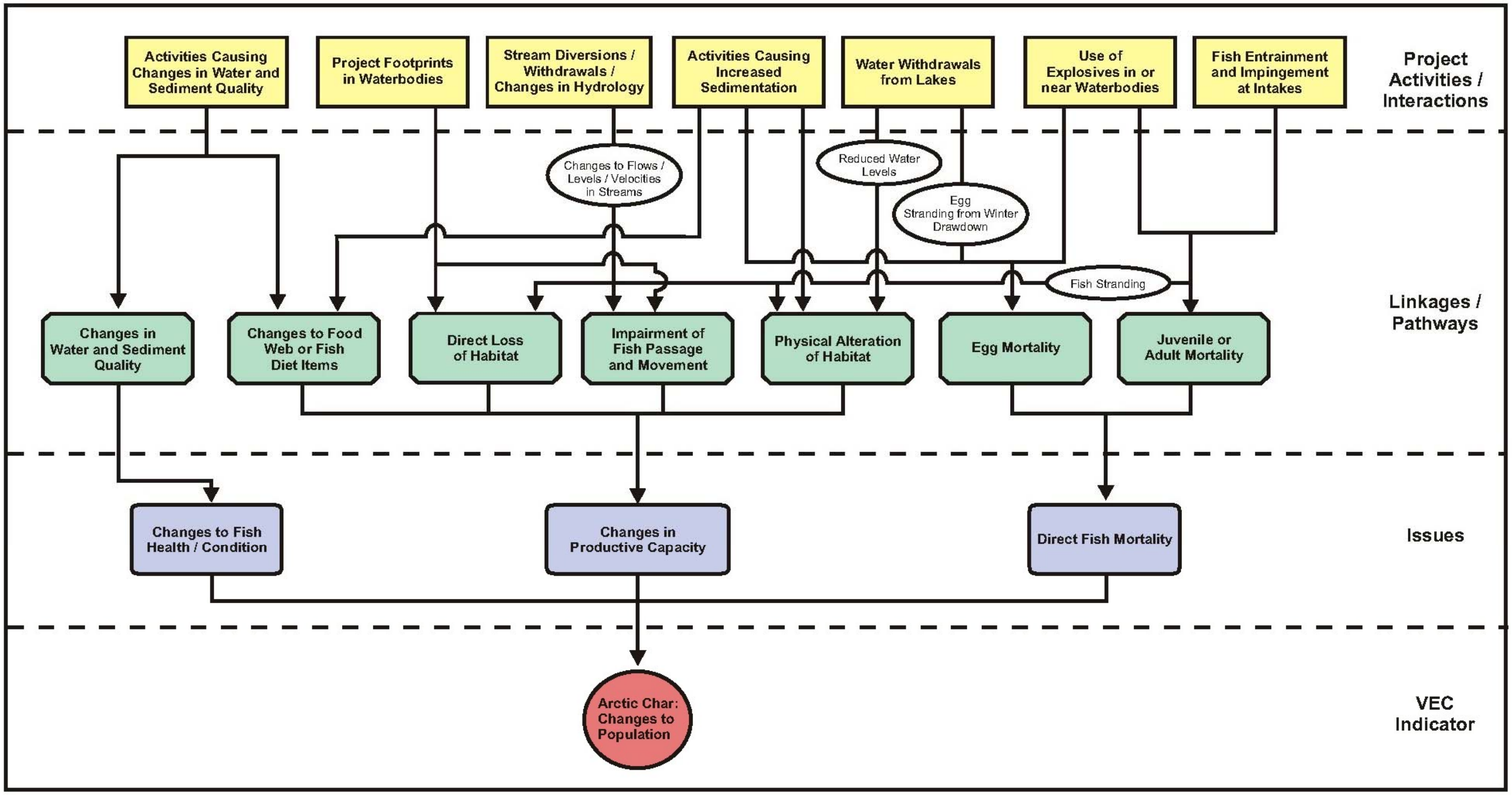
2.4.2 Potential Effects on Fish Habitat

Project activities with the potential to affect Arctic Char habitat include the following:

- Placement of Project infrastructure in water bodies (e.g., water intakes, sewage outfalls, stream crossings, lake encroachments, laydown areas);
- Various Project-related effects pathways that may alter other aquatic biota that are food sources for Arctic Char or form a component of the food web and thus may affect the productive capacity of their habitat (i.e., lower trophic level biota);
- Project-related effects on sedimentation rates that may result in alteration of habitat quality (e.g., due to dust deposition);
- Project-related changes to hydrology and subsequent effects on aquatic habitat (e.g., water withdrawal, stream diversion);
- Project-related effects on fish passage, with subsequent effects on the availability of habitat, including:
    - Stream crossing construction and operation; and
    - Changes in hydrology that may alter hydraulic conditions necessary for fish passage (e.g., stream velocities, water depth).

Most of these key issues relate to construction activities in or near water bodies.

Figure 2-4 Project Activities/Pathways of Potential Effects to Arctic Char



The following changes are associated with mine site development and also have the potential to affect fish and fish habitat:

- Water withdrawn from Camp Lake for domestic and industrial consumption will be discharged (after treatment) to the Mary River;
- Water withdrawal from Camp Lake will affect lake water levels and outflow discharge;
- Drainage patterns where the Mine site infrastructures/facilities are located will be altered. Most site runoff will be redirected to Mary River. As a result, less runoff will discharge to Sheardown Lake and Camp Lake. Tributaries of Sheardown Lake will be impacted. Lower flows may create barriers to fish passage; and
- Mine pit dewatering, when it eventually occurs, will be directed to the waste rock sedimentation pond or to other permitted containment structures as required.

2.4.3 Potential Effects on Direct Fish Mortality

Project-related activities with the potential to cause direct mortality of Arctic char that are considered include the following:

- Effects of sedimentation on mortality of eggs;
- Potential egg stranding related to winter drawdown at water source lakes;
- Blasting in or near Arctic Char habitat;
- Placement of Project infrastructure in Arctic Char habitat (i.e., potential spawning areas);
- Potential for entrainment and/or impingement of Arctic Char eggs and juveniles at water intakes; and
- Potential fish stranding related to water diversions and/or alterations in discharge or water levels.

Potential effects of sedimentation on survival (hatching success) of Arctic Char eggs will be addressed through monitoring sediment deposition rates in Sheardown Lake as a target study (see Section 8). Potential for winter drawdown to cause egg stranding will be addressed through monitoring of water levels as the primary indicator, supported by information on Arctic char population monitoring (e.g., year class strengths, recruitment). Potential effects of blasting in or near Arctic Char habitat is addressed through the blasting management and monitoring program (see Section 4.11). The potential for placement of Project infrastructure to cause direct mortality of Arctic Char (i.e., placement of infrastructure on fish eggs) is addressed through mitigation and management, specifically through avoidance of potential spawning areas and/or by adherence to timing windows to avoid the egg incubation period. Potential for entrainment and impingement of fish at water intakes will be mitigated through adherence to DFO`s Freshwater intake end-of-pipe fish screen guideline (DFO, 1995). The last potential pathway of effect will be addressed through a follow-up target study to confirm fish passage at Mine area streams affected by water diversions (see Section 8.1.2).

2.4.4 Potential Effects of Blasting on Fish

Blasting will be conducted to support the construction and operation phases of the Project. The concern for potential effects on fish due to blasting overpressure mainly arises for the railway construction along Cockburn Lake where significant blasting is required for the following project components:

- The railway embankment on the east flank of Cockburn Lake; and
- The tunnel construction.

Effects of blasting on free-swimming Arctic Char and their eggs will be mitigated through the implementation of a detailed blasting management plan developed in accordance with DFO's blasting guidelines (Wright and Hopky, 1998).

2.4.5 Stream and River Crossing Construction and Lake Encroachments

Construction activities at watercourse crossings along the railway, railway access road, and Milne Inlet Tote Road have the potential to cause the following effects:

- Stranding of Arctic Char due to the need for isolation of the watercourses. This effect will be mitigated through the use of appropriate timing windows for construction when possible and through fish salvage operations when required.
- Potential impediments to fish passage at stream crossings due to changes in water levels, flows and/or velocities. This potential pathway of effect would be addressed through follow-up monitoring at selected stream crossings (i.e., a subset) to evaluate fish passage. This monitoring is described in detail in Appendix I.

2.5 POTENTIAL ISSUES AND CONCERNS BY PROJECT COMPONENT

Potential effects on aquatic ecosystems are presented below for each of the Project components within the two geographical areas for the construction and operation phases of the Project. Since abandonment and reclamation activities are similar in nature to construction activities, the concerns identified for the construction phase are also relevant for the closure phase.

2.5.1 Mine Site (Water Management Area 48)

The Mine Site includes the infrastructure required to support mining activities (camp, maintenance shops, fuel depots, wastewater treatment facility (WWTF), laydown areas, waste handling and storage facilities, landfill site and landfarm, explosives storage, manufacture and use). The freshwater supply for the Mine Site will be drawn from Camp Lake. Several quarries and borrows will be developed within the Mine Site area to provide aggregate material for the site development and ongoing operations and maintenance.

Potential aquatic effects at the Mine Site are listed in Table 2.2. The locations of all controlled discharges from the Mine Site are presented in Section 3.4.

2.5.2 Milne Port (Water Management Area 48)

The construction period at Milne Port began in the summer of 2013 following issuance of the Type A Water Licence (NWB, 2013). For the longer term mining project Milne Port will serve both as the main staging areas for material and equipment required for the construction activities at the Mine Site, as well as for the sole shipping point during the ERP phase of the mine. The site includes the fuel depots, camp and WWTF, laydown areas, maintenance facilities, and, temporary waste transit areas. Two sites have been identified for the fresh water supply for this facility (Phillip's Creek in summer; Km32 Lake in winter). A number of quarries will be developed near Milne Port to provide aggregate for the site development and ongoing operations and maintenance.

Table 2.2 Potential Residual Effects to the Mine Site Aquatic Environment

VEC	CONCERN	PATHWAY	INDICATOR
Water Quantity	Withdrawal of water from Camp Lake		Volume withdrawn
	Flow diversion from Sheardown Lake		Visual – water level
Water and Sediment Quality	Earthworks	Surface runoff discharging to Camp Lake, Sheardown Lake, lake tributaries and Mary River	TSS, dust, spills
	Construction activities		TSS, dust, spills
	Site drainage		TSS, dust, spills
	Quarry site drainage		TSS, dust, spills, residual ammonia
	Fuel tank farms	Discharges from secondary containment areas to receiving environment – surface drainage	Hydrocarbons
	Waste storage area		Metals
	Bermed storage area		Metals, hydrocarbon
	Landfarm		Metals, hydrocarbon
	Landfill		Metals, hydrocarbon
	Treated Sewage Effluent (exploration camp)	Outfall to Sheardown Lake	BOD, TSS, nutrient
	Treated Sewage Effluent (main camp)	Outfall to Mary River	BOD, TSS, nutrient
	Treated Effluent from Oily Water Treatment Plant	Outfall to Mary River	TSS, hydrocarbon
	Waste rock stockpile drainage	Discharge to Camp Lake tributary	TSS, metals, nutrients
	Waste rock stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	ROM stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	Ore stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	Mine pit dewatering	Discharge to Camp Lake tributary	TSS, metals, nutrients/blasting residues
	Mine pit water post closure	End of life mine life pit water quality	Metals
	Dust	TSS in runoff	TSS
Freshwater Biota and Fish Habitat	Footprint of facilities in water bodies – water crossings	Loss of habitat – crossing of Mary River , Camp Lake tributaries	Habitat compensation
	Integrity of water crossing	Alteration of habitat	Erosion, blockage
	Fish passage	Alteration of habitat	Blockage, barrier
	Water diversions – changes in streams	Alteration or loss of habitat	Low flow and barrier to fish passage
	Changes in water and sediment quality (point and non-point sources)	Effects on Arctic Char health and condition; effects on lower trophic level biota (Arctic Char habitat)	Arctic char health and condition; population metrics; benthic invertebrate community metrics
	Dust Deposition	Alteration of habitat	Increased sediment deposition in streams and lakes Benthic invertebrate community metrics
		Deposition on Arctic Char eggs – reduced egg survival	Sedimentation rates in Arctic Char spawning habitat
Groundwater quality	Landfill	seepage in groundwater	Metals

At Milne Port, runoff from the ore stockpiles is channeled to two sedimentation ponds on the North end of the Ore Stockpile Pad. Site drainage from the Camp Pad is channeled to a series of natural swales located along the shoreline of Milne Inlet (ocean). Treated sewage and oily water effluent are discharged to a natural swale located North of the Bulk Fuel Tank Farm (refer to Figure 3.3). Both sedimentation ponds and swales along the Milne Inlet shoreline drain directly into the ocean without coming in contact with any freshwater body. As a result, site drainage and effluent discharge at Milne Port have no effects on the freshwater receiving environment.

The concerns for potential freshwater aquatic effects during the construction, operation and closure of the Milne Port site are listed below:

Water Quantity

- Withdrawal of water from Philips Creek (summer) and KM 32 Lake (winter)

Water and Sediment Quality

- Quarry management (runoff quality, ARD potential, residual ammonia from blasting activities)
- Construction of water intakes - TSS/turbidity
- Spills caused by accidents and malfunctions

Freshwater Biota and Fish Habitat

- Low magnitude effects to fish and fish habitat related to water quality changes

The discharge criteria for the effluent and runoff water quality are presented in the Type A Water Licence Amendment No.1. The locations of all controlled discharges from the Milne Port site are presented in Section 3.4.

2.5.3 Tote Road (Water Management Area 48)

The Milne Inlet Tote Road connects Milne Port to the Mine Site. All material received at Milne Port will be transported by truck on the Tote Road. Realignment and re-grading of some road sections will be required to support the ore transport required for the ERP phase of the Project.. Select water crossings may be rebuilt as part of the ongoing maintenance of the road and upgrades to support the ERP. A number of borrow pits have been identified along the Tote Road that will provide the necessary aggregate and material for ongoing road maintenance and road improvement.

The concerns for potential aquatic effects during construction, operation and closure of the Tote Road are related to:

Water and Sediment Quality

- Dustfall from road traffic and related effects on water quality
- Drainage management from borrow pits

Freshwater Biota and Fish Habitat

- Construction and ongoing maintenance of stream crossing
- Changes in water quality that may affect biota
- Bank erosion, stability, blockage, integrity of the water crossings, fish passage

2.5.4 Railway (Water Management Areas 48 and 21)

The longer term plans for the Project involve the transportation of iron ore from the Mine Site to the Steensby Port by railway. The concerns for potential aquatic effects occur mainly during the construction period of the railway embankment. Four construction camps (with sewage treatment plant and waste incinerators) will be established at the onset of the construction period. Sewage effluent from these camps will be transported by truck to either the Mine Site or the Steensby Port sewage treatment facilities for treatment. There will be no local discharges of treated effluent (trucked to Steensby or Mine site sewage treatment plant). Domestic water supply and water required for construction activities will be drawn from a number of local lakes. A number of quarries will be developed along the railway alignment in order to provide the necessary rock and aggregate required for the rail embankment, stream crossing and bridge construction.

The concerns for potential aquatic effects during construction, operation and closure of the railway are related to the loss or alteration of fish habitat:

<u>Water Quantity (Potable Water and Construction Activities)</u>

- Water withdrawals affecting downstream flows

<u>Water and Sediment Quality</u>

- Surface runoff water quality (TSS, spills, dust from traffic)
- Quarry management (runoff water quality, TSS, ARD, blasting and ammonia)

<u>Freshwater biota and fish habitat</u>

- Stream/river crossings - flow velocity, TSS, erosion, fish stranding, fish passage and integrity of the water crossing
- Lake and river encroachment - loss of habitat, TSS (construction)
- Changes in water quality (e.g., dust, sewage effluent) - effects on Arctic Char health and condition/habitat
- Blasting near water (blasting overpressure) along Cockburn Lake

2.5.5 Steensby Port (Management Area 21)

The longer term plans for the Project involve the sizing and stockpiling of iron ore at Steensby Port prior to being loaded into the ore carriers for shipment. Steensby Port will contain large infrastructure required for ongoing support of the Port, the railway operation as well as the mine. The infrastructure at Steensby will include an airstrip, maintenance facilities (vehicles and railway), fuel depots, camps, a WWTF, warehouses, laydown areas, waste handling and storage facilities, landfill site, landfarm, explosives storage facilities, a freight dock, an ore stockpile and the ore loading dock. The freshwater supply for the Steensby Port will be drawn from two local lakes. Two quarries will be developed to provide aggregate for the development of the site.

At the Steensby site, surface drainage will be directed toward Steensby Inlet. Treated sewage effluent and treated oily water will discharge to Steensby Inlet via an outfall at a 35 meter depth. As a result, site drainage and effluent discharge have minimal effects on the freshwater receiving environment.

The concerns for potential freshwater aquatic effects during the construction, operation and closure of the Steensby port are related to:

Water Quantity

- Withdrawal of water from 3 KM Lake (dust suppression and other minor uses) and ST347 Lake (permanent camp)

Water and Sediment Quality

- Quarry management (runoff quality, ARD potential, residual ammonia from blasting activities)
- Construction of water intakes - TSS/turbidity
- Spills caused by accidents and malfunctions

Freshwater Biota and Fish Habitat

- Stream/river crossings - flow velocity, TSS, erosion, fish stranding, fish passage and integrity of the water crossing
- Lake and river encroachment - loss of habitat, TSS (construction)
- Construction of water intakes - avoidance of spawning areas

The discharge criteria for the effluent and runoff water quality are presented in the Type A Water Licence Amendment No.1.

3 AEMP RELATED MONITORING PROGRAMS

A number of environmental monitoring programs relate to and support the AEMP.

3.1 INUIT QAUJIMAJATUQANGIT

The INAC (2009) AEMP Guidelines provide a basis for incorporating traditional knowledge (in the case of Nunavut this is termed Inuit Qaujimajatuqangit or IQ) into AEMP programs in an efficient and effective manner. The guidelines recognize a need for a flexible process for developing and implementing AEMPs that provide opportunities for input by interested parties including local communities and organizations. This is to ensure that Inuit interests and needs are understood and respected, especially in regard to potential effects of land or water use in potentially affected watersheds. The INAC (2009) AEMP Guidelines identify three key sources of IQ that contribute to an understanding of the environment.

1. Shared information within the community, and an oral history spanning multiple generations including specific observations, patterns of biophysical, social, and cultural phenomena, inferences relative to cause and effect, and predictions of the impacts of human activities. This information is obtained by means of direct observation and experience of the Inuit peoples.
2. Essential information on the use and management of the environment which can enhance understanding of cultural practices and social activities, land use patterns, archeological sites, harvesting practices, and harvesting levels, both now and in the past.
3. Information on the values that people place on the environment.

During the development of the AEMP, the Qikiqtani Inuit Association (QIA) participated in the consultation activities listed in Section 1.3, so that IQ may be incorporated into AEMP development and the implementation process. During these meetings, several of the participants had extensive experience with past projects where attempts were made to incorporate IQ and western science based programs as part of the AEMP. These participants openly shared their experiences with meeting attendees especially in regard to the difficulties involved in successfully incorporating IQ into AEMPs which by their very nature are highly scientific and statistical. However, success was made, and based on suggestions and discussions between Baffinland and QIA, and the application of the INAC Guidelines (2009), the following initiatives are proposed for consideration.

- As has been the practice over the last several years, Baffinland will continue to recruit and train local skilled Inuit environmental technologists to assist with future AEMP field sampling and monitoring programs. In this way, Baffinland Project staff can continue to mentor local Inuit in regards to the scientific and technical aspects of the AEMP and the Inuit can share their practical, historical, and traditional knowledge with Baffinland personnel.
- The QIA will have an Environmental Monitor on-site. The Environmental Monitor will be involved in field data collection and will have an opportunity to review and comment on monitoring results.
- The QIA is expected to continue to utilize suitably qualified technical staff and consultants to review the AEMP and future revisions as well as monitoring data.

In the first half of 2014, Baffinland consulted with the Mittimatalik Hunters and Trappers Organization (MHTO) regarding plans for fish habitat compensation off-sets in the marine environment, related to construction of the ore dock at Milne Port. This type of opportunistic discussion and consultation on aquatic related programs and monitoring will be undertaken from time to time.

3.2 METEOROLOGICAL STATIONS

Three meteorological stations have been established, one each at the Mine Site, Steensby Port, and Milne Port locations. The stations record air temperature, relative humidity, precipitation, wind direction, and wind speed.

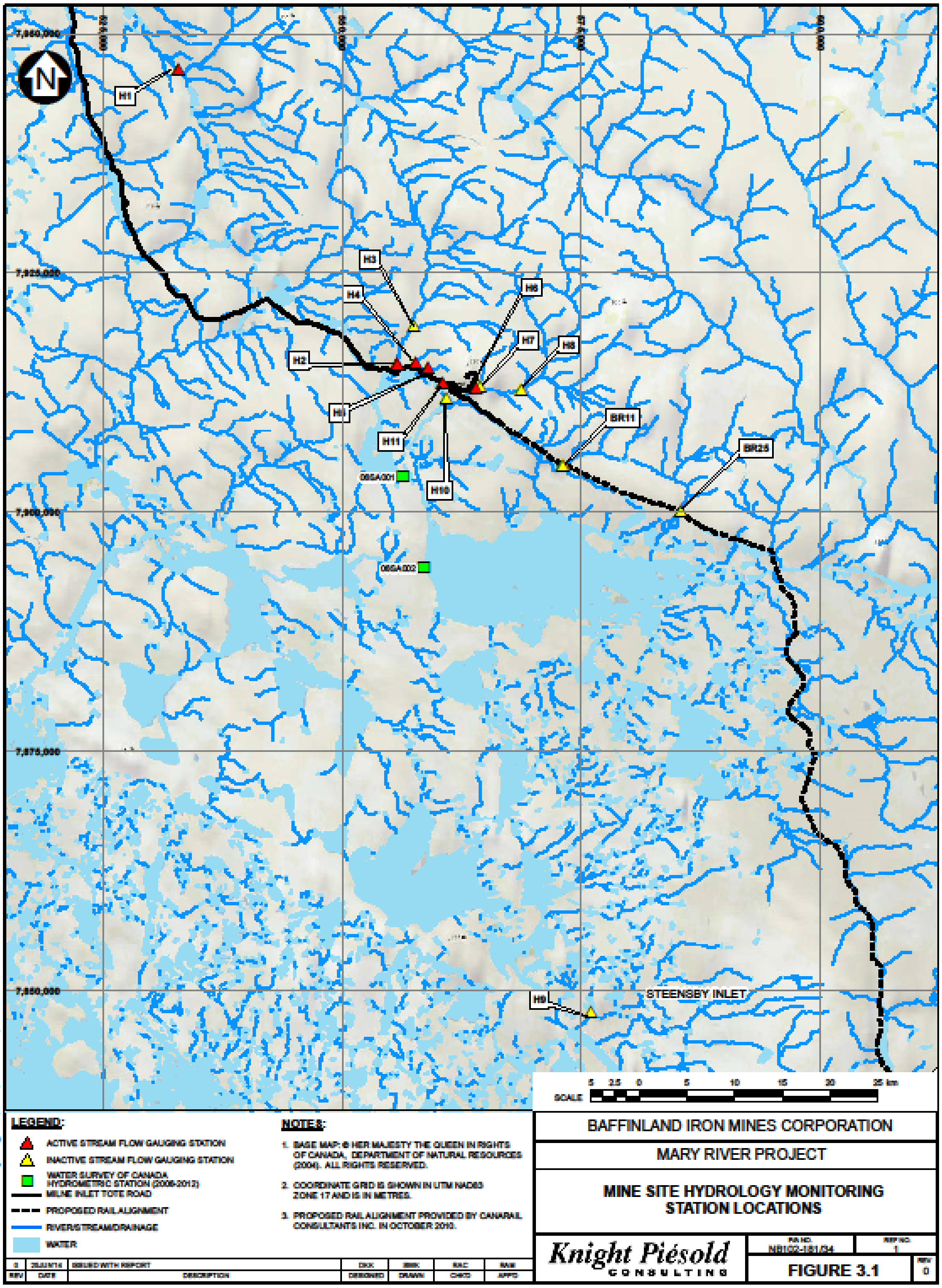
3.3 STREAMFLOW MONITORING

A long-term hydrological record does not exist for the North Baffin Region. Stream flow has been monitored at the Mary River Project since 2006, with up to 16 seasonal stream gauges on smaller river/creek systems and four year-round hydrometric stations operated by the Water Survey of Canada operated at various times. The hydrometric stations installed by the Water Survey have not been active since 2011. Table 3.1 summarizes the stream flow record. Six of the stations will continue to be operated in 2015 and onward (bolded in Table 3.1; shown on Figure 3.1). In addition to these six stations, nine Surveillance Network Monitoring (SNP) stations have hydrometric stations installed, six at the Mine Site and three at Milne Port (indicated in Table 3.2; depicted in Figure 3.2, 3.3). The 9 hydrometric monitoring stations were installed to measure surface water discharge at or near each of the SNP stations.

Table 3.1 Project Stream Gauging Record

STATION ID	STATION TYPE	PERIOD OF RECORD	DRAINAGE AREA (km^2)	COORDINATES (UTM)		
				Zone	Easting	Northing
H01	Stream flow	2006-2008, 2011-2015	250	17W	532831	7946247
H02	Stream flow	2006-2008, 2010, 2012-2015	210	17W	555712	7915514
H03	Stream flow	2006-2008, 2010	30.5	17W	557485	7919401
H04 (CLT-2)	Stream flow	2006-2008, 2010, 2012-2015	8.3	17W	557639	7915579
H05 (CLT-1 L1)	Stream flow	2006-2008, 2010-2015	5.3	17W	558906	7915079
H06 (Mary River)	Stream flow	2006-2008, 2010-2015	240	17W	563922	7912984
H07	Stream flow	2006-2008, 2011, 2013	14.7	17W	564451	7913194
H08	Stream flow	2006-2008	208	17W	568732	7912881
H09	Stream flow	2006-2008	158	17W	576011	7847687
H10	Water Level	2008	8.2	17W	560905	7911838
H11 (SDLT-1)	Stream flow	2011-2015	3.6	17W	560503	7913545
H12	Water Level	2011, 2012	-	17W	597867	7800065
BR11	Stream flow	2008, 2012	53	17W	573122	7904914
BR25	Stream flow	2008, 2012	113	17W	585420	7900082
BR96-2	Stream flow	2008, 2012	31	17W	609300	7839474
BR137	Stream flow	2008,2010-2012	314	17W	598663	7807981
Isortoq River	Stream flow	2006-2012	7170	18W	432810	7780920
Mary River	Stream flow	2006-2012	690	17W	556360	7903750
Raven River	Stream flow	2006-2012	8220	17W	558020	7894160
Rowley River	Stream flow	2006-2012	3500	18W	411230	7818830

Figure 3-1 Mine Site Hydrology Monitoring Stations



The following stream gauges are directly relevant to the stream diversion study (Section 4.3.3 and AppendixI):

- Station H05 – located on Camp Lake Tributary 1 (CLT-1), which will receive mine effluent from the west pond (Station H05);
- Station H04 – located on Camp Lake Tributary 2 (CLT-2), which will experience reductions in streamflow during the full-scale Project; and
- Station H11 – located on Sheardown Lake Tributary 1 (SDLT-1), which will experience decreased flows due to diversions associated with the west pond and open pit.

In addition, Station H06 is located on the Mary River, which will receive mine effluent from the east pond, ROM pond and ore stockpiles along with treated sewage effluent from the camp.

The data quality to date has been good though the record is relatively short. The AEMP and Water Licence stations have been installed and are operated in consideration of the national standards set out by the Water Survey of Canada (WSC). Baffinland is committed to maintaining and operating all the hydrometric stations to the WSC standards whenever possible.

3.4 SURVEILLANCE NETWORK PROGRAM

3.4.1 Surveillance Network Program Overview

The Surveillance Network Program (SNP) is a compliance-based monitoring program defined in the Type A Water Licence Amendment No.1. The SNP is the "General Monitoring Program" outlined in Schedule I of the Type A Water Licence Amendment No.1, Conditions Applying to General and Aquatic Effects Monitoring. Data generated by the SNP will help inform effects evaluations conducted as part of the AEMP by providing the loading information on controlled and authorized discharges (flow and quality).

A number of discharges are authorized and regulated by the Type A Water Licence Amendment No.1, including:

- Mine effluent (pit water and runoff from ore and waste rock stockpiles);
- Treated sewage effluent;
- Sewage sludge;
- Oily water;
- Solid waste landfilled on-site;
- Hazardous and non-hazardous wastes taken off-site for disposal;
- Landfill seepage/effluent;
- Water from bulk fuel storage containment facilities;
- Hydrocarbon impacted soil treated in landfarms; and
- Waste rock disposal.

The coordinates for each discharge location and SNP monitoring stations are listed in Table 3.2 and are shown on the following figures:

- Mine Site Surveillance Network Program (Figure 3.2);
- Milne Port Surveillance Network Program (Figure 3.3); and
- Steensby Port Surveillance Network Program (Figure 3.4).

SNP stations that include hydrological monitoring are denoted in Table 3.2 and distinguished in Figure 3.2 and Figure 3.3.

SNP stations associated with the rail project that are identified in the Type A Water Licence Amendment No.1 will be listed in a future revision to the AEMP, once that project phase is pursued by Baffinland.

Schedule I, Table 12 of the Type A Water Licence Amendment No.1 presents the monitoring group parameters. Tables 13, 14 and 15 of Schedule I present the SNP stations at the Milne Port, the Mine Site and Steensby Port, respectively.

Some SNP stations will be utilized for monitoring of contact mine water under the EEM Program (Section 4.1). The SNP results are integrated into interpretation and recommendations of the annual AEMP program.

3.4.2 Effluent Quantity and Quality

The Water Licence requires the reporting of monthly and annual volumes of effluents and wastes discharged by the Project, as well as discharge quality criteria applicable to the various effluents generated by the Project. Effluent quantity and quality together provide loadings data for downstream receiving environments.

3.4.3 Acute Toxicity

Periodic acute toxicity testing for end of pipe sewage effluent discharge locations provides data on possible acute impacts to effluent exposure areas. Testing of treated sewage effluent is required by the licence to confirm that the effluent is not acutely toxic.

3.5 AIR QUALITY MONITORING

The Air and Noise Abatement Management Plan provides guidance on the abatement and management of air emissions and noise from construction and operation activities. The plan also describes the air quality monitoring that will be carried out for the Project.

Passive and active air quality monitoring will be conducted at Milne Port, the Mine Site and Steensby Port. Active monitoring will involve measuring total suspended particulate (TSP) in areas of activity at the Mine Site, Milne Port and Steensby Port. Passive sampling will include collecting sulphur dioxide (SO_2), nitrogen dioxides (NO_2), ozone (O_3), and dustfall samples simultaneously.

During both construction and operation, the monitoring program will focus on TSP and dust deposition. Air quality data will be collected via active (TSP) and passive sampling methods (SO_2, NO_2, O_3, and dustfall, including metal deposition). Emission testing is being conducted on Project incinerators. Dustfall monitoring is being conducted at transects along the Milne Inlet Tote Road, at Milne Port and the Mine Site as part of the TEMMP (Appendix H).

The approach, indicators, thresholds and proposed response actions are described in the Air and Noise Abatement Management Plan.

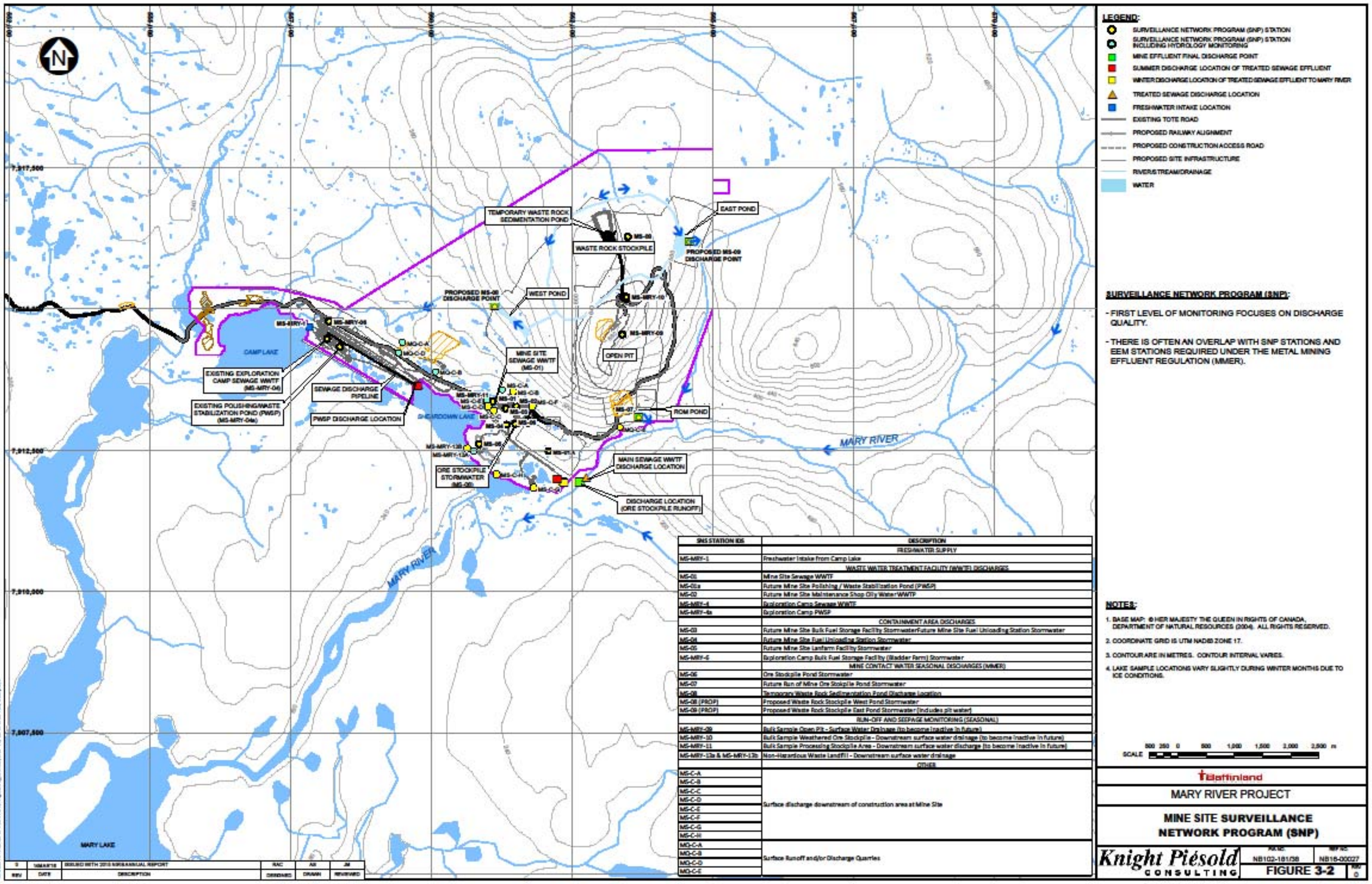
Air quality monitoring program is a supporting monitoring program to the AEMP as dustfall monitoring is required by PC Condition #21. Dustfall monitoring may be able inform the findings of monitoring of the aquatic environment under the AEMP, as well as measure changes in dustfall due to changes in the Project or in the application of mitigation measures (Section 4.3.2; Appendix H).

Table 3.2 Established SNP Monitoring Stations Associated with ERP

Monitoring Station	Description	UTM Coordinates (NAD83, Zone 17) Easting (m)	Northing (m)	Status
Milne Port Site				
MP-MRY-2	Fresh Water Intake at Philips Creek (Summer)	514,503	7,964,579	Active
MP-MRY-3	Fresh Water Intake from Km 32 Lake (Winter)	521,547	7,953,735	Active
MP-01	Milne Port Sewage Treatment Facilities (discharge into ditch prior to ocean)	503,209	7,976,485	Active
MP-01a	Milne Port Waste Stabilisation Pond	503,625	7,976,015	Active
MP-02	Milne Port Maintenance Shop Oily Water	503,319	7,975,805	Inactive (not yet constructed)
MP-03	Milne Port Bulk Fuel Storage Facility Storm Water	503,638	7,976,272	Active
MP-04	Milne Port Landfarm Facility Storm Water	503,710	7,975,574	Active
MP-05	Milne Port Ore Stockpile Settling Pond (East)	503,469	7,976,383	Active
MP-06	Milne Port Ore Stockpile Settling Pond (West)	503,125	7,976,364	Active
MP-MRY-04	Milne Exploration Phase Sewage Treatment Facilities	503,462	7,975,764	Inactive (decommissioned)
MP-MRY-04a	Milne Exploration Phase Sewage PWSP	503,344	7,976,118	Inactive (decommissioned)
MP-MRY-7[1]	Milne Exploration Phase Bladder Farm Fuel Storage Facility Storm water	503,309	7,976,097	Inactive (decommissioned)
MP-MRY-12	Bulk Sample Stockpile Area Seepage	503,357	7,976,453	Inactive
MP-C-A	Surface discharge downstream of construction area at Milne Port	503,214	7,976,483	Inactive
MP-C-B		503,191	7,975,396	Active / Hydrology
MP-C-C		503,436	7,975,427	Inactive
MP-C-D		503,651	7,976,363	Inactive
MP-C-E		503,736	7,976,346	Inactive
MP-C-F		503,922	7,976,304	Active
MP-C-G		503,006	7,976,484	Inactive
MP-C-H		504,113	7,976,509	Active
MP-Q1-01	Surface Runoff and or Discharge Quarries	503,828	7,975,062	Active / Hydrology
MP-Q1-02		503,811	7,975,272	Active / Hydrology
Mine Site				
MS-MRY-1	Fresh Water Intake from Camp Lake	557,793	7,914,684	Active
MS-01	Mine Site Sewage Treatment Facilities	561,322	7,913,257	Active
MS-01a	Mine Site Polishing/Waste Stabilization Pond (PWSP)	TBD	TBD	Not yet established
MS-02	Mine Site Maintenance Shop Oily Water WWTF (Truck Wash)	561,638	7,913,222	Inactive (not yet commissioned)
MS-03	Mine Site Bulk Fuel Storage Facility Storm Water	561,258	7,913,304	Active
MS-MRY-4	Exploration Camp Sewage Treatment Facility	558,141	7,914,427	Inactive
MS-MRY-4a	Exploration Camp Polishing Waste Stabilization Ponds	558,470	7,914,237	Active
MS-04	Mine Site Fuel Unloading Station Storm Water	561,258	7,913,304	Not yet established
MS-05	Mine Site Landfarm Facility	TBD	TBD	Not yet established
MS-MRY-6	Exploration Camp Bulk Fuel Storage Facility (Bladder Farm) Storm Water	558,186	7,914,780	Active
MS-06+	Ore Stockpile Pond Storm Water (Crusher Pad)	561,475	7,913,000	Active
MS-07	Run of Mine Ore Stockpile Pond Stormwater	TBD	TBD	Not yet established

Monitoring Station	Description	UTM Coordinates (NAD83, Zone 17)		Status
		Easting (m)	Northing (m)	
MS-08	Waste Rock Stockpile West Pond	563,492	7,916,273	Active
MS-09	Waste Rock Stockpile East Pond	562,984	7,916,316	Not yet established
MS-MRY-9	Bulk Sample Open Pit - Surface water drainage	563,246	7,914,632	Inactive
MS-MRY-10	Bulk Sample Weathered Ore Stockpile - Downstream surface water drainage	563,488	7,915,197	Inactive
MS-MRY-10A	Surface discharge downstream of km 107 on Haul Road	564531	7913652	Active
MS-MRY-11	Bulk Sample Processing - Downstream surface water discharge	560,690	7,913,350	Inactive
MS-MRY-13a & MS-MRY-13b	Non-Hazardous Waste Landfill - Downstream surface water drainage	13a: 560,754 13b: 560,642	13a: 7,912,484 13b: 7,912,527	Active / Hydrology
MS-C-A	Surface discharge downstream of construction area at Mine Site	561,263	7,913,571	Active / Hydrology
MS-C-B		561,454	7,913,537	Active
MS-C-C		561,110	7,913,199	Active
MS-C-D	Surface discharge downstream of construction area at Mine Site	561,008	7,913,280	Active
MS-C-E		560,980	7,913,388	Active / Hydrology
MS-C-F		561,797	7,913,278	Active
MS-C-G		561,813	7,911,830	Active
MS-C-H		561,162	7,912,067	Active
MQ-C-A	Surface Runoff and or Discharge Quarries	559,489	7,914,408	Active / Hydrology
MQ-C-B		560,083	7,913,905	Active / Hydrology
MQ-C-D		559,447	7,914,258	Active / Hydrology
MQ-C-E		563351	7912902	Active

Figure 3-2 Mine Site Surveillance Network Program (SNP)



SNS STATION IDS	DESCRIPTION
	FRESHWATER SUPPLY
MS-MRY-1	Freshwater Intake from Camp Lake
	WASTE WATER TREATMENT FACILITY (WWTF) DISCHARGES
MS-01	Mine Site Sewage WWTF
MS-01a	Future Mine Site Polishing / Waste Stabilization Pond (PWSP)
MS-02	Future Mine Site Maintenance Shop Oily Water WWTP
MS-MRY-4	Exploration Camp Sewage WWTF
MS-MRY-4a	Exploration Camp PWSP
	CONTAINMENT AREA DISCHARGES
MS-03	Future Mine Site Bulk Fuel Storage Facility StormwaterFuture Mine Site Fuel Unloading Station Stormwater
MS-04	Future Mine Site Fuel Unloading Station Stormwater
MS-05	Future Mine Site Lanfarm Facility Stormwater
MS-MRY-6	Exploration Camp Bulk Fuel Storage Facility (Bladder Farm) Stormwater
	MINE CONTACT WATER SEASONAL DISCHARGES (MMER)
MS-06	Ore Stockpile Pond Stormwater
MS-07	Future Run of Mine Ore Stokpile Pond Stormwater
MS-08	Temporary Waste Rock Sedimentation Pond Discharge Location
MS-08 (PROP)	Proposed Waste Rock Stockpile West Pond Stormwater
MS-09 (PROP)	Proposed Waste Rock Stockpile East Pond Stormwater (includes pit water)
	RUN-OFF AND SEEPAGE MONITORING (SEASONAL)
MS-MRY-09	Bulk Sample Open Pit - Surface Water Drainage (to become inactive in future)
MS-MRY-10	Bulk Sample Weathered Ore Stockpile - Downstream surface water drainage (to become inactive in future)
MS-MRY-11	Bulk Sample Processing Stockpile Area - Downstream surface water discharge (to become inactive in future)
MS-MRY-13a & MS-MRY-13b	Non-Hazardous Waste Landfill - Downstream surface water drainage
	OTHER
MS-C-A	Surface discharge downstream of construction area at Mine Site
MS-C-B	
MS-C-C	
MS-C-D	
MS-C-E	
MS-C-F	
MS-C-G	
MS-C-H	
MQ-C-A	Surface Runoff and/or Discharge Quarries
MQ-C-B	
MQ-C-D	
MQ-C-E	

Figure 3-3 Milne Port Surveillance Network Program (SNP)

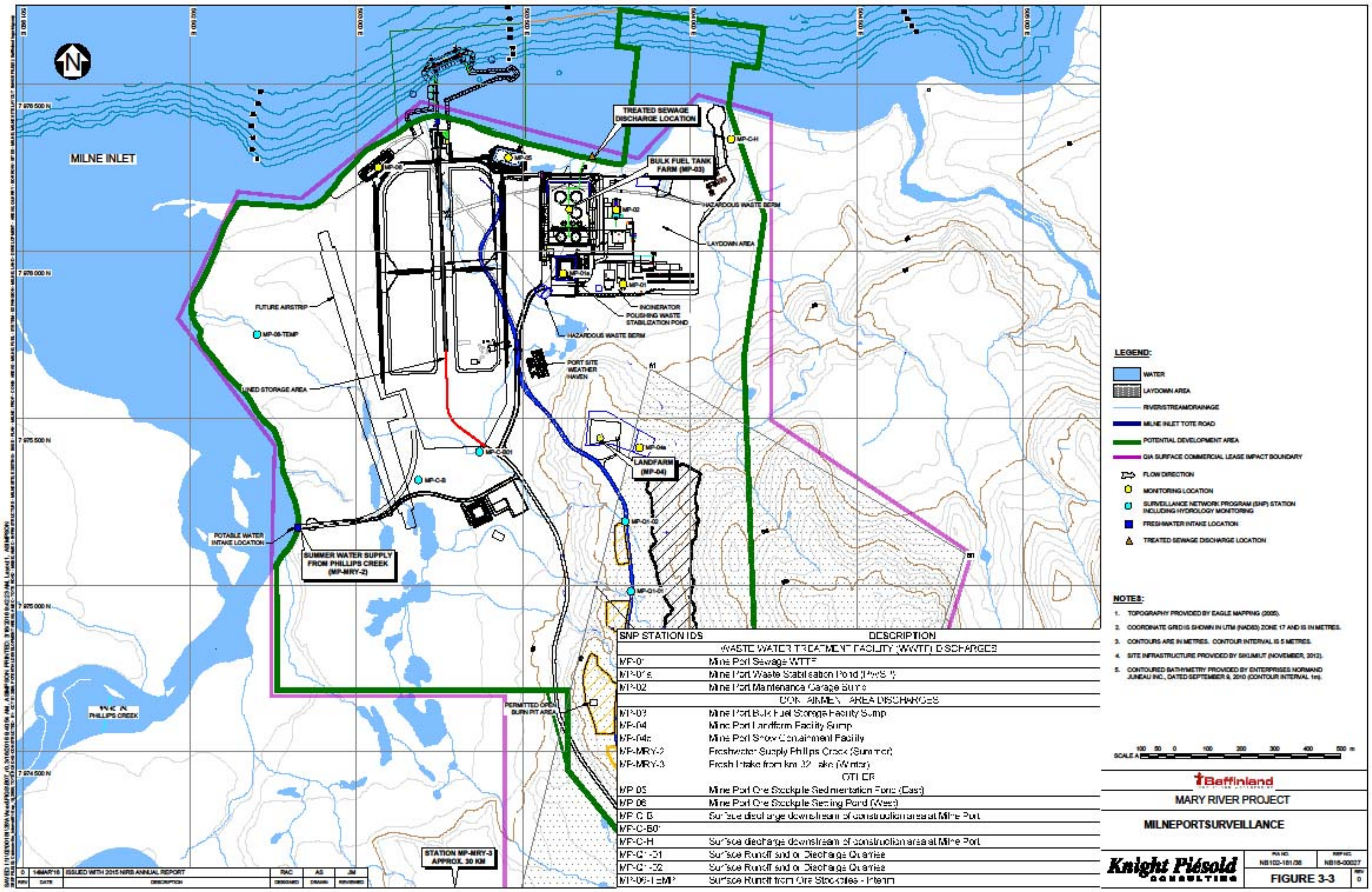
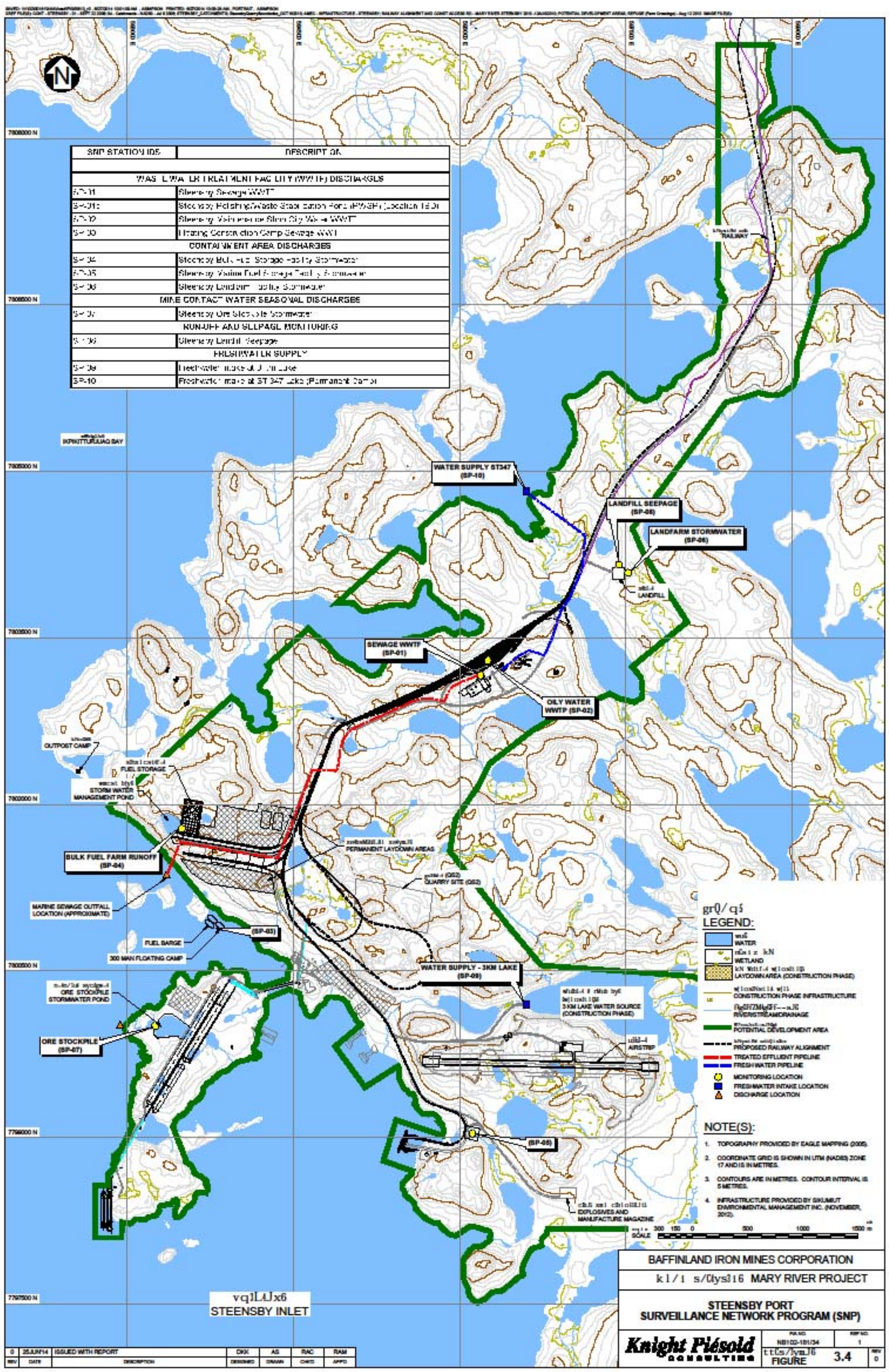


Figure 3-4 Steensby Port Surveillance Network Program (SNP)



3.6 HABITAT COMPENSATION

Baffinland must obtain appropriate authorizations or letters of advice from the DFO for in-water construction activities such as at water crossings. Section 35 of the *Fisheries Act* prohibits the serious harm to fish that are part of, or that support, a commercial, recreational or Aboriginal fishery, and provides the Minister with the power to authorize terms and conditions which would allow projects to proceed in compliance with the *Act*. Serious harm occurs when the physical, chemical, or biological features of a water body are sufficiently altered, such that habitat becomes less suitable for one or more life history processes of fish. Habitat offsetting is an option for mitigating residual impacts of projects on habitat productive capacity that are deemed harmful after other less invasive options have been implemented. Habitat offsetting involves replacing the loss of fish habitat with newly created habitat or improving the productive capacity of some other natural habitat. Depending on the nature and scope of the compensatory works proposed, habitat offsetting may require multiple seasons of post-construction monitoring. A Fish Habitat Offsetting Plan is a requirement of a *Fisheries Act* authorization.

Mitigation measures are likely to be implemented during the project's planning, design, construction and/or operation phases in order to protect fish and fish habitat. The mitigation plans are prepared and implemented by the Company with advice typically provided by DFO staff.

Commonly used mitigation measures can include:

- Working within fisheries timing windows to minimize interference with fish migration and spawning
- Selecting the least harmful equipment/materials/construction methods
- Ensuring fish passage around obstructions during and after construction
- Implementing measures to control siltation at construction sites

Upgrades to some of the existing Tote Road crossings will be required to support the construction phase of the project and the installation of new crossings and encroachments within lakes will be required as part of the railway construction and operation.

Permanent or temporary water crossings are also authorized under the Type A Water Licence Amendment No.1, provided the DFO has granted authorizations for undertaking the proposed work.

3.6.1 Tote Road Upgrade (Water Management Area 48)

The Bulk Sampling Program completed in 2007-2008 involved upgrading the Milne Inlet Tote Road to all-season capability. The upgrades completed included adjustments to the road alignment to facilitate haul road travel, road bed improvements, road widening and installation of drainage crossings along the route. The Tote Road upgrades were designed to enhance the flow conditions of the waterways, reduce potential erosion-related effects, and improve the opportunity for fish to access upstream habitat.

The DFO issued a HADD authorization (Harmful Alteration, Disruption or Destruction of Fish Habitat authorization; now a Serious Harm authorization) for approximately 8,500 m^2 of fish habitat that was to be disturbed for the Tote Road upgrade. Based on subsequent monitoring, this estimate was revised to 7,850 m^2 of disturbance with habitat compensation (now habitat offsetting) measures to be implemented that would restore and enhance approximately 15,000 m^2 of habitat. The original *Fisheries Act* Authorization and Fish Habitat No Net Loss and Monitoring Plan to support the construction of 25 crossings identified as HADD (and 14 crossings identified as Habitat Compensation) were issued and approved in 2007 (Knight Piésold, 2007). The Plan outlined the measures necessary to mitigate and compensate, to the greatest possible extent practicable, the impacts to fish habitat at the Tote Road watercourse crossings. The plan also described a monitoring plan to be implemented during and after construction. A fisheries biologist conducts a survey of the performance of the stream crossings on an annual basis and the results of this survey are provided in an annual report provided to the DFO and other regulators/agencies including the QIA. Monitoring downstream of quarries and borrow source operations is currently a requirement of the Water Licence as well as quarry and borrow source management plans that are submitted under the Water Licence. The Water Licence provides water quality criteria for areas downstream of construction and quarries/borrow sources. This plan has been implemented during the period of construction (2007-2009) and post-construction from 2009 to the present. Baffinland has submitted annual reports for the above to DFO each year since 2007.

In addition, Letters of Advice were issued by the DFO to Baffinland for construction of smaller watercourses along the road.

Road upgrades associated with the mine development project include the replacement of box culvert (sea can) crossings with bridge structures and extension/reinstalls for a large number of stream crossings. DFO has issued Letters of Advice for this work and indicated that an authorization under the *Fisheries Act* will not be required. Nevertheless, monitoring of the tote road crossings continues as per the original authorization and Fish Habitat No Net Loss and Monitoring Plan (Knight Piésold, 2007).

3.6.2 Milne Port Ore Dock (Water Management Area 48)

In accordance with the revised *Fisheries Act*, the footprint of the Milne Ore Dock was determined by DFO to constitute a Serious Harm to fish habitat. In its decision, DFO has indicated that the required Habitat Offset can be addressed through designed-in mitigation in the form of placement of coarse habitat features along the perimeter of the structure.

3.6.3 Rail Phase Infrastructure (Water Management Areas 21 and 48)

The northern portion of the railway is located in Water Management Area 48. The southern portion of the railway and Steensby Port are located in Water Management Area 21.

Once Baffinland decides to pursue the rail phase of the Project, the company will seek an authorization under the revised *Fisheries Act* for components of the Project that DFO constitutes a Serious Harm to fish habitat. This may include the following infrastructure:

- Select crossings and lake encroachments along the railway
- Steensby ore and freight docks

It is expected that habitat offsets will be required under a future *Fisheries Act* authorization. The authorization will require the implementation of various mitigation measures, and will specify monitoring required during and following construction.

3.7 OTHER ENVIRONMENTAL MANAGEMENT AND MONITORING PLANS

A number of management and monitoring plans (EMMPs) were developed as part of the FEIS and/or the Amended Type A Water Licence. These plans include:

- Environmental Protection Plan
- Surface Water and Aquatic Ecosystems Management Plan
- Quarry and Borrow Pit Management Plan
- Freshwater Supply, Sewage and Wastewater Management Plan

- Waste Management Plan
- Hazardous Materials and Hazardous Waste Management Plan
- Explosives Management Plan
- Blasting Management Plan
- Waste Rock Management Plan
- Emergency Response Plan
- Spill Contingency Plan
- Abandonment and Reclamation Plan

The above management plans all have linkages to water, and the issues and concerns identified in Section 2 involve mitigation measures identified in the above plans. Like the AEMP, these plans are living documents which will be updated periodically throughout the Project life to account for changes in the Project, the success of mitigation measures and the results of monitoring.

4 AEMP COMPONENT STUDIES

As described in Section 1, the following are component studies that comprise the AEMP:

- **EEM Program**, as required under the MMER;
- **CREMP**, which includes monitoring of the core mine site area (water, sediment, benthic invertebrates and fish);
- **Lake Sedimentation Monitoring Program**, evaluating baseline and project-influenced lake sedimentation rates;
- **Dustfall Monitoring Program**, evaluating dustfall rates in proximity to the road, port and mine; and
- **Stream Diversion Barrier Study**, an initial study evaluating potential for fish barriers under natural conditions and due to Project-related stream diversions.

The EEM Program is a legal requirement of metal mines such as the Mary River mine. The Draft EEM Cycle One Study Design has been included under the umbrella of the AEMP and follows a separate but related regulatory function.

The CREMP forms the backbone of the AEMP. The CREMP is a detailed aquatics monitoring program intended to complement and expand the scope of an EEM Program required under the MMER. The CREMP is intended to monitor the effects of multiple stressors on the aquatic environment, including the discharge of mine effluents and treated sewage effluent as well as ore dust deposition. The CREMP will include the monitoring of water, sediment, phytoplankton, benthic invertebrates and fish in the lakes and streams within the area of the Mine Site.

Specific effects monitoring (or targeted monitoring) is defined as monitoring conducted to address a specific question or potential impact and/or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Targeted Study, Dustfall Monitoring Program, and the Stream Diversion Monitoring Targeted Study are such studies.

Stand-alone study designs have been prepared. These are briefly summarized below and are included in the appendices of this report.

4.1 EEM CYCLE ONE STUDY DESIGN

4.1.1 Overview

As a metal mine, the discharge of mine effluents from this metal mine is regulated by the MMER. These regulations, administered under the federal *Fisheries Act*, apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. Mining began September 2014, at which time temperatures are below 0 °C, precipitation falls as snow, and runoff has ceased in local rivers and streams. Therefore, the 50 m^3/day mine effluent discharge rate was achieved during freshet on July 10, 2015.

The MMER outline requirements for routine effluent monitoring, acute lethality testing, and EEM. The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues).

This Cycle One EEM study design in Appendix A has been prepared in accordance with the MMER as prescribed by the Environment Canada (2012) EEM technical guidance document. The study design describes in detail how the Cycle One EEM biological monitoring study will be undertaken. It outlines the proposed activities involved in the investigation of water quality, sediment quality, and freshwater biota community to meet the objectives of the EEM program in accordance with the MMER. In accordance with the technical guidance document (Environment Canada, 2012), this study will take into account all relevant site characterization information, previous biological monitoring data, and comments and/or recommendations stemming from previous efforts in the area.

Any comments on this draft study design will be incorporated into a final study design that will be formally submitted for review and approval by the Environment Canada Technical Advisory Panel (TAP) prior to initiation of the Cycle One EEM biological monitoring study field work.

4.1.2 Final Discharge Points

Mine effluent will be discharged to two watercourses (Figure 4.1):

- Mary River (early in mine life); and
- Camp Lake Tributary 1 (later in mine life).

There will be three final discharge points where mine effluent will be discharged to the Mary River. The three discharge points are as follows:

- East Pond discharge (MS-08) collecting stormwater from the east side of the waste rock stockpile;
- Run-of-mine (ROM) and crusher stockpile discharge; and
- The main ore stockpile at the rail load-out area.

There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

4.1.3 Site Characterization

Baseline environmental data has been collected at the exposure and reference areas by North/South Consultants Inc. (NSC) and Knight Piésold Ltd. (KP) on behalf of Baffinland. The exposure and candidate reference areas are listed in Table 4.1. The study area site characterization program involved:

- Identifying the in-situ habitat conditions;
- In-situ and laboratory water quality sampling;
- Sediment quality sampling;
- Benthic invertebrate community sampling; and
- Fish community and population sampling.

The exposure area habitat information was used to evaluate suitability of the candidate reference study areas, and to position the proposed field replicate stations. Candidate reference areas are shown on Figure 4.2. Characterizing more than one reference site for each exposure area increases the ability to evaluate natural variability, ecological relevance and confounding factors, and improves the ability to evaluate the adequacy of the chosen reference site(s) (Environment Canada, 2012)

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Figure 4-1 EEM Program Exposure Areas

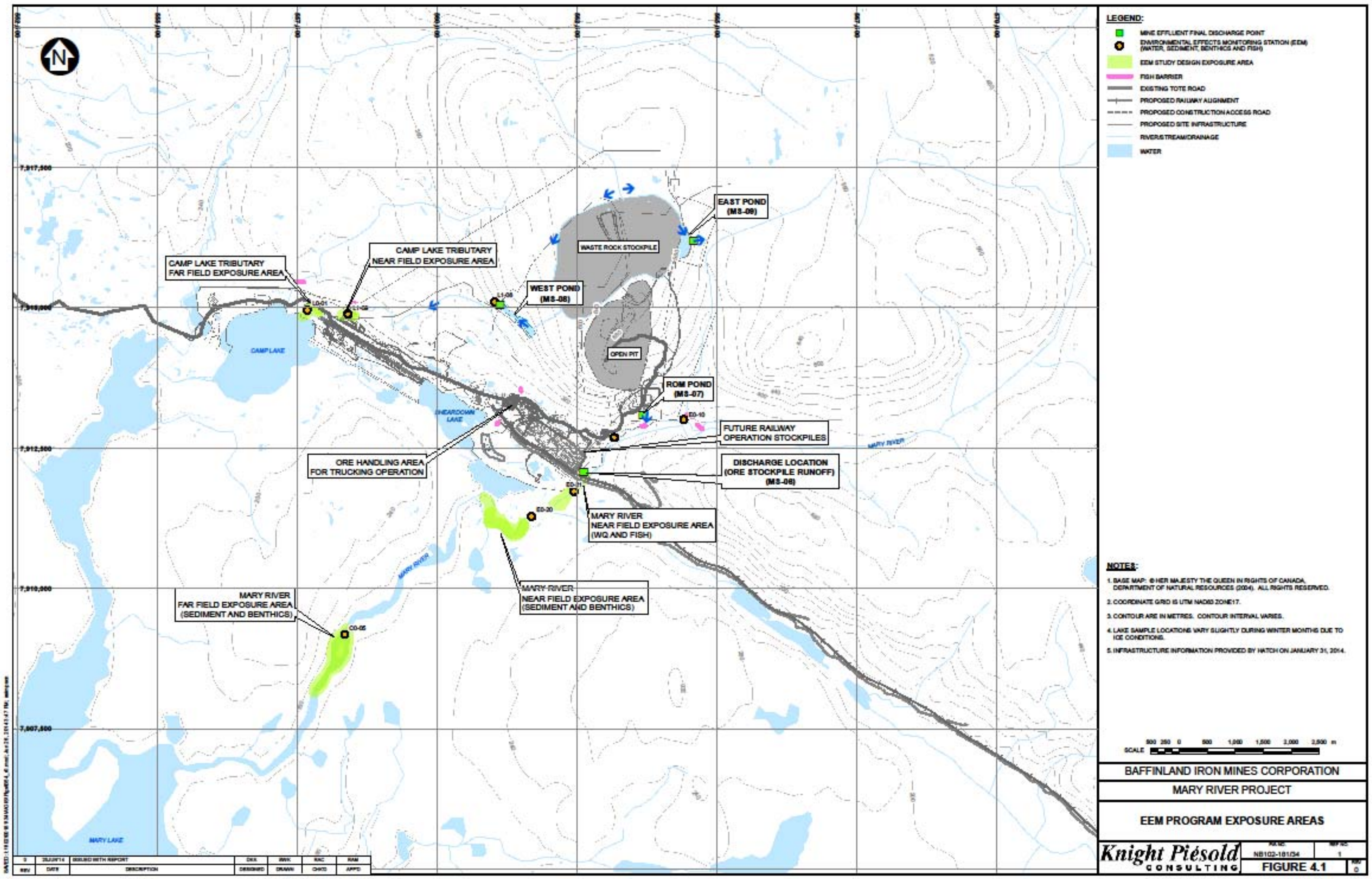


Table 4.1 Freshwater EEM Study Design Exposure and Candidate Reference Areas

Study Area ID	UTM Coordinates (NAD83, Zone 17)	
	Easting (m)	Northing (m)
Camp Lake Tributary Near Field Exposure Area	558,491	7,914,932
Camp Lake Tributary Far Field Exposure Area	557,896	7,914,916
Camp Lake Tributary Reference Area 2	526,105	7,936,762
Camp Lake Tributary Reference Area 3	567,831	7,908,076
Camp Lake Tributary Reference Area 4	569,093	7,907,247
Mary River Near Field Exposure Area (Surface water & Fish at outfall)	562057	7,911,436
Mary River Near Field Exposure Area (Sediment & Benthos)	561,567	7,911,174
Mary River Far Field Exposure Area	558,396	7,909,227
Mary River Reference Area 1	538,169	7,901,494
Mary River Reference Area 2	570,186	7,903,346
Mary River Reference Area 3	584,310	7,898,422
Mary River Reference Area 4	571,350	7,917,086

NOTE:
1. AREA COORDINATES REPRESENT THE UPSTREAM EXTENT OF EACH STUDY AREA.

4.1.4 Study Design Methodology

4.1.4.1 Effluent Plume Delineation Study

Based on estimated effluent discharge volumes compared with the estimated 10-year low flow conditions of the receivers, effluent concentrations in the Mary River and Camp Lake Tributary are estimated to be greater than 1% within 250 m of the final discharge points. Therefore, an effluent plume delineation study will be carried out to confirm the estimated effluent concentration and the manner in which mine effluent will mix with the receiving environment.) It is noted that the most practical approach to plume monitoring would be to conduct a pro-rated evaluation based on a known volume of effluent released and the available hydrology data.

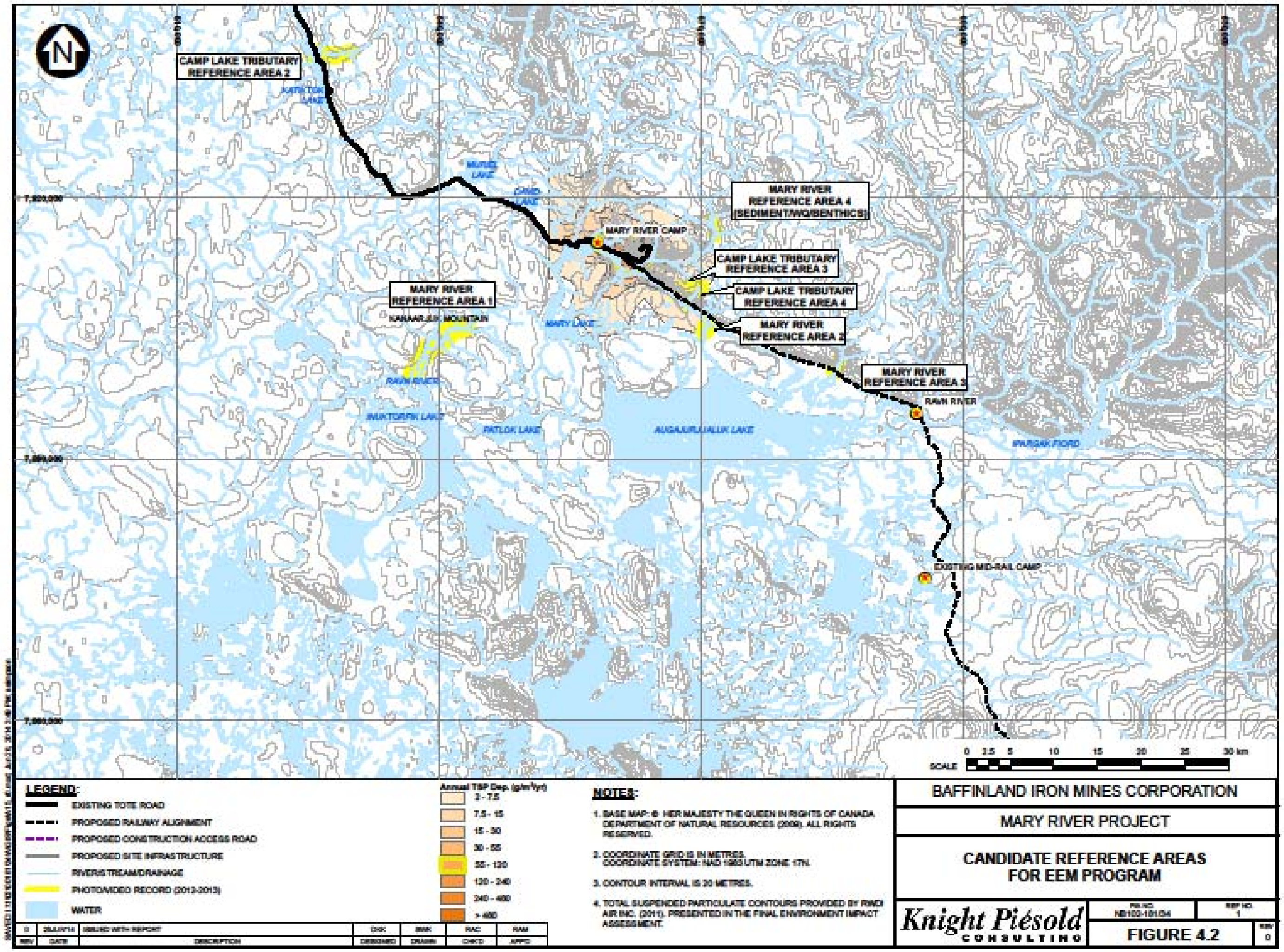
4.1.4.2 Water Quality Monitoring

Sampling and analysis of water quality will be undertaken as part of the cycle one EEM biological monitoring study to compare the current water quality of the reference locations to that of the exposure locations. Water quality samples will be taken concurrently with sediment and benthic sampling unless otherwise noted.

4.1.4.3 Supporting Benthic Invertebrate Community Measures

Supporting measures for the benthic invertebrate community survey will be recorded to support the appropriateness of the selected reference areas. These measures include hydrology, stream morphology and substrate characterization.

Figure 4-2 Candidate Reference Areas for EEM Program



4.1.4.4 Benthic Invertebrate Community Survey

A benthic invertebrate community survey will be conducted as part of the cycle one EEM biological study as required by the MMER. The results of this survey will compare the benthic invertebrate communities between the exposure and reference areas. It is proposed that the benthic invertebrate survey take place in the late summer or early fall (late July to late August), as previous studies have indicated that this is an appropriate season to ensure the collection of the widest diversity of invertebrates.

Benthic samples will be analyzed by a taxonomist. Following identification and enumeration, a list of individuals collected for each sample will be included in the final interpretive report.

The benthic community will be investigated to determine if mine discharge is having an effect on the receiving system, as defined by Environment Canada (2012).

4.1.4.5 Fish Community, Population and Usability Survey

Sufficient historical data have been collected to properly characterize the freshwater fish community in the study areas. Only two fish species are present in the exposure areas; Arctic char and ninespine stickleback.

A fish population survey of the exposure and reference areas will be conducted as required under the MMER. This is required as the effluent concentration is estimated to be above 1% at a distance of 250 metres from the final discharge points. This study will attempt to collect sufficient numbers (n=100) of the proposed sentinel species (Arctic char). The absence of ninespine stickleback in suitable numbers in the exposure and proposed reference areas precludes their use as a second sentinel species. Environment Canada officials will be notified of insufficient collection numbers during the study, and an agreed upon course of action will be followed to complete the study.

Non-destructive capture methods will be employed for all fish population sampling. Backpack electrofishing will be utilized as the primary means of sampling. A non-lethal survey will pose less of an impact on the fish population than a lethal survey.

Aging using otoliths as the primary structure for 10% (min. n=10) of the individuals collected will be undertaken. Pectoral fin rays will also be sampled from the retained individuals to evaluate accuracy of ages between ageing structures. This will evaluate the need for 10% intentional mortality future studies versus a completely non-lethal survey utilizing fin rays as the primary ageing structure.

Effluent quality has been estimated using humidity cell testing results of the ore, local precipitation volumes as well as contact time that precipitation will have with the ore and waste rock stockpiles. The effluent quality is not expected to contain mercury concentrations ≥ 0.01 µg/L, therefore a fish usability study is not proposed in this study design. Should effluent characterization results report concentrations of mercury ≥ 0.01 µg/L a fish usability study will be undertaken as required by the MMER.

4.1.5 Summary and Schedule

The 2013 site characterization program confirmed in-situ conditions at the exposure areas and candidate reference areas. The most suitable reference areas to evaluate the benthic invertebrate community effect endpoints are as follows:

- Camp Lake Tributary Near Field (CLT-NF):
  - Camp Lake Tributary Reference Area 3 (CLT-REF3)
  - Camp Lake Tributary Reference Area 4 (CLT-REF4)
- Mary River Near Field (MRY-NF):
  - Mary River Reference Area 2 (MRY-REF2)
  - Mary River Reference Area 4 (MRY-REF4)

The statistical comparisons of the fish population data between the exposure and reference areas for both receivers show significant difference within and between all groups. As such, additional data analysis may be performed following discussions with Environment Canada to determine an acceptable reference area for the fish component of the EEM cycle one biological monitoring study.

The current and anticipated timeline that includes milestones associated with the MMER requirements is provided below, and is subject to change based on regulatory approvals and the start of mining.

July 10, 2015	The mine became subject to MMERs (effluent discharge rate reached 50 m^3/day)
September 9, 2015	Submission of Identifying Information & Final Discharge Points (within 60 days after date mine is subject to MMERs)
July 10, 2016	Submission of Cycle One Study Design to Environment Canada (12 months from initial date when Mine was subject to MMERs)
	Environment Canada review of Cycle One Study Design (At least 6 months prior to commencing study)
August-Sept 2017	Conduct Cycle One Biological Monitoring Study (conducted no sooner than 6 months after Cycle One SD submission date)
January 10, 2018	Submission of Cycle One Interpretive Report (within 30 months from initial date when Mine was subject to MMERs)

Based on comments on the draft study design presented in Appendix A and summarized above, the Cycle One Study Design report will be formally submitted to Environment Canada in accordance with the schedule outlined above.

4.2 CREMP STUDY DESIGN

4.2.1 CREMP Overview

The Core Receiving Environment Monitoring Program (CREMP) is being established to monitor effects of the Project on the downstream aquatic environment. The CREMP focuses on follow-up monitoring to validate predictions to aquatic valued ecosystem components (VECs) and key indicators, as follows:

- Water quantity;
- Water and sediment quality; and
- Freshwater biota (benthic invertebrate indicators, phytoplankton and Arctic Char).

The EEM study design (Section 4.1) identifies the exposure areas in the freshwater environment that will receive mine effluent discharges. The CREMP encompasses a larger geographic extent than the EEM program and is intended to monitor potential effects to the aquatic environment via other pathways such as dust deposition or changes in water flow due to diversions.

Based on the conclusions in the FEIS, mine site aquatic effects will be primarily confined to the Mary River, Camp Lake, Sheardown Lake and their associated tributaries (Figure 2.1). Mary Lake is the ultimate receiving water for these drainage areas, but is of sufficient size that detectable effects are not predicted. The CREMP includes monitoring in Mary Lake to confirm this prediction.

The CREMP is intended to monitor effects as follows:

- Camp and Sheardown Lake tributaries - will be affected by dust deposition and water diversions; Camp Lake Tributary 1 will receive waste rock stockpile runoff from the West Pond;
- Sheardown Lake - will experience changes in water quality due to airborne dust dispersion and runoff, sewage effluent discharges from the exploration camp during construction, changes in hydrology, and potential changes in productivity to tributaries of Sheardown Lake;
- Camp Lake – will receive runoff from tributaries affected by dust deposition and mine effluent (west pond), will be affected by water diversions and withdrawals, as well as changes in water quality due to airborne dust dispersion;
- Mary River – will be subject to airborne dust dispersion and will receive three streams of mine effluent as well as treated sewage effluent; and
- Mary Lake – is the ultimate receiving waters of Camp Lake, Sheardown Lake and the Mary River.

In 2015, Reference Lake 3 was established as the reference lake for the CREMP. Reference Lake 3 will be used to assist in identifying mine influenced changes to the water, sediment and freshwater biota of mine area lakes.

After completing the CREMP in 2015, Minnow proposed several modifications to the CREMP in an effort to provide greater efficiencies to the program and improve the program's ability to achieve its objectives.

A brief description of the CREMP by component is provided below. The water and sediment quality CREMP is presented in more detail in Appendix B (Knight Piésold, 2014a), and the freshwater biota CREMP (inclusive of phytoplankton, benthic invertebrates and fish) is presented in Appendix E (NSC, 2014a). Both the brief descriptions of each CREMP component below and the CREMP appendices (Appendix B and E) have been revised to reflect the modifications proposed by Minnow.

4.2.2 Water Quality

The key pathways of potential effects of the Project on water quality include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and CLT-1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to water quality is related to the combined effects on metal and TSS concentration from mine effluent discharges and ore dust deposition on water quality in adjacent lakes and streams. As such, the CREMP and the baseline data review (Appendix B) focused on waterbodies that will receive mine effluent discharges and are closest to the sources of ore dust. Camp Lake and CLT-1, as well as the Mary River and Mary Lake, will receive mine effluent discharges. These waterbodies, along with Sheardown Lake, may also be affected by ore dust deposition and non-point sources of fugitive dust (i.e., road dust).

The discharge of treated sewage effluent also has the potential to cause eutrophication, with total phosphorus (TP) being the limiting nutrient. TP concentrations are highly variable, however, making it a poor indicator. While TP will continue to be monitored as part of the CREMP, chlorophyll a will be monitored as a more reliable indicator of potential eutrophication, as part of the freshwater biota CREMP (Section 4.2.4 and Appendix D).

Within the list of recommendations, Minnow noted that no consistent spatial differences in water quality/chemistry were evident in any of the study lakes in 2015, nor during any of the baseline studies, suggesting that study lakes are generally well mixed with relatively uniform water chemistry throughout the year. (Minnow, 2016). Because of this, Minnow recommended three modifications to the CREMP lake water quality sampling program:

1. Reduce the number of water quality monitoring stations to three (3) in each of Camp, Sheardown NW and SE lakes and four (4) in Mary Lake (Item 7; Minnow, 2016);
2. Collect a single water quality sample at mid-depth instead of collecting two samples, surface and bottom, at each lake water quality monitoring station (Item 9; Minnow, 2016) and;
3. Conduct water quality *in-situ* profiling at the main (i.e. deepest) basin of the study lakes to evaluate the occurrence of anoxic conditions and guide the subsequent sampling approach (Item 8; Minnow 2016).[1]

Lake water quality stations selected by Minnow for i*n-situ* profiling are listed below.

- Camp Lake Station - JL0-07
- Sheardown Lake NW Station – DL0-01-2
- Sheardown Lake SE Station – DL0-02-3
- Mary Lake (North Basin) Station – BL0-1A

[1] Anoxic conditions have not been observed at any of the study lakes since baseline studies began in 2005.

- Mary Lake (South Basin) Station – BL0-9
- Reference Lake 3 (NW Basin) Station – REF03-3

In addition to the recommendations pertaining to the lake water sampling program, Minnow also recommended the following modifications be made to the CREMP lotic (stream) water quality sampling program:

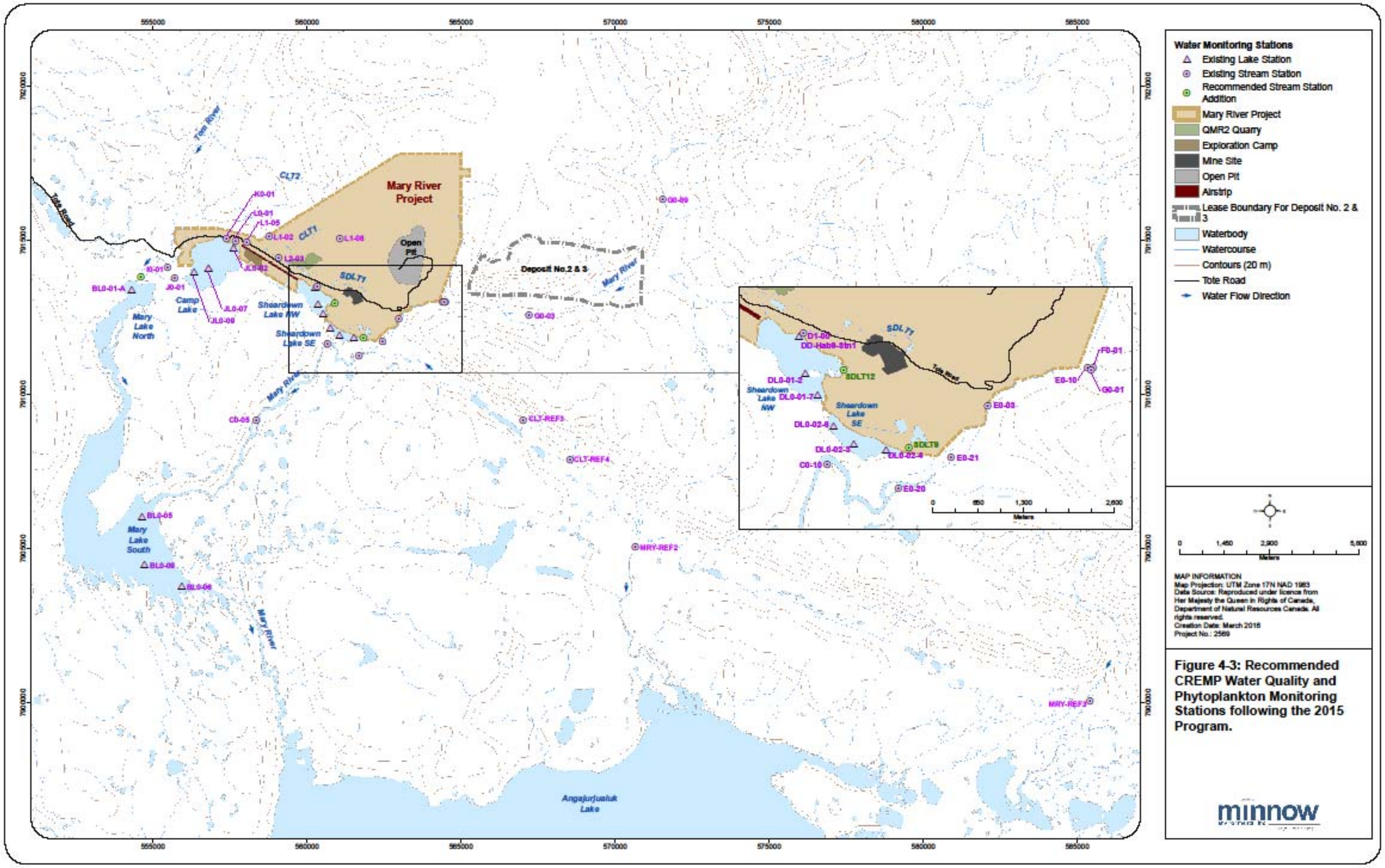
1. The addition of three stream water quality monitoring stations, including at lower Tom River, Sheardown Lake Tributary 9 and Sheardown Lake Tributary 12.
2. Discontinue water quality monitoring at stations L1-09 (Camp Lake Tributary 1) and D1-05 (Sheardown Lake Tributary 1).
3. Discontinue water quality monitoring at stations G0-09A, G0-09B and C0-01 on the Mary River.

CREMP water quality stations are monitored three (3) times per year. Stream water quality will be monitored during the spring, summer and fall, whereas, lake water quality monitoring will take place during the winter (late April), summer and fall. This sampling frequency should be adequate to detect early warning flag concentrations and determine significance for most water quality parameters. The sampling frequency and schedule will be re-evaluated after the first three years of mine operation.

This revision of the AEMP (Rev. 2) has been updated to reflect all Minnow's recommendations listed above. Additional details regarding the CREMP water quality sampling program are presented in Appendix B.

The CREMP water quality (phytoplankton) monitoring stations recommended by Minnow are shown on Figures 4.3 and 4.5.

Figure 4-3 Recommended CREMP Water Quality and Phytoplankton Monitoring Stations following the 2015 Program



4.2.3 Sediment Quality Study Design

The key pathways of potential effects of the Project on sediment quality include:

- Sediment quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Sediment quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Sediment quality changes due to direct deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Sediment quality changes due to dust deposition on land and subsequent runoff into lakes and streams (Mine Area in zone of dust deposition).

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to sediment quality is the effect of ore dust containing elevated metals being deposited on, or running off into lakes and streams. As such, the CREMP sediment quality monitoring program has historically focused upon waterbodies (lakes and streams) closest to the sources of ore dust.

Prior to 2016, the sediment quality monitoring program did not sample sediment at each lake benthic macroinvertebrate (BMI) station. Therefore, in effort to harmonize the sediment quality and benthic macroinvertabrate monitoring programs and refocus the lake benthic macroinvertebrate program solely on littoral (shallow) habitats, Minnow proposed the following recommendations:

1. Establish five (5) sediment quality/BMI stations located in littoral (shallow) habitat at each mine exposed study lake and Reference Lake 3.
2. Continue sediment quality monitoring at three (3) existing sediment quality stations located in profundal (deep) habitat at Reference Lake 3 and each mine exposed study lake, with the exception of Sheardown Lake SE, where profundal habitat is limited to only a small proportion of the lake.

Littoral sediment sampling stations will be situated at the same locations as the littoral BMI stations. Utilizing the same littoral stations for both sediment quality and benthic macroinvertebrate community sampling will provide supporting information for interpretation and analysis of BMI results (e.g., metals concentrations) and allow the CREMP to establish potential linkages between sediment metal concentrations and their potential effects on benthic macroinvertebrates.

To the extent possible, littoral sediment quality/BMI stations proposed by Minnow were established at existing (historic) BMI stations. However, in some cases, new stations will be established to ensure sufficient coverage of the lake, and to ensure that substrate properties for sampling stations are comparable among and within lakes.

In contrast, all profundal sediment quality stations recommended by Minnow were selected from existing sediment stations. Because the majority of Sheardown Lake is less than 12 meters deep and represents primarily littoral habitat, no profundal sediment quality stations will be established in Sheardown Lake SE.

Lake sediment quality stations are positioned to allow for the evaluation of any spatial differences in sediment chemistry in order to determine potential gradients in metal concentrations associated with mine sources (i.e. mine exposed tributaries). At each station, field technicians will establish final locations for the sediment stations that are within depositional areas of the lake. This field fit of the sampling stations will likely result in some modifications to the gradient study design.

Moreover, in addition to modifications to the lake sediment quality program, Minnow also recommended that the CREMP sediment monitoring program focus solely on depositional lake environments and that CREMP sediment monitoring stations in streams and rivers be discontinued in future CREMP studies, This recommendation was based on the observation that the majority of streams and rivers in the Mary River Project local study area (LSA) contain very limited depositional habitat suitable for the collection of fine sediments. As observed during the 2015 CREMP and baseline studies (KP, 2015), the general absence of any substantial accumulation of fine sediments within these watercourses preclude any meaningful assessment of potential mine-related influences on sediment quality within, along and/or between watercourses. As a result, all sediment quality stations in streams and rivers near the Mine Site have been removed from future CREMP studies.

In the long-term, sediment sampling under the CREMP will be conducted every three years, coinciding with biological monitoring studies. However, Baffinland will conduct sediment quality sampling in annually for the first three years of mining. After monitoring three operating (mining) years, the sediment sampling program will be conducted on a three year cycle, consistent with the Environment Canada (2012) recommendations for EEM sampling.

Additional details regarding the CREMP sediment quality sampling program are presented in Appendix B. CREMP sediment quality and benthic monitoring stations recommended by Minnow are shown in Figures 4.4 and 4.5.

Figure 4-4 Recommended CREMP Sediment and Benthic Monitoring Stations Following the 2015 Program

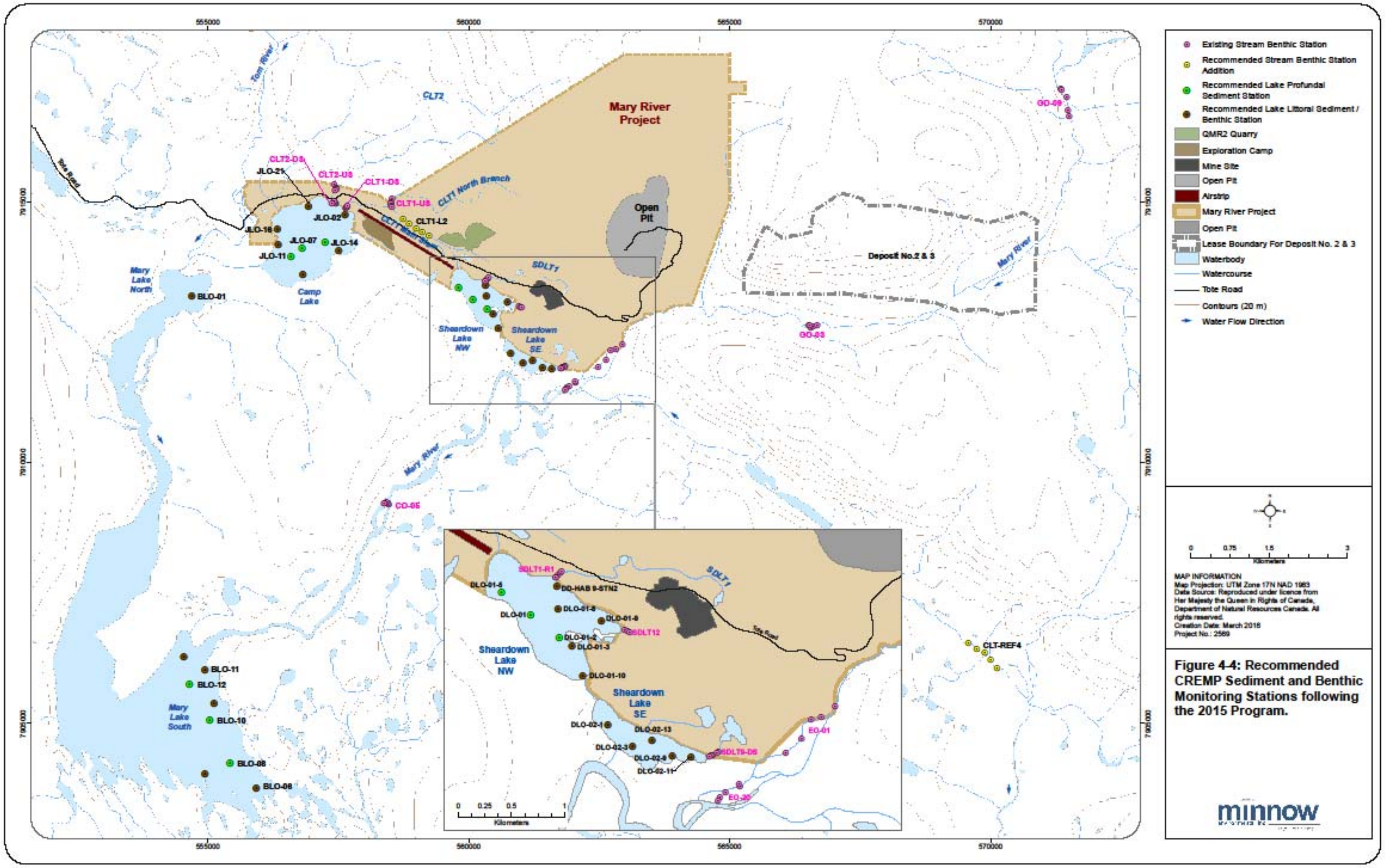
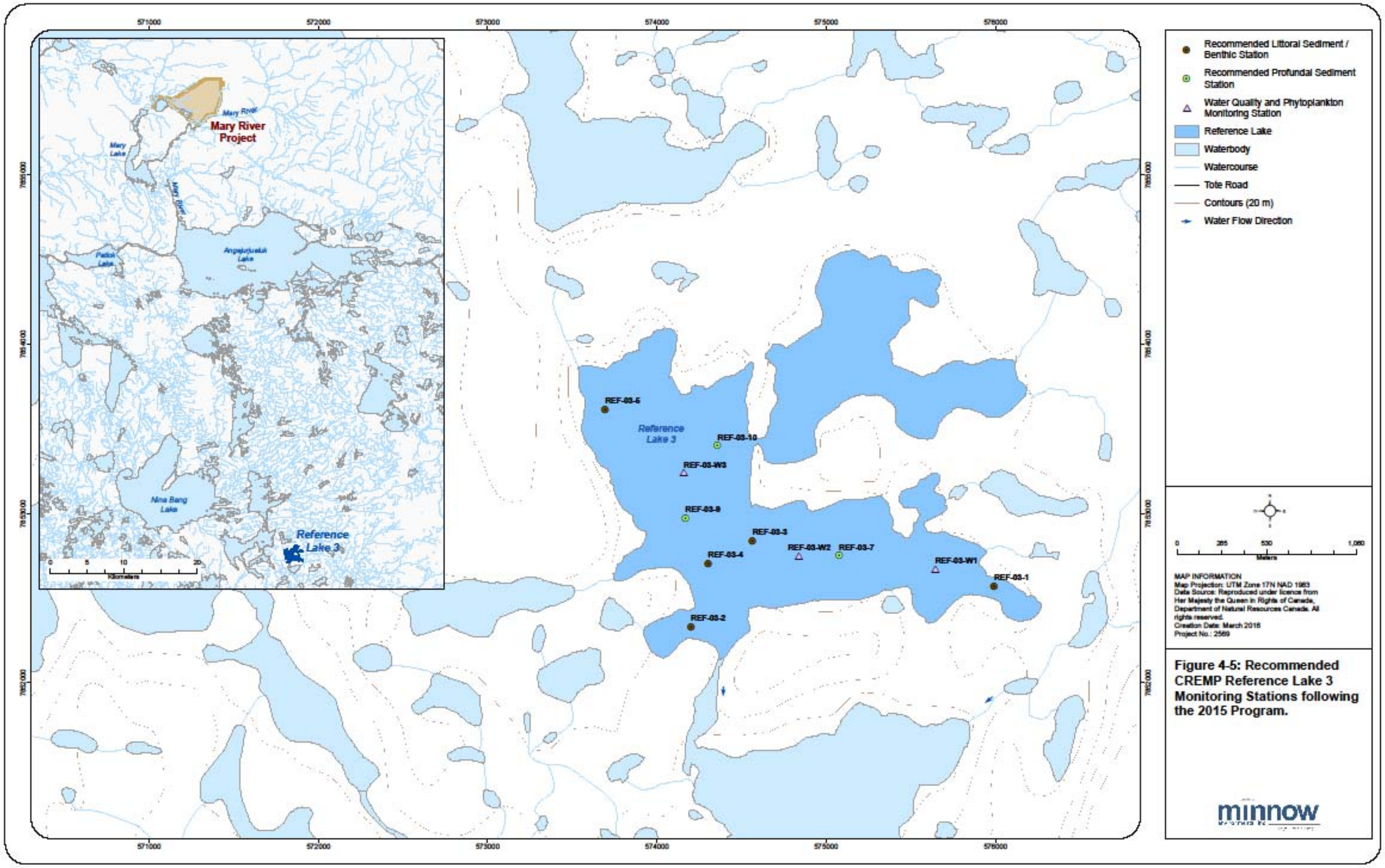


Figure 4-4: Recommended CREMP Sediment and Benthic Monitoring Stations following the 2015 Program.

Figure 4-5 Recommended CREMP Reference Lake 3 Monitoring Stations following the 2015 Program



Phytoplankton

The following section provides a description of monitoring of phytoplankton under the CREMP, with an emphasis on monitoring of lakes in the Mine Area, where potential for eutrophication is greatest.

The key pathways of potential effects of the Project on phytoplankton communities include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources on phytoplankton abundance in Mine Area lakes?

The primary issue of concern with respect to the phytoplankton community is related to nutrient enrichment and eutrophication, though effects on water clarity (e.g., changes in TSS) could also affect primary productivity. As such, the CREMP and the baseline data review presented in Appendix E focused upon waterbodies most at risk to eutrophication in relation to pathways of effect for the Project; in general, lakes (rather than streams) are most vulnerable to eutrophication in the mine area. Sheardown Lake NW has received treated sewage effluent discharge during the construction phase and may also be affected by dust deposition, stream diversions, and non-point sources. Although treated sewage effluent will be discharged to the Mary River during the operation phase, Mary Lake is the ultimate receiving environment for all point sources in the Mine Area, including discharge of treated sewage effluent, and is more vulnerable to effects of nutrient enrichment due to its lacustrine nature.

The selected indicator will be chlorophyll *a* and the benchmark will be 3.7 µg/L. Further description on the selection of a suitable indicator and derivation of the benchmark is provided in Section 5.3.4.

The monitoring area for phytoplankton includes mine area lakes, specifically Camp Lake, Mary Lake and Sheardown Lake NW and SE as well as selected streams. In addition, monitoring will be conducted at Reference Lake 3. (NSC, 2014b; Appendix F). Chlorophyll-a will be sampled at all water quality stations and will coincide with water quality sampling events..

Sampling will be conducted annually during the initial three years of mine operation. However sampling frequency will be evaluated regularly (i.e., each year) to determine if modifications are warranted. Chlorophyll-a sampling in lakes will consist of two open-water periods (summer and late summer/fall) and once in late winter (April/May). Streams will be sampled three times in the open-water season (spring, summer, fall). Sampling of phytoplankton biomass and taxonomy will occur twice a year (summer and late summer/fall).

Phytoplankton data will be assessed during each year of monitoring and will follow the assessment framework presented in Section 5.2. The phytoplankton CREMP study design and review of baseline data is described in detail in Appendix E.

4.2.4 Benthic Invertebrates

Key questions were developed to guide the design of the monitoring program. These questions and metrics focus upon key potential effects identified in the FEIS, as well as metrics commonly applied for characterizing the BMI community.

The key pathways of potential effects of the Project on the BMI community include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Changes in sediment quality due to effluent discharge and/or dust deposition;
- Dust deposition in aquatic habitat (i.e., sedimentation); and
- Effects of the Project on primary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, aquatic habitat loss or alteration, sedimentation, and changes in primary producers on BMI abundance and community composition in Mine Area lakes?

A description of the selection of BMI indicators and derivation of benchmarks is provided in Section 5.3.5.

The Overall objective of this program is the evaluation of mine related influences to benthic invertebrates in the Mine Area lakes and streams. The benthic invertebrate community survey is one of a main tools utilised for assessing mine-related influences on biota

The monitoring area for BMI includes Mine Area lakes, specifically Camp, Sheardown NW and SE, and Mary lakes, and Sheardown Lake tributaries 1, 9, and 12, several sites on the Mary River located upstream and downstream of effluent discharges, and Camp Lake tributaries 1 and 2. In addition, monitoring will be conducted at Reference Lake 3 along with BMI reference stream station CLT-REF4.

Benthic invertebrate composition, distribution and relative abundance of dominant groups, including metal-sensitive taxa, naturally differ significantly between littoral (shallow) and profundal (deep) habitats of area lakes. The sampling of benthic invertebrates at profundal depths can confound the evaluation of mine related effects on biota due to the fact that at deeper depths natural factors, such as low oxygen and food resources, become more important drivers in shaping BMO community structure than mine-related contaminants. Because of this, Minnow has recommended that benthic invertebrate community sampling stations be established solely in littoral habitats. Five (5) replicate stations will be sampled in each lake and will coincide with each study lakes five (5) littoral sediment quality stations.. Utilizing the same littoral stations for both sediment quality and benthic invertebrate community sampling will provide supporting information for interpretation and analysis of benthic invertebrate results (e.g., metals concentrations) and allow the CREMP to establish potential linkages between sediment metal concentrations and their potential effects on benthic invertebrates. Recommended BMI community monitoring stations by Minnow are presented in Figure 4.4

Figure 4.4 has also been updated to reflect Minnow's additional recommendations of (1) discontinuing BMI monitoring on the two upper reaches of Sheardown Lake Tributary 1, (2) adding BMI monitoring station CLT1-L2 near water quality station L2-03 to monitor the effect of mine-influenced water quality changes on BMI communities and (3) establishing a stream reference BMI community station at CLT-REF4.

Timing of sampling will be concentrated within a single sampling season; benthic invertebrate sampling has been consistently conducted in the mine area in late summer/fall. This is an ecologically relevant time for sampling and is most appropriate considering the effluent discharge regime (i.e., discharge during the open-water season only), hydrology (i.e., streams/rivers freeze solid), and dust deposition (i.e., introduction during the open-water season).

As existing baseline data for Reference Lake 3 and stream reference station CLT-REF4 are minimal the monitoring program will primarily focus upon before-after comparisons of key metrics within the mine area waterbodies, with an emphasis on mine area lakes.

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency will be evaluated (i.e., each year of monitoring) to determine if modifications are warranted.

BMI data will be assessed during each year of monitoring and would follow the assessment framework presented in Section 5.2. The BMI CREMP study design and baseline data review is described in detail in Appendix E.

4.2.5 Fish (Arctic Char)

Key questions were developed to guide the design of the fish monitoring program. The key pathways of potential residual effects of the Project on Arctic Char include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and CLT-1);
- Water quality changes related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);

- Water quality changes due to deposition of dust in lakes and streams (mine area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (mine area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Dust deposition (i.e., sedimentation) in Arctic Char spawning areas (habitat) and on Arctic Char eggs; and
- Effects of the Project on primary and secondary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, sedimentation, habitat loss or alteration, and changes in primary or secondary producers on Arctic Char in mine area lakes (Sheardown Lake NW and SE, Camp Lake, and Mary Lake) and streams?

Given that there are only two fish species present in the area, fish monitoring in the mine area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback are absent or uncommon in a number of waterbodies. For these reasons only a single species, Arctic Char, will be targeted under the CREMP.

Non-lethal sampling methods will be used to the extent possible to minimize impacts of monitoring on the Arctic Char populations. As a result, metrics that can be reliably obtained from live fish will be included in CREMP. Metrics will include indicators of fish growth, condition, and reproduction. The evaluation and selection of indicators and benchmarks for Arctic Char are presented in Section 5.3.6.

The monitoring area for Arctic Char includes mine area lakes, specifically Camp Lake, Mary Lake and Sheardown Lake NW and SE. Monitoring of lakes is a key component of the CREMP because the mine area lakes provide overwintering and spawning habitat, support the full range of age classes, and because they may be affected differently than streams. In addition, monitoring will be conducted at Reference Lake 3, and potentially in one reference stream.

The lake-based Arctic Char sampling program is designed to be non-lethal and is based upon Environment Canada's EEM survey design (EC 2012). As such, the lake-based sampling program is focused upon obtaining measures of metrics for juvenile and adult fish using standardized sampling methods (i.e., standard gang index gillnetting and shoreline backpack electrofishing).

After completing the 2015 CREMP field program, Minnow recommended two (2) modifications to the CREMP adult Arctic char survey in order to reduce the amount incidental mortalities and optimize gill net capture rates.

1. Reduce the non-lethal adult Arctic char sample size to 50 fish per study lake and;
2. Standardize mesh size of gill nets used to optimize capture rates for adult Arctic char.

Based on data collected during the 2015 CREMP, power analysis conducted by Minnow indicated that total samples sizes for the adult fish survey can be reduced by half (i.e. 50 fish) while still maintaining the ability to detect changes between lakes and/or between study periods with sufficient power.

Additionally, during the 2015 CREMP the majority of adult Arctic char were captured in net mesh sizes ranging from 38 – 64 mm, which was also similar to the most efficient mesh size used to capture adult Arctic char during previous CREMP studies. As a result, the fish CREMP study design has been modified to reflect these recommendations.

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency should be regularly evaluated (i.e., each year of monitoring) to determine if modifications are warranted. Lake monitoring will occur in late summer/fall near the end of the growing season.

Fish data will be assessed during each year of monitoring and would follow the assessment framework presented in Section 5.2. The fish CREMP study design and baseline data review is described in detail in Appendix E.

4.3 TARGETED STUDIES

As described in Section 1, specific effects monitoring (or targeted monitoring) programs/studies have been identified to address specific questions or potential impacts. These are programs or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Study, Dustfall Monitoring Program, and the Stream Diversion Barrier Study are the targeted studies identified in this AEMP.

4.3.1 Lake Sedimentation Monitoring Program

A specific effects monitoring study will be conducted to monitor effects related to the introduction of dust, and other sources of suspended solids, in surface waters and subsequent deposition in aquatic habitat (NSC, 2014c; Appendix G).

Sedimentation rates will be monitored in Sheardown Lake NW through deployment of sediment traps, as described in detail in Appendix G. In brief, the program will involve year-round deployment of sediment traps in different lake habitat types for the analysis of total dry weight of sediment. Traps will be emptied and redeployed after ice-off and in fall to provide measures of seasonal (i.e., open-water and ice-cover season) deposition rates. This sampling program was initiated in 2013 and is currently on-going. Through comparisons of the measured sedimentation at Sheardown Lake NW to sedimentation amounts known to adversely affect salmonid egg survival that are available from published literature, the current lake sedimentation monitoring program will provide a strong scientific basis for the determination of any sediment deposition effects on Arctic char egg survival at Sheardown Lake NW.

4.3.2 Dustfall Monitoring Program

The amended NIRB Project Certificate No. 005 included requirements for dustfall monitoring. In 2013, Baffinland implemented a dustfall monitoring program as part of the TEMMP that meets the requirements (Baffinland, 2014). A description of this program is included in Appendix H. The dustfall monitoring program consists of operating dustfall buckets positioned along transects radially out from the main development areas: Milne Port, the Tote Road and the Mine Site, along with reference dustfall monitoring stations. Dustfall measurements (the amount of dustfall per unit time) will be completed seasonally (summer and winter) and the dustfall will be analyzed to determine the metals composition of the dust.

The dustfall monitoring results will be reviewed to estimate the seasonal deposition (rates, quantities) and chemical composition of dust entering aquatic systems along representative distance transects at right angles to the Tote Road and radiating outward from Milne Port and the Mine Site, as per PC Condition #21.

4.3.3 Initial Stream Diversion Barrier Study

A streamflow reduction barrier study was identified as a follow-up program in the FEIS (Baffinland, 2012). The Initial Stream Diversion Barrier Study is presented in Appendix I (Knight Piésold, 2014c).

The primary objectives of the study are to monitor the effects of both increases and reductions in streamflow at several mine site streams and to further understand how Project-related reductions in streamflow may result in the creation of fish barriers that have the potential to occur at low flows. The monitoring program may identify the need for mitigation measures to address Project-related fish stranding.

The initial study conducted in 2013, focused on obtaining a better understanding for baseline flow conditions and, in particular, the frequency and duration of the occurrence of fish barriers and fish stranding in five (5) mine site streams (see Figure 1.1):

- CLT-1;
- CLT-2;
- SDLT-1;
- SDLT-9;
- And SDLT-12.

This initial study was exploratory in nature with the following objectives (which contribute to the primary objectives stated above):

- Develop an understanding of low-flow conditions that may result in barriers to fish passage within two tributaries of Camp Lake and three tributaries of Sheardown Lake; and
- Document fish presence throughout the stream length under various flow conditions. It is important to document upstream access during spring freshet, since high water velocities in the spring can prevent fish passage. It is also important to document the downstream passage of fish in the fall, when they are returning to overwintering habitat in the lakes.

The five streams of interest were monitored in the spring and fall of 2013. Low and high flow periods were targeted where possible. In spring, all five streams were visually assessed to monitor for potential barriers and obstructions to upstream fish passage. Surveys documented conditions within the monitoring streams between the upstream fish barriers and their outlets into Camp Lake and Sheardown Lake. Implementation of these visual assessments by an experienced biologist allowed for the effective determination of whether perceived barriers resulted in the prevention of fish migration within each tributary, and thus electro fishing surveys were not deemed necessary for the assessment. During the 2013 field program, the combination of visual observations of barriers, fish presence and associated flows at the time of the survey were used to determine the conditions in which fish migration will be limited within each tributary under various flow conditions

Other monitoring programs will contribute data relevant to this study. For example, Baffinland`s hydrology monitoring program includes stream gauges on three streams monitored under this program, and the freshwater biota monitoring will be undertaken as part of the CREMP. Monitoring data from both these programs will be used in the analysis of data from this initial stream diversion monitoring study.

Since the stream diversion barrier study was identified in the FEIS, Baffinland started operating under an Early Revenue Phase (ERP) of the Project (Baffinland, 2013). The ERP involves mining 3.5 million tonnes per annum (Mt/a) of iron ore. The iron ore is transported year-round by truck to Milne Port and then to market by ship during the open water season. Baffinland has contemplated a 5-year operating plan for the ERP, after which time the full-scale railway project would also be brought on-line. However, the development of the railway will be subject to a commercial decision by Baffinland to proceed and will be heavily influenced by both market conditions and available financing.

The reduced production rate associated with the ERP will result in a considerably smaller mining footprint (open pit and waste rock stockpile) than was originally envisioned with Project-related stream diversions during the ERP being negligible. As a result, this study was discontinued for the next several years following the initial 2013 field program.

Resumption of of this monitoring program will depend upon the schedule and size of the Project. The Approved full scale Project (18 Mt/a) will result in meaningful reductions in streamflow and therefore monitoring under this program will be required to identify Project-related fish barriers and fish stranding. If possible, monitoring for the Approved Project will start one year prior to the start of larger scale mining.

5 ASSESSMENT APPROACH AND MANAGEMENT RESPONSE

5.1 OBJECTIVES

As stated in Section 1, the AEMP is a monitoring program designed to:

- Detect short-term and long-term effects of the Project's activities on the aquatic environment resulting from the Project;
- Evaluate the accuracy of impact predictions;
- Assess the effectiveness of planned mitigation measures; and
- Identify additional mitigation measures to avert or reduce unforeseen environmental effects.

Monitoring data will be collected from the various programs. A common approach for the assessment of data and the implementation of a management response will be applied to all AEMP monitoring programs.

5.2 ASSESSMENT APPROACH AND RESPONSE FRAMEWORK

Monitoring data collected through the AEMP requires a systematic data evaluation process, as well as management responses that would be taken, in response to certain data evaluation outcomes. A common assessment (data evaluation) and management response framework will be implemented, as outlined on Figure 5.1.

This multi-step process includes the following:

Step 1 - Data Management and Evaluation

This step includes the QA/QC; comparisons to the AEMP benchmark and to reference and/or baseline; and review of the data using various tools such as Exploratory Data Analysis (EDA) and Statistical Data Analysis (SDA), to determine if change is occurring. A change may be detected statistically or qualitatively, relative to benchmarks, baseline values and/or spatial or temporal trends. A change may be statistically significant, but professional judgement will also be applied using the various evaluation tools to detect a change qualitatively.

If Step 1 does not detect change, then no action is required. If a change is observed, then further evaluation of the data for that/those indicator(s) will be carried out under Step 2.

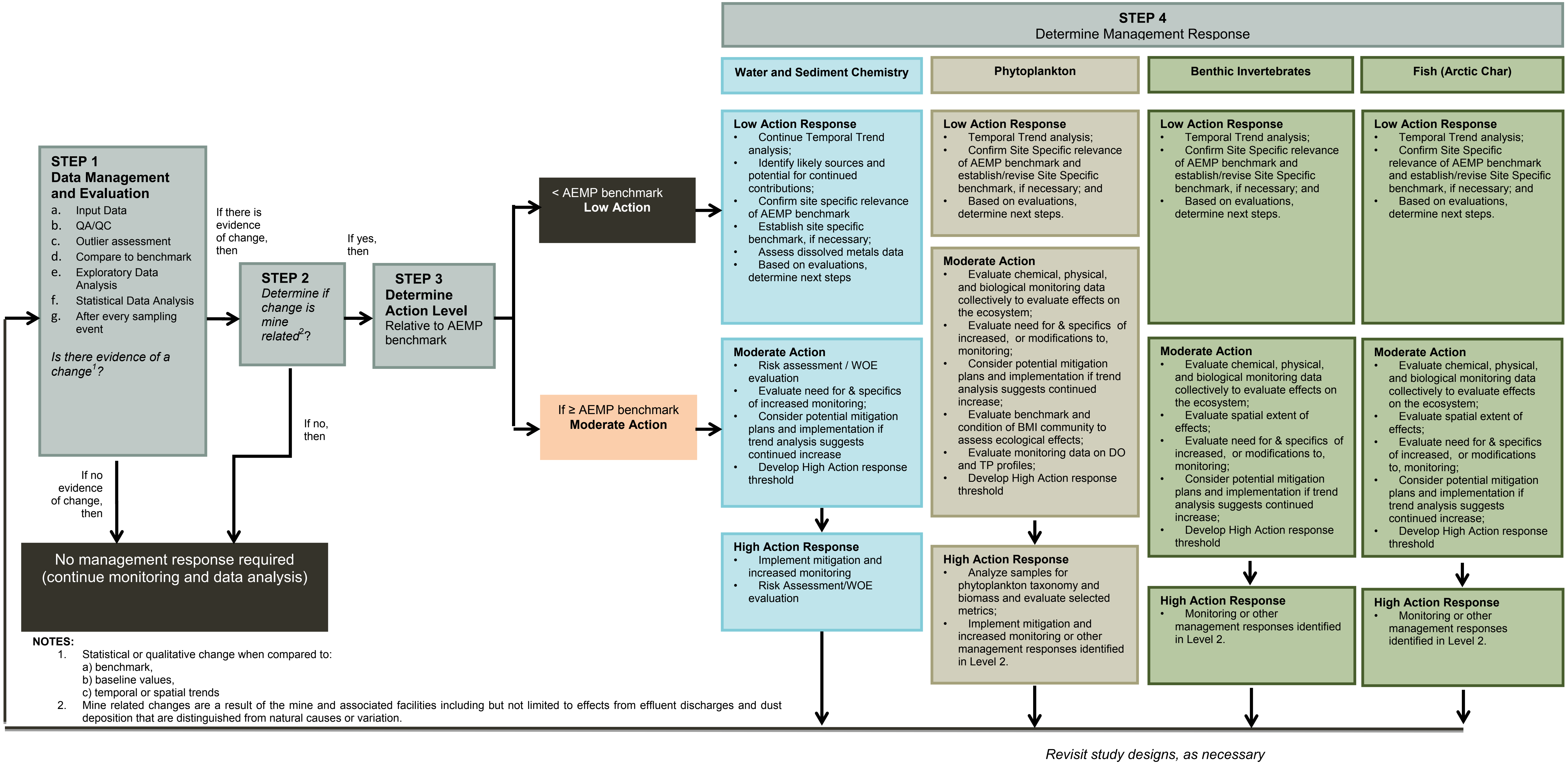
Step 2 – Determining Whether the Observed Change is Mine-Related

Step 2 involves determining if the changes in the indicator(s) of concern are due to the Project or due to natural variability or other causes.

Project activities with the potential to induce the observed change will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

This question will be addressed using EDA and subsequently using SDA. EDA will be completed to visualize overall data trends, and could include evaluating spatial patterns, to examine the spatial extent and pattern of observed changes.

Figure 5-1 Data Assessment Approach and Response Framework



NOTES:

1. Statistical or qualitative change when compared to:
   a) benchmark,
   b) baseline values,
   c) temporal or spatial trends
2. Mine related changes are a result of the mine and associated facilities including but not limited to effects from effluent discharges and dust deposition that are distinguished from natural causes or variation.

The exploratory data analyses could include comparisons of data from Mine Area streams to data from reference streams and comparisons of Mine Area Lakes to reference lake(s). This can further assist with determining whether the observed changes were due to natural variability or the Project. Graphical analyses may be used to confirm assumptions required for statistical testing (normality, sample size, independence). Differences in fish and other biotic endpoints between mine-exposed and reference areas will be preferentially tested using pair-wise, single factor ANOVA. Prior to ANOVA, all data will be evaluated for normality and homogeneity of variance to ensure that applicable statistical test assumptions will be met. In instances in which normality cannot be achieved through data transformation, non-parametric Mann-Whitney U-test statistics will be used to confirm the statistical results from the ANOVA using transformed data. Similarly, in instances in which variances of normal data could not be homogenized by transformation, pair-wise comparisons will be conducted using Student's t-tests assuming unequal variance to confirm the statistical findings of the ANOVA tests. SDA will be used as outlined in the individual assessment frameworks and can be applied to the parameters of interest to test the primary hypothesis for the effects of mine-related change.

If the Step 2 analysis concludes that the changes in water quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

Step 3 - Determine Action Level

If the evaluation conducted in Step 2 has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark. Three levels of action have been identified: low, moderate, and high; and the response actions range from increased monitoring and data analysis (e.g., trend analysis); identification of possible sources; to risk assessment and/or mitigation. The specifics for each aquatic component (water and sediment quality, phytoplankton, benthic invertebrates and arctic char) are summarized in Figure 5.1 and are described further in each of the component study designs. Below is a generic description of each of the levels of response.

If the benchmark is not exceeded, a **low action response** would be undertaken and could include any number of potential responses, including the following:

- Evaluate temporal trends
- Identify likely source(s) and potential for continued contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Further evaluation of data (for example, for water quality, review dissolved metals data or supporting variables).
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be Project-related, a **moderate action level response** would be undertaken and could include, in addition to analyses identified for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with the indicator that has changed, to evaluate effects on the ecosystem
- Evaluate the need for and specifics of increased monitoring

- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in the indicator parameter(s) of concern on the lakes as a whole. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Level 2 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) could include:

- Implementation of increased monitoring to further assess the potential for effects and/or define magnitude and spatial extent if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

The specifics of how the framework is implemented are described in the individual study designs in the appendices.

5.3 INDICATORS AND BENCHMARKS

Indicators are measurable parameters that can be used to detect change in the environment. Benchmarks are established for various indicators to establish the point at which actions will be triggered before unacceptable adverse effects occur (INAC, 2009). Benchmarks have been identified for each of the aquatic components to be monitored at the mine.

5.3.1 Process for Developing Water and Sediment Quality Benchmarks

Since the Mine Site occurs within an area of metals enrichment, generic water quality and sediment guidelines established for all areas within Canada may naturally be exceeded near the Mine Site. Therefore, the selection of appropriate benchmarks must consider established water and sediment quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME), as well as site-specific natural enrichment, and other factors such as Exposure Toxicity Modifying Factors (ETMF), including pH, water hardness, dissolved organic carbon, etc. (CCME, 2007).

The assessment of surface water and sediment quality data over the life of the Project will be on-going, and the identified benchmarks may change throughout this process, as more data become available. For example, an AEMP benchmark established early on in the life of the mine may require updating in 10 years to a site-specific water quality objective (SSWQO), based on new published literature which has become available, or site specific toxicity tests conducted to further understand ETMF or resident species toxicity. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

The approach for benchmark development involved the following steps:

- Determine, using the FEIS, which substances are present at naturally elevated concentrations, and/or those that could be released at elevated concentrations as a result of mining activities, into the future, as well as substances regulated or potentially regulated under the MMER;
- Evaluate baseline data, and determine a statistical metric of baseline levels which is considered representative of background for any naturally occurring substances (metals/metalloids);
- Evaluate national (CWQG-PAL or CSQG-PAL) or other relevant guidelines from other regulatory jurisdictions, where appropriate. Appropriate guidelines could include Site-Specific Water Quality Objectives (SSWQOs) developed using data from the Mary River area, or from other northern Mine sites, where data are appropriate; and
- Select the higher of either baseline or regulatory or SSWQO as the benchmark for the AEMP.

During 2014 and 2015, Intrinsik Environmental Sciences Inc. was retained by Baffinland to develop water and sediment quality benchmarks to be applied in the CREMP. The specifics of the benchmark selection process for both sediment and surface water are outlined in Appendix C and D, with a summary provided herein.

5.3.2 Water Quality Benchmarks

Selection of Substances for Benchmark Development

Based on the baseline data collected between 2005 and 2013, and the outcomes of the FEIS, substances having the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities in lake water were identified as requiring AEMP benchmarks. In addition, metals regulated or which may be potentially regulated under MMER for base metal mines (as a result of the current re-evaluation of the MMER regulations) were similarly considered for benchmark development. The substances of interest shortlisted for benchmark development in surface waters were as follows:

- Metals/Metalloids: Al, As, Cd, Cr, Co, Cu, Fe, Pb, Ni, Ag, Tl, V, Zn; and
- General Parameters and Nutrients: Chloride, Sulphate, Ammonia, Nitrite, Nitrate.

In addition, numerous parameters will be evaluated in the Exploratory Data Analysis (Step 1 of Assessment Framework), including pH, DO, hardness, TSS, Alkalinity, Mg, P, K, Total Organic Carbon and Dissolved Organic Carbon, to monitor potential change. If changes in these substances are noted, benchmarks can be developed at a later stage.

Baseline Data Evaluation

Data treatment conducted in the water and sediment quality baseline review (Knight Piésold, 2014a; Appendix B) involved the following steps:

- Removing all duplicate samples, to avoid “double counting” of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Where detection limits were elevated compared to later sampling events, they were substituted with lower detection limits (Appendix B).

A detailed assessment of the lake and river/stream data is presented in the Water and Sediment Quality CREMP Study Design and the baseline review in the appendices (Appendix B). A summary of trends observed in lakes and rivers, respectively, in addition to how the data were treated for benchmark development is as follows (details are provided in Intrinsik, 2014; Appendix C):

- Geographic trends between discrete sampling sites within lakes were not observed in Camp Lake or Sheardown Lake NW, although some substances were elevated within Mary Lake at the inlet. No geographic trends were observed within Mary River, but within Camp Lake Tributary, Station L0-01 had higher concentrations of several substances;
- Within lakes, distinct depth trends were not observed for Camp Lake, Mary Lake or Sheardown Lake NW and lakes were considered to be completely mixed (Knight Piésold, 2014; Appendix B), with the exception of aluminum in Sheardown Lake NW. This suggests that combining the shallow and deep datasets would be appropriate (with the exception of aluminum), since the shallow and deep samples were collected on the same day at the same site. The possible effects of pseudoreplication (since both shallow and deep samples were taken on the same day) were explored, and deemed to be not significant, and hence, these samples were combined.
- An evaluation of the water quality samples from Sheardown Lake NW, Sheardown Lake SE and Sheardown Lake near shore was also undertaken, to determine if these datasets could be combined to calculate a lake-specific AEMP benchmark, and it was concluded that this was a reasonable approach.
- Seasonality was observed for several substances in lakes (e.g., Aluminium had higher concentrations in summer in all lakes; whereas copper, nickel and/or arsenic tended to have higher concentrations in winter).

For the purposes of water quality benchmark development, each water body was assessed separately. Statistical summaries are provided in Appendix C of all lakes and rivers, with respect to minimum, maximum, % detects, mean, median, 95th percentile, and 97.5th percentile for each substance of interest (Intrinsik, 2014).

The typical starting point for assessment of surface water data collected in any aquatic effects monitoring program are the Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life (CWQG-PAL) values, established by the Canadian Council of Ministers of the Environment (CCME, various years, with updates up to 2012). These guidelines reflect the most current scientific data at the time they were developed, and are intended to provide protection to all forms of aquatic life and aquatic life cycles, including the most sensitive life stages, at all locations across Canada (CCME, 2007). Since they are generic and do not account for site-specific factors that can alter toxicity, these national guidelines can be modified using widely accepted procedures, to derive site-adapted or site-specific guidelines or objectives for a given project or location (CCME, 2003).

The focus of AEMP benchmark development was on total metals, since available CWQG-PAL focus on total metals benchmarks, as opposed to dissolved metals data. Dissolved data will be assessed under the Assessment Approach and Response Framework in the Low Action Response (Step 3 of Figure 5.1) to examine trends, and where deemed appropriate, based on assessment of both dissolved and total analyses, dissolved benchmarks will be considered for development if data are suggesting mine-related increases are occurring. Dissolved water quality guidelines are available for some parameters from the US EPA (2014), as well as British Columbia Ministry of Environment, and these guidelines would be considered as a first point of comparison, in conjunction with baseline levels, as well as SSWQO, where appropriate.

The approach for selecting water quality benchmarks was the following:

- Select CWQG-PAL guideline, where available or a SSWQO, if already derived;
- Where CWQG-PAL are not available, or are not considered relevant, a surrogate guideline from another jurisdiction was selected (e.g., provincial water quality guideline; US EPA; relevant guideline from another operator, etc.);
- In addition, baseline data was assessed, and a statistical metric of baseline levels (e.g., 97.5th percentile of baseline data) for any naturally occurring substances (metals/metalloids) was calculated;
- The higher of the CWQG-PAL/surrogate guideline or natural baseline was selected as the benchmark;
- Where no water quality guidelines are available, the 97.5th percentile was selected to represent the benchmark;
- Where data had <5% detected values, the higher of the water quality guideline (where available), or 3 times the method detection limit (MDL) was selected;
- Where modifications were required based on site-specific parameters, such as hardness or pH, the 25% percentile hardness and 25% percentile pH values for the water body in question was used in order to calculate a protective guideline. For ammonia, the 75th percentile temperature and pH were used to calculate the guideline. Where parameters are trending up towards these benchmarks, site-specific values should be substituted for comparison purposes (in Low Action).
- Where no CWQG-PAL guideline was available for a substance of interest, a BC MOE (Ministry of the Environment) Approved or Working guideline for the water column were used, where available (BC MOE, undated website). In addition, several water quality guidelines established by the CCME are currently under revision (i.e., lead and iron) or have been released in draft form for comments (silver). Once finalized, these revised benchmarks should be evaluated, using the benchmark selection process outlined, and benchmarks updated accordingly. Details on the specific guidelines selected are presented in Appendix C (Intrinsik, 2014).

Based on the approach used, proposed water quality benchmarks for area lakes and rivers are presented in Tables 5.1 and 5.2, respectively. In most cases, the recommended AEMP benchmarks are consistent between lakes and rivers, with the vast majority of selected benchmarks being regulatory water quality guidelines.

Table 5.1 Selected Water Quality Benchmark Approach and Values for Mine Site Lakes

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
Metals [3]							
Aluminium	mg/L	0.1	0.026	0.137	0.179 (Shallow) 0.173 (Deep)	CL = 0.1 ML = 0.13; SDL shall/deep = 0.179/0.173	A (CL), B (ML/SDL)
Arsenic	mg/L	0.005	NC	0.00018	0.0001	0.005	A
Cadmium	mg/L	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	NC	0.000023	0.000017	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	A
Chromium	mg/L	NGA	NC	0.001	0.000641	0.0003 (CL) (ML) = 0.0005[8] (SDL) = 0.000642[9]	B (ML/SDL), C (CL)
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	NC	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	0.001	NC	0.003 – 0.015	C

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
						(CL)[5] 0.003 (ML/SDL)[5]	
Cobalt	mg/L	0.004	NC	NC	0.0002	0.004	A
Copper	mg/L	0.002	0.0113	0.00239	0.00243	(CL) = 0.004[7] (ML) = 0.0024 (SDL) = 0.0024	B
Iron	mg/L	0.3	0.0421	0.173	0.211	0.3	A
Lead	mg/L	0.001	0.000334	0.00013	0.00026	0.001	A
Nickel	mg/L	0.025	0.000941	0.00080	0.000973	0.025	A
Silver	mg/L	0.0001	NC	NC	0.0000104	0.0001	A
Thallium	mg/L	0.0008	NC	NC	0.0001	0.0008	A
Vanadium	mg/L	0.006	NC	0.00146	0.001	0.006	A
Zinc	mg/L	0.030	0.0037	0.003	0.00391	0.030	A
Water Quality Parameters							
Chloride (Cl^-)	mg/L	120	4	13	5	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[4]	0.84	0.32	0.44	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.1[6]	0.1[6]	0.1[6]	0.060	A
Nitrate (NO_3)	mg N/L	13	NC	0.11	NC	13	A
Sulphate	mg/L	218	3	7	5	218	A

NOTES:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; CL = CAMP LAKE; ML = MARY LAKE; SDL = SHEARDOWN LAKE.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. TOTAL METALS UNLESS OTHERWISE NOTED.
4. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH OF 8.
5. THE 2013 DETECTION LIMIT FOR Cr^{6+} INCREASED IN 2013 FROM 0.001 to 0.005, HENCE THIS AFFECTS THE 3* MDL CALCULATION FOR THE BENCHMARK IN CAMP LAKE. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE LOWER OF THE 2 BENCHMARKS WOULD THEN BE APPLIED IN CAMP LAKE. IF DETECTION LIMITS IMPROVE, METHOD A (SELECTION OF THE GUIDELINE) MAY BE IMPLEMENTED.
6. THESE VALUES ARE ELEVATED DETECTION LIMITS, AND HENCE, THE GUIDELINE HAS BEEN SELECTED AS THE AEMP BENCHMARK.
7. THE MAXIMUM VALUE OF 0.0113 MG/L COPPER WAS REMOVED TO CALCULATE THE 97.5TH PERCENTILE, AS THIS VALUE APPEARS TO BE AN OUTLIER.
8. AN ELEVATED DETECTION LIMIT OF 0.001 MG/L WAS REMOVED FROM THE DATASET AND CALCULATIONS, AND THE AEMP SELECTED WAS THE 97.5th PERCENTILE, WHICH IS 0.0005 mg/L.
9. SEVERAL DETECTED VALUES RANGING FROM 0.00079 - 0.00316 mg/L Cr HAVE BEEN REPORTED IN THE DATASET FOR SDL, AND HENCE, THESE VALUES WERE CONSIDERED TO REPRESENT BASELINE, AND WERE INCLUDED IN THE 97.5th PERCENTILE CALCULATION.

Table 5.2 Selected Water Quality Benchmark Approach and Values for Mine Site Streams

Parameter	Units	Water Quality Guideline	Camp Lake Tributary	Mary River[3]	Selected Benchmark	Benchmark Method
Metals[4]						
Aluminum	mg/L	0.1	0.179	0.97	CLT = 0.179 MR = 0.966	B
Arsenic	mg/L	0.005	0.00012	0.00013	0.005	A
Cadmium	mg/L	0.00008 (CLT) 0.00006 (MR)	NC	0.00002	CLT = 0.00008 MR = 0.00006	A
Chromium	mg/L	NGA	0.000856	0.0023	CLT = 0.000856 MR = 0.0023	B
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	NC	0.003[5]	C
Cobalt	mg/L	0.004	NC	0.0004	0.004	A
Copper	mg/L	0.002	0.00222	0.0024	CLT = 0.0022 MR = 0.0024	B
Iron	mg/L	0.3	0.326	0.874	CLT = 0.326 MR = 0.874	B
Lead	mg/L	0.001	0.000333	0.00076	0.001	A
Nickel	mg/L	0.025	0.00168	0.0018	0.025	A
Silver	mg/L	0.0001	NC	0.0001	0.0001	A
Thallium	mg/L	0.0008	0.0002	0.0002	0.0008	A
Vanadium	mg/L	0.006	NC	0.002	0.006	A
Zinc	mg/L	0.030	0.0035	0.01	0.030	A
Water Quality Parameters						
Chloride (Cl^-)	mg/L	120	23	21.55	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[6]	0.60	0.60	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.095[7]	0.06	0.060	A
Nitrate (NO_3)	mg N/L	13	0.118	0.14	13	A
Sulphate	mg/L	218	6	8	218	A

NOTES:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; MR = MARY RIVER; CLT = CAMP LAKE TRIBUTARY.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. ONE SAMPLE (OUTLIER) CONTAINING CHEMICAL CONCENTRATIONS ORDERS OF MAGNITUDE ABOVE OTHER VALUES WAS NOT INCLUDED IN THE CALCULATIONS FOR MARY RIVER.
4. TOTAL METALS UNLESS OTHERWISE NOTED.
5. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE HIGHER OF THE METHOD A OR C WOULD THEN BE APPLIED AS THE AEMP BENCHMARK.
6. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH of 8.0.
7. 97.5th PERCENTILE IS BEING DRIVEN BY ELEVATED DETECTION LIMIT, THEREFORE, THE GUIDELINE WAS SELECTED.

In most cases, the benchmarks are consistent between lakes and streams, with the vast majority of selected benchmarks being generic WQOs (i.e., CWQG-PAL or surrogate). Where natural concentrations varied, and exceeded available WQOs, or < 5% of values was detected, recommended benchmarks varied.

5.3.3 Sediment Quality Benchmarks

Selection of Substances for Benchmark Development

Based on the baseline data collected between 2005 and 2014, and the outcomes of the FEIS, the following substances have the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities. Therefore, these substances merited benchmark development:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Iron;
- Manganese;
- Nickel; and
- Phosphorus.

In addition, lead, mercury and zinc were also included for benchmark development, as CCME sediment quality guidelines exist for these substances. Further details are presented in Appendix D (Intrinsik, 2015).

Baseline Data Evaluation

Data treatment conducted in the Water and Sediment Quality Baseline Review (Knight Piésold, 2014; Appendix B) involved the following steps:

- Removing all duplicate samples, to avoid “double counting” of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Review of sediment quality laboratory detection limits.

Additional assessment of baseline data was conducted to examine metals concentrations relative to depositional characteristics of sampling locations, in order to explore the relationships between depositional characteristics (such as Total Organic Carbon (TOC) (e.g., high TOC represents a higher propensity to accumulate metals) and presence of sand (% sand; e.g., high sand content would represent lower potential for accumulation of metals, due to lower binding potential), and metal concentrations (Appendix B). This assessment concluded that all sediment sampling locations with TOC concentrations < 60% (0.6) and sand content of > 80% or those stations wherein sand alone was > 90% (irrespective of TOC) do not represent depositional zones, and these stations should no longer be included as potential monitoring stations. As such, these stations were removed from the baseline chemistry calculations. Removal of these stations is justified since stations exhibiting these characteristics have a low potential to accumulate metals, and hence, will have a low likelihood of exhibiting substantial changes in chemistry in the future.

The remaining data were evaluated using two approaches, based on the dataset as a whole (N=67), and also on an area-by-area basis, to attempt to evaluate similarities and differences between the lakes, and to determine if there were differences between lakes which would suggest a need for differing AEMP benchmarks for different lakes. With respect to possible approaches that can be taken to estimate background, upper percentile values are frequently used (either 95th percentile or 97.5th percentile) as reasonable metrics for characterizing upper estimate of baseline. While both statistical metrics are presented, the final metric used to represent baseline was the 97.5th percentile, based on approaches established by Ontario Ministry of Environment (OMOE, 2011). Details of the assessment of the entire area-wide dataset, as well as lake by lake comparisons, are presented in Appendix C and D (Intrinsik, 2014; Intrinsik 2015).

The outcomes of the final assessment in 2015 can be summarized as follows:

- Sheardown Lake SE has lake-specific benchmarks, based on the dataset of 2007– 2014;
- Mary Lake and Camp Lake have combined, lake-specific benchmarks, based on the dataset of 2007 – 2014:
- Due to complicating factors related to the Sheardown Lake data set, it is difficult to determine, based on the available dataset, whether recent construction-related activities have influenced sediment chemistry in this lake. The main factors include the change in sediment sampling protocol (ponar grab of top 5 cm in early years, versus a 0 – 2 cm coring approach since 2012), the lack of monitoring of several long standing stations in 2014, which limits temporal comparisons at specific locations. As a result, further study is recommended in 2015 for Sheardown Lake NW, and the interim benchmarks are suggested for comparison purposes for the 2014 dataset.

The approach used for selecting AEMP sediment benchmarks included the following:

- Select CCME sediment quality guidelines, where available. The ISQG will be considered as the initial point of comparison, where one exists. The PEL is also being considered to provide added perspective related to risk potential.
- Where CCME guidelines are not available, a surrogate guideline from another jurisdiction will be selected (e.g., provincial sediment quality guidelines; US EPA, etc.).
- In addition, baseline data will be assessed, and a statistical metric of baseline levels (e.g., 97.5th percentile of baseline data) for any naturally occurring substances (metals/metalloids) will be calculated.

The higher of the CCME/surrogate guideline or natural baseline was selected as the Final AEMP benchmark. The outcome of this evaluation process is presented in Table 5.3.

5.3.4 Nutrient/Eutrophication Indicators and Benchmarks

During the NIRB review of the FEIS as well as the water licensing technical review and final hearings, Environment Canada expressed concern regarding the potential for discharges of treated sewage effluent to result in eutrophication of the receiving waters (Sheardown Lake NW and Mary River).

Although phosphorus is typically the limiting nutrient in freshwater ecosystems, eutrophication response variables (e.g., abundance of phytoplankton, dissolved oxygen depletion) are typically what are of concern in freshwater environments.

Therefore, while nutrients (i.e., TP and TN) will continue to be monitored under the water quality component of the CREMP, effects of nutrient enrichment on Mine Area waterbodies will be monitored through measurement of primary productivity (i.e., phytoplankton).

The indicator for phytoplankton abundance will be chlorophyll *a* (NSC, 2014a; Appendix E). Chlorophyll *a* is the most widely used indicator of phytoplankton abundance and is relatively easy to sample. It is also associated with lower analytical variability and is more cost-effective than biomass and community composition metrics. Further, biological benchmarks for phytoplankton community metrics have not been developed to the same extent as for chlorophyll *a* and phytoplankton indices are not as strongly linked to primary drivers of eutrophication (i.e., nutrients). While this parameter is associated with relatively high variability in the lakes currently, the variability is largely a function of low concentrations and in particular, a relatively high frequency of censured values (i.e., below detection; Appendix E).

The phytoplankton monitoring program will also consider related/supporting variables including nutrients (phosphorus and nitrogen), measures of water clarity (i.e., TSS, turbidity, Secchi disk depth), and temperature in the data analysis and reporting phase.

Phytoplankton abundance may either be increased by the Project through nutrient enrichment or may be decreased by the Project through changes in other factors such as water clarity. Therefore, the phytoplankton monitoring component is intended to monitor for either increases or decreases in algal abundance. However, owing to the particular concern related to nutrient enrichment and potential for eutrophication in Mine Area lakes related to phosphorus additions, the benchmark for the CREMP was developed to address potential increases in chlorophyll *a*. In addition, decreases in chlorophyll *a* relative to current (baseline) conditions would be difficult to measure owing to the low concentrations and high frequency of censured values.

While there are no established benchmarks for phytoplankton metrics for application in monitoring programs, there is an extensive literature base regarding the issue of eutrophication of freshwater ecosystems as well as numerous trophic categorization schemes for lakes and several for freshwater streams. Mine Area lakes are currently oligotrophic based on several different lake trophic categorization schemes using chlorophyll *a*. While a significant relationship was found between total phosphorus (TP) and chlorophyll *a* in Mine Area lakes, the relationship is weak and cannot be used to construct a predictive model linking nutrient concentrations to phytoplankton. Therefore, a benchmark for chlorophyll *a* was derived based on existing baseline data and in consideration of approaches applied in other recent/ongoing arctic AEMPs and trophic categories/status.

Table 5.3 Development of Area-Specific Aquatic Effects Sediment Benchmarks, based on Area-Specific Baseline Calculations and Relevant Sediment Quality Guidelines (mg/kg; dw; Intrinsik, 2015)[2]

Jurisdiction, Type of Guideline and Statistical Metric		Hg	As	Cd	Cr	Cu	Fe	Mn	Ni	P*	Pb	Zn
CCME (2014)	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario (OMOE, 2008)	**LEL**	0.2	6	0.6	26	16	20,000	460	16	600	31	120
	SEL	2	33	10	110	110	40,000	1100	75	2,000	250	820
97.5th Percentiles of Lake Areas and Lake Specific Benchmarks by Area												
Mary Lake (2007 – 2014) and Camp lake (2007 – 2014) (N=31)		<0.1	5.3	<0.5	98	50	52,400	4,370	72	1580	25	135
Proposed AEMP Benchmark – Mary Lake and Camp Lake		0.17A	5.9A	1.5C	98B	50B	52,400B	4,370B	72B	1,580B	35A	135B
Sheardown Lake SE (2007 – 2014) (N=11)		<0.1	2	1	79	56	34,400	657	66	1278	18	63
Proposed AEMP Benchmark – Sheardown Lake SE		0.17A	5.9A	1.5C	79B	56B	34,400B	657B	66B	1278B	35A	123A
Sheardown Lake NW (2007-2014, excluding 2008) (N=25)		<0.1	6.4	<0.5	96	62	53,000	4,300	84	1,100	24	107
Interim AEMP Benchmark – Sheardown Lake NW		0.17A	6.2B	1.5C	97B	58B	52,200B	4,530B	77B	1958B	35A	123A

NOTES:

*=N for phosphorus is lower than other elements / parameters

A = guideline is based on sediment quality guideline (CCME or Ontario)

B = guideline is based on 97.5% percentile of baseline data

C = guideline is based on 3 times MDL

Where mercury and cadmium were not detected in any samples in a given area; the detection limit is used to represent the 97.5% percentiles.

[2] As recommended by Minnow, arsenic, copper and iron sediment quality benchmarks presented in Table 5.3 may be modified in the future to account for the elevated levels of these metals observed in sediments of Reference Lake 3 during the 2015 CREMP field program.

The benchmark for chlorophyll *a* for the Mary River Project (3.7 µg/L) is based on maintaining the trophic status (i.e., oligotrophic) of Mine Area lakes. Specifically, the benchmark represents the average of the upper and lower ranges of trophic boundaries for lakes based on chlorophyll *a*, as designated and/or adopted in the scientific literature (Table 5.4).

This benchmark is lower than the recently developed benchmark for Lac de Gras in relation to the Diavik Diamond Mines Project. Lac de Gras has a similar background concentration of chlorophyll *a*; the "normal range" of chlorophyll *a* in Lac de Gras (mean±2 x SD) was identified as 0.89 µg/L and the mean was 0.52 µg/L for the open-water season (Golder Associates Ltd., 2014). This value is similar to the same statistic for Sheardown Lake NW but much lower than statistics for the other mine area lakes.

Table 5.4 Derivation of the Benchmark for Chlorophyll a

Reference	**Chlorophyll *a* (µg/L)**	
	Maximum Oligotrophic	**Minimum Mesotrophic**
OECD (1982) and AENV (2014)	2.5	2.5
Wetzel (2001)	4.5	3
Nürnberg (1996)	3.5	3.5
Carlson (1977)	2.6	2.6
Swedish EPA (2000)	5	5
USEPA (2009)	2	2
University of Florida (2002)	3	3
Galvez-Cloutier R. and M. Sanchez. (2007)	3	3
Ryding and Rast (1989)	8	8
Mean	**3.79**	**3.62**

5.3.5 Benthic Macroinvertebrate Indicators and Benchmarks

A number of BMI metrics were reviewed for inclusion in the CREMP, including:

- abundance - total macroinvertebrate density (individuals/m^2±SE);
- composition - Chironomidae proportion (% of total density);
- Shannon's Equitability (evenness);
- Simpson's Diversity Index; and
- Richness metrics (total taxa and Hill's Effective richness, both at the genus level).

The variability of the BMI metrics measured during the baseline studies program were evaluated and described to assist with identifying the most robust metrics for further statistical exploration and consideration under the CREMP. The least variable metrics identified for both mine area lakes and streams through this process were:

- Chironomidae proportion;
- Shannon's Equitability;
- Simpson's Diversity Index; and
- Total Taxa Richness.

Total BMI density was associated with a relatively high variability in all lake habitat types and stream reaches. However, this metric was retained as it is one of the most commonly used indicators for the status of the benthic macroinvertebrate community in waterbodies.

Unlike water or sediment, where protection of aquatic life guidelines may be used to develop triggers or thresholds for effects assessment, there are no universal benchmarks for biological variables such as abundance or diversity. Rather, the magnitude of change or difference relative to expected conditions is typically used to establish CESs for biological variables.

Environment Canada (2012) identifies CESs for a BMI metric as multiples of within-reference-area standard deviations (i.e., ±2SD). As for fish, confirmed effects are based on the results of two consecutive surveys.

The benchmark for the BMI program that will be conducted under the CREMP is a change of ± 50% in the mean of key metrics. A preliminary assessment of the statistical power of baseline data indicated that the power of the data set for Sheardown Lake NW and Tributary 1, Reach 4 to be able to detect a post-Project change in the mean of ± 50% was high for the majority of metrics investigated, with the exception of total macroinvertebrate density. More sensitive metrics to change were identified and these include Chironomidae proportion, Shannon's Equitability, Simpson's Diversity Index, and total taxa richness. In before-after comparisons of metrics, the power to detect differences is greater when there are more monitoring events in the before and after periods included in the analysis. Overall, it is expected that the CREMP will be capable of detecting larger impacts in a short time period, but will require longer time periods to detect more subtle effects (i.e., as more data are acquired).

In June 2014, after reviewing the final draft of the AEMP Environment Canada requested that the Bray-Curtis Index of Dissimilarity (Bray-Curtis Index) be added to the list of BMI metrics used to assess CREMP benthic macroinvertebrate data. In order to comply with the request, Baffinland has added the Bray-Curtis Index to the list of metrics above.

5.3.6 Arctic Char Indicators and Benchmarks

The Mine Area streams and lakes support only two fish species: land-locked Arctic Char; and, Ninespine Stickleback (*Pungitius pungitius*). Of these, abundance and distribution of Ninespine Stickleback are relatively limited and highly localized while Arctic Char are overwhelmingly the most abundant and widely distributed fish species in the area. As mine area streams freeze solid during winter, overwintering habitat is provided exclusively by lakes.

Environment Canada (2012) recommends monitoring of sexually mature individuals of a minimum of two fish species for EEM programs and use of invasive sampling (i.e., lethal) if acceptable. Alternative study designs include non-lethal sampling methods for fish populations/communities, as well as studies of juvenile fish if appropriate and/or required.

Given that there are only two fish species present in the area, fish monitoring in the mine area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback is absent or uncommon in a number of waterbodies. It is unlikely, even with extensive effort, that sufficient numbers of Ninespine Stickleback could be captured for monitoring purposes from either the receiving environments or from prospective reference areas. For these reasons only a single species, Arctic Char, will be targeted under the CREMP program.

Non-lethal sampling methods will be used to the extent possible to minimize impacts of monitoring on the Arctic Char populations. As a result, metrics that can be reliably obtained from live fish will be included in CREMP. Metrics will include indicators of fish growth, condition, and reproduction.

Environment Canada (2012) recommends that non-lethal sampling should include fork length for fish with a forked caudal fin (±1 mm), total body weight (±1.0%), assessment of external condition (i.e., deformities, erosion, lesions, and tumours [DELTs]), external sex determination (if possible), and age (where possible; ±1 year). Metrics based on these measurements that will be examined under the CREMP are indicated in Table 5.4. In addition, catch-per-unit-effort (CPUE) will be calculated and examined in the analysis and reporting as a general indicator of abundance.

Although there are no established benchmarks for biological variables (e.g., abundance), including fish, that can be readily adopted or considered for monitoring effects on freshwater biota, CESs for selected biological metrics are prescribed in the EEM Guidance Document (Environment Canada, 2012) and have been proposed and applied in other recent monitoring programs that fall outside of EEM requirements, such as the Diavik Diamond Mine in the Northwest Territories (Golder Associates Ltd., 2014).

The MMER identifies CESs for a fish population as a percentage of change from the "reference mean" (Table 5.5). As noted by Indian and Northern Affairs Canada (INAC 2009), "these effect sizes do not reflect the method recommended by Environment Canada (2004); namely effect sizes that correspond with unacceptable ecological changes." INAC (2009) also notes that Environment Canada (2008) identified these CESs "in the absence of clear scientific understanding of the long-term implications of these effects". However, as further noted by INAC (2009), these CESs "may serve as a starting point for discussions on acceptable effect sizes that occur during AEMP development".

As it is not possible to identify a level of change in Arctic Char population metrics that would be indicative of long-term effects or "unacceptable ecological changes" for the mine area fish populations, the CREMP will initially apply the recommended EEM benchmarks (Table 5.6). However, it is recommended that the applicability/appropriateness of these benchmarks be reviewed on a regular basis and, if appropriate, modified as the CREMP progresses. The management response framework should also be regularly reviewed and adjusted over time to ensure the program is effective, sensitive, and ecologically meaningful.

5.4 EFFECTS EVALUATION FRAMEWORK

A risk-based approach to integrating the results of the component monitoring programs will be undertaken, drawing from the approach applied at the Meadowbank Mine (Azimuth, 2010). Monitoring results will be evaluated using the following risk-oriented criteria:

- Magnitude – the degree to which an indicator approaches or exceeds the established benchmark (or other guideline, if different than the benchmark)
- Extent – the scale at which the change or exceedance occurs
- Causation – the strength of evidence for a mine-related cause
- Reversibility – the likelihood that the effect may be reversed over time
- Uncertainty – the confidence or lack thereof in the findings regarding the above criteria

Table 5.5 Fish Metrics and Statistical Analysis Methods Recommended Under EEM

Effect Indicators	Fish Effect Endpoint	
	Non-Lethal Survey	Statistical Test
Growth	*Length of YOY (age 0) at end of growth period	ANOVA
	*Weight of YOY (age 0) at end of growth period	ANOVA
	*Size of 1+ fish	ANOVA
	*Size-at-age (body weight at age)	ANCOVA
	Length-at-age	ANCOVA
	Body Weight	ANOVA
	Length	ANOVA
Reproduction	*Relative abundance of YOY (% composition of YOY)	Kolmorgorov-Smirnov test performed on length-frequency distributions with and without YOY included; OR proportions of YOY can be tested using a Chi-squared test.
	OR relative age-class strength	
Condition	*Condition Factor	ANCOVA
Survival	*Length-frequency distribution	2-sample Kolmorgorov-Smirnov test
	*Age-frequency distribution (if possible)	2-sample Kolmorgorov-Smirnov test
	YOY Survival	

NOTE:
1. METRICS INDICATED WITH AN ASTERISK ARE ENDPOINTS USED FOR DETERMINING EFFECTS UNDER EEM, AS DESIGNATED BY STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN EXPOSURE AND REFERENCE AREAS. OTHER ENDPOINTS MAY BE USED TO SUPPORT ANALYSES.

Table 5.6 MMER EEM Critical Effects Sizes for Fish Populations Using Non-Lethal Sampling

Effect Indicators	Fish Effect Endpoint	CES[1]
Growth	Length and weight of YOY (age 0) and age 1+ at end of growth period	± 25%
Reproduction	Relative abundance of YOY (% composition of YOY) OR relative age-class strength	± 25%
Condition	Condition Factor	± 10%
Survival	Length or age frequency distribution	± 25%

NOTE:
1. CES'S ARE EXPRESSED AS A PERCENTAGE OF THE REFERENCE MEANS.

The above criteria will be applied to each monitoring indicator for each aquatic component, with results summarized using the rating system presented in Table 5.7.

5.5 INTEGRATED DATA EVALUATION

Once data are summarized for each component program, key findings from each program will be evaluated together in the AEMP so that issues can be identified and response actions developed. The data evaluation will be based on the Data Assessment Approach and Response Framework presented as Figure 5.1, applied at the AEMP level.

5.6 MANAGEMENT ACTIONS

Management actions will be implemented as identified in the low and moderate action responses for each aquatic component, based on assessment of whether the change is considered to be mine-related, and the action level determined relative to the benchmark(s) (Figure 5.1). In the instance of detecting change among multiple stressors, action will be implemented according to a weight of evidence evaluation.

Table 5.7 Aquatic Effects Evaluation Rating Criteria

Criteria	Classification	
Magnitude The degree of change; specific to the Indicator/VEC and the impact	Level I	Change to the Indicator is not distinguishable from natural variation and is well below benchmark
	Level II	Change to the Indicator is clearly distinguishable and approaching benchmark
	Level III	Change to the Indicator is clearly distinguishable and exceeds to the benchmark
Extent The physical extent of the effect, relative to study area boundaries	Level I	Isolated occurrence or very small area
	Level II	Moderately sized area affected, such as a portion of a basin
	Level III	An entire lake basin or lake is likely to be affected
Causation The strength of evidence that the effect is mine-related	Level I	No evidence that effect is mine-related
	Level II	Some likelihood that the effect is mine-related
	Level III	Very likely to be mine-related
Reversibility The likelihood of the Indicator/VEC to recover from the effect	Level I	Fully reversible in less than 10 years
	Level II	Reversible over a long period of time (i.e., decades)
	Level III	Largely irreversible for at least several decades
Certainty Degree of certainty or uncertainty in the findings of the monitoring data	High	Limited or conflicting monitoring data, resulting in a low certainty
	Medium	Moderate certainty in findings based on monitoring data
	Low	High certainty in findings based on monitoring data

Mitigation measures will be evaluated, as outlined in Figure 5.1, and implemented on a case-by-case basis, based on an issue-specific assessment of the situation, and action level. Exceedance of a benchmark triggers a moderate action response. Moderate Action Responses may include mitigation measures that are easily implemented at low-cost and in a short time-frame. Such mitigation measures may already be identified as contingency or adaptive management measures within various management plans for the Project.

One of the moderate action responses is to develop a High Action Responses, which will be implemented if the trend over time is a continued change relative to the benchmark (increase in the magnitude of the effect). High Action Responses will be reviewed by key regulatory agencies prior to implementation.

6 QUALITY ASSURANCE AND QUALITY CONTROL

Each of the monitoring programs comprising the AEMP will implement standard QA/QC measures as follows:

- Staffing the project with experienced and properly trained individuals
- Ensuring that representative, meaningful data are collected through planning and efficient research
- Using standard protocols for sample collection, preservation, and documentation
- Calibrating and maintaining all field equipment

Various additional QA/QC measures will be implemented for each of the components studies, as described below.

6.1 WATER AND SEDIMENT QUALITY

A strict QA/QC program is in place to ensure that high quality and representative data are obtained in a manner that is scientifically defensible, repeatable and well documented. This program aims to ensure that the highest level of QA/QC standard methods and protocols are used for the collection of all environmental media samples. Quality assurance is obtained at the project management level through organization and planning, and the enforcement of both external and internal quality control measures. In addition to those standard QA/QC measures listed in Section 6 above, the following QA/QC procedures and practices will be implemented in water and sediment quality programs:

- Internal Quality Control:
  - Collecting duplicate, blank, filter and travel blank samples for submission for analysis (approximately 10% of overall samples)
- External Quality Control:
  - Employing fully accredited analytical laboratories for the analysis of all samples
  - Determining analytical precision and accuracy through the interpretation of the analysis reports for the blind duplicate, blank, filter and travel blank samples

The field sampling protocols being applied to the water and sediment quality program is presented as an appendix of the Water and Sediment Quality CREMP Study Design in Appendix B (Knight Piésold, 2014b).

The quality of the data obtained for a project is assessed via their adherence to the pre-set data quality objectives (DQOs). DQOs provide a means of assessing whether the data in question are precise, accurate, representative, and complete. The results from QA/QC samples are reviewed to determine if sample contamination occurred. These data are further used to determine if the contamination occurred during collection, handling, storage, or shipping. Upon receipt from the laboratory, the data are uploaded into a database along with copies of field notes, photos, Sample Receipt Confirmations, Microsoft Excel data, and Certificates of Analysis.

6.2 BENTHIC INVERTEBRATE SURVEY

Field sub-samples will be collected from each BMI replicate station, to compensate for the spatial variability encountered with these organisms. Sub-samples collected from Sheardown Lake NW in 2013 were analysed separately to evaluate precision and to advise on study design. The results of this analysis indicated a high level of precision associated with five sub-samples and the CREMP will therefore continue to collect five sub-samples but will pool the sub-samples in the field.

Appropriate QA/QC measures related to processing and identification of BMI samples, as outlined in the EEM technical guidance document will be followed and are described below (Environment Canada, 2012). These measures will incorporate the proper steps related to re-sorting, sub-sampling and maintenance of a voucher collection, as needed. The voucher collection will be taxonomically analysed by a second qualified invertebrate taxonomist.

BMI samples will be sorted with the use of a stereomicroscope. Samples will be washed through a 500 micron sieve and sorted entirely, except in the following instances: those samples with large amounts of organic matter (i.e., detritus, filamentous algae) and samples with high densities of major taxa. In these cases, samples will be first washed through a large mesh size sieve (3.36 mm), to remove all coarse detritus, leaves, and rocks. Large organisms such as leeches, crayfish, late instar dragonflies, stoneflies, and mayflies retained in the sieve will be removed from the associated debris. The remaining sample fraction will be sub-sampled quantitatively, if necessary. For QA/QC evaluation, the sorted sediments and debris will be re-preserved and retained for up to six months following submission of the first cycle interpretive report for the EEM program. For those samples that were sub-sampled, sorted and unsorted fractions will be re-preserved separately. Sorted organisms will be re-preserved.

All invertebrates will be identified to the lowest practical level, usually genus or species level. Chironomids and oligochaetes will be mounted on glass slides in a clearing media prior to identification. In samples with large numbers of oligochaetes and chironomids, a random sample of no less than 20% of the selected individuals from each group will be removed from the sample for identification, up to a maximum of 100 individuals.

Following identification and enumeration, a detailed list of individuals collected will be submitted for each replicate station. The list will be in a standard spreadsheet format.

6.3 FISH

QA/QC technical procedures will be utilized for all field sampling, laboratory analysis, data entry and data analysis.

The fish ages will be determination by experienced technicians and a minimum of 10% of fish ageing structures that are processed will be independently and blindly aged by a second technician.

All data entered electronically will undergo a 100% transcription QA/QC by a second person to identify any transcription errors and/or invalid data.

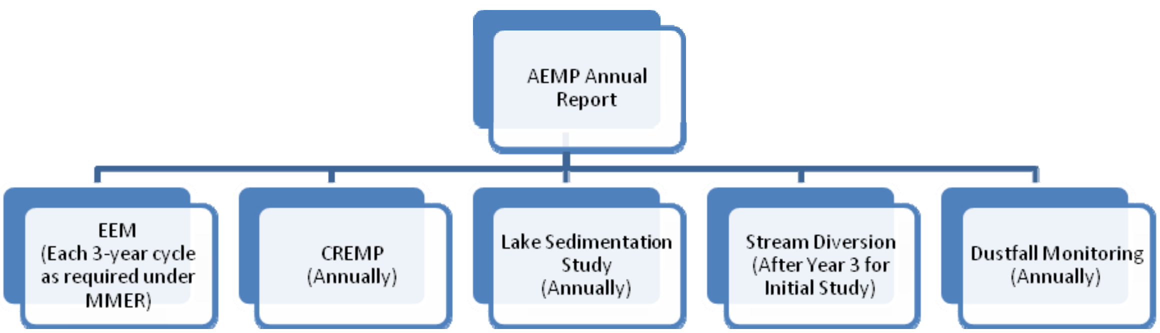
6.4 DATA EVALUATION

All data will be entered into an electronic database with controlled access. Screening studies will be employed to check for transcription errors or suspicious data points. An individual not responsible for entering the data will confirm that the data entered represents the original.

7 ANNUAL REPORTING

AEMP monitoring results will be presented an a AEMP Annual Report that will accompany the Type A Water Licence Amendment No.1 Annual Report, as required by Schedule B, Section e, Item (i) of the Water Licence. The AEMP Annual Report will consist of a high level summary of monitoring activities and outcomes and any management responses. Monitoring results will be presented in technical reports for each component study as appendices to the AEMP Annual Report, with the exception of the Stream Diversion Study. The AEMP Annual Report structure and frequency of reporting of component studies is shown on Figure 7.1.

Figure 7-1 AEMP Annual Report Structure



The AEMP Annual Report will provide a compilation, assessment and interpretation of findings across monitoring programs, and present an evaluation of effects. Revisions to study designs or management response actions will be summarized and discussed for each key issue.

The AEMP will be updated periodically, as required. Updates to the AEMP will be filed with the Water Licence Annual Report in accordance with Schedule B, Section g, Item (ii) of the Water Licence. Updates to the AEMP may consist of modifications to study designs, or termination of shorter-term targeted studies accompanied by adequate rationale.

8 LIST OF CONTRIBUTORS

This document has been prepared by Baffinland and a consultant team as follows:

Baffinland

- Erik Madsen – Overall corporate responsibility
- Oliver Curran – Primary client contact and reviewer
- Jim Millard – technical review
- Fernand Beaulac – consultant advisor contributing to initial AEMP Framework

Knight Piésold Ltd.

- Richard Cook – Consultant Team Project Manager; contributions to the water and sediment quality CREMP; management response framework; senior review
- Dale Klodnicki – EEM Study Design; QA/QC; EEM, water and sediment quality field programs
- Pierre Stecko (Minnow Environmental) – senior technical review of EEM Study Design
- Laurie Ainsworth – Graphical analysis and statistical design of water and sediment quality baseline and CREMP
- Elizabeth Ashby – water and sediment quality baseline review and CREMP study design

North/South Consultants Inc.

- Megan Cooley – Freshwater biota baseline review and CREMP study design
- Richard Remnant – Freshwater biota baseline review
- Mike Johnson – Fisheries field programs
- Leanne Zrum – benthic macroinvertebrate baseline review and CREMP study design

Intrinsik Environmental Sciences Inc.

- Christine Moore – development of management response framework and benchmarks for water and sediment quality; senior review

Minnow Environmental Inc.

Paul LePage - Consultant Team Project Manager, 2015 CREMP field program; Mary River Project CREMP Recommendations for Future Monitoring (2016)

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APPENDICES

Appendix A

Draft EEM Cycle One Study Design

Baffinland

MARY RIVER PROJECT

DRAFT – REV B
EEM CYCLE ONE STUDY DESIGN

JUNE 2014

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FIGURES

APPENDICES

1 INTRODUCTION

1.1 OVERVIEW

The Mary River Project is an iron ore mine located on northern Baffin Island in the Qikiqtani Region of Nunavut. The Project is owned by Baffinland Iron Mines Corporation (Baffinland).

As a metal mine, the discharge of mine effluents from this metal mine is regulated by the Metal Mining Effluent Regulations (MMER) (MOJ, 2012). These regulations, administered under the federal *Fisheries Act* (1985), apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. Mining is expected to begin as early as the second half of September 2014 at which time temperatures are below zero, precipitation falls as snow, and runoff has ceased in local rivers and streams. Therefore, the 50 m^3/day mine effluent discharge rate will be achieved during freshet in June 2015.

The MMER outline requirements for routine effluent monitoring, acute lethality testing, and Environmental Effects Monitoring (EEM). The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues).

This Draft EEM Cycle One Study Design has been prepared in accordance with the MMER as prescribed by the EEM technical guidance document (EC, 2012), for inclusion as a component study to Baffinland's Aquatic Effects Monitoring Plan (AEMP). The study design describes in detail how the Cycle One EEM biological monitoring study will be undertaken. It outlines the proposed activities involved in the investigation of water quality, sediment quality, and freshwater biota community to meet the objectives of the EEM program in accordance with the MMER. In accordance with the technical guidance document (EC, 2012), this study will take into account all relevant site characterization information, previous biological monitoring data, and comments and/or recommendations stemming from previous efforts in the area.

Any comments on this draft study design will be incorporated into a final study design that will be formally submitted for review and approval by the Environment Canada Technical Advisory Panel (TAP) prior to initiation of the Cycle One EEM biological monitoring study field work.

1.2 OTHER MONITORING PROGRAMS

With respect to regulations that apply to the discharge of contact water and surface runoff from the Mary River Mine, and in addition to the MMER, the Nunavut Water Board (NWB) issued a Type A Water Licence (2AM-MRY1325) that came into effect on June 10, 2013 and is due to expire on June 10, 2025 (NWB, 2013). This Type A Water Licence is a requirement under the Nunavut Waters and Nunavut Surface Rights Tribunal Act and the Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada (referred to as the Nunavut Land Claims Agreement; NLCA).

The Type A Water Licence effluent quality limits for the open pit, stockpile and sedimentation ponds are generally more restrictive than those in the MMER (Table 1.1). The points of compliance at the mine for the effluent quality standards included in this Licence are the final points of control at stations MS-06, MS-07, MS-08, and MS-09 as shown on Figure 1.1. All test results for the effluent water quality parameters listed in this Licence shall be provided by a laboratory accredited by the Canadian Association for

Laboratory Accreditation (CALA). Effluent characterization and water quality monitoring conducted under the Type A Water Licence is consistent with MMER protocols.

Table 1.1 Compliance Monitoring Limits Applicable to Mine Effluent Discharges

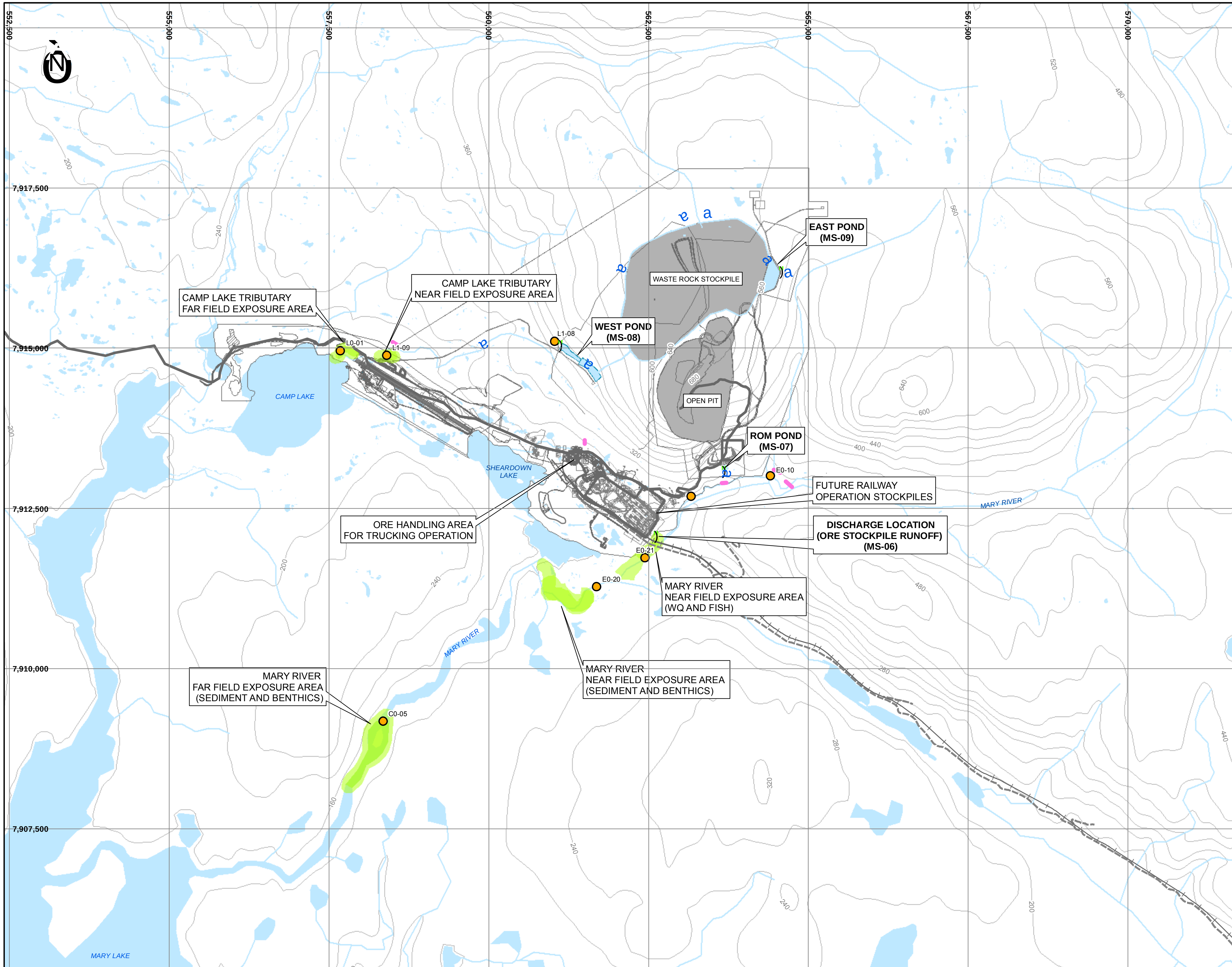
Parameter	MMER Effluent Quality Standards (Schedule 4)			Water Licence 2AM-MRY1325 Open Pit, Stockpile and Sedimentation Ponds Effluent Discharge Quality Limits
	Maximum Monthly Mean Concentration	Maximum Concentration in a Composite Sample	Maximum Concentration in a Grab Sample	Maximum Concentration of Any Grab Sample
Arsenic	0.50	0.75	1.00	0.50
Copper	0.30	0.45	0.60	0.30
Cyanide	1.00	1.50	2.00	
Lead	0.20	0.30	0.40	0.20
Nickel	0.50	0.75	1.00	0.50
Zinc	0.50	0.75	1.00	0.50
TSS	15.00	22.50	30.00	15
Radium 226 (Bq/L)	0.37	0.74	1.11	
pH (pH units)	-	-	-	Between 6.0 and 9.5
Oil and Grease	-	-	-	No visible sheen
Acute Toxicity Testing				
96-hr Rainbow Trout	$Pass_{50}$ [2]			Not acutely toxic

NOTES:

1. ALL PARAMETER CONCENTRATIONS ARE TOTAL VALUES, EXPRESSED IN MG/L UNLESS OTHERWISE SPECIFIED.
2. A PASS RESULT IS <50% MORTALITY IN 100% EFFLUENT.

The Type A Water Licence requires the development of an Aquatic Effects Monitoring Plan (AEMP). A number of component studies form the AEMP for the Mary River Project, including this EEM Program. Another component study is the Core Receiving Environment Monitoring Program (CREMP), which draws upon the same technical guidance document as the EEM Program to monitor aquatic effects due to multiple pathways (i.e., mine effluent discharges, but also sewage effluent discharges and effects due to dust deposition) within the near and far-field streams and mine site lakes: Camp, Sheardown NW and SE, and Mary Lake.

Additional details on the AEMP including the CREMP can be found in the AEMP (Baffinland, 2014).



LEGEND:

- FINAL DISCHARGE POINT
- ENVIRONMENTAL EFFECTS MONITORING STATION (EEM) (WATER, SEDIMENT, BENTHICS AND FISH)
- EEM STUDY DESIGN EXPOSURE AREA
- FISH BARRIER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

DRAFT

SCALE 500 250 0 500 1,000 1,500 2,000 2,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PROPOSED EXPOSURE AREAS FOR THE ENVIRONMENTAL EFFECTS MONITORING (EEM) PROGRAM

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 1.1 REV A

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B45_rA.mxd; May 21, 2014 11:45 AM; asimpson

2 SITE CHARACTERIZATION

2.1 PROJECT DESCRIPTION

The Project is an iron more mine with a production rate of 21.5 Mt/a, consisting of the following major components:

- Milne Port
- Mine Site
- Railway
- Steensby Port

Each development site (excluding the railway) will have all the facilities it needs to operate effectively including maintenance and administrative buildings, warehouses and laydown areas, ore stockpiles and associated runoff management facilities, camps, water supply, wastewater treatment plants, waste management facilities including landfills, power generation, fuel depots, telecommunication facilities, and airstrips.

Baffinland is approved to mine Deposit No. 1 at the mine site by open pit mining methods. Since the Mary River iron ore is of a very high-grade, there is no need to have a process plant (or mill) on site, resulting in no tailings being generated. As such, no tailings pond will be required. This is accomplished by crushing and screening of the ore to produce two iron ore products:

- Lump ore – sized between 6.3 mm and 31.5 mm (about golf ball size), and
- Fine ore - sized less than 6.3 mm (about pea size).

Ore will be stockpiled at the mine site and transported either by truck to Milne Port or by railway to Steensby Port. Ore handling facilities at the mine site will consist of the open pit, separate ore stockpiles for the trucking and railway operations, and water management facilities to collect runoff from ore stockpiles. Waste rock will be stockpiled in a single stockpile next to the open pit, and up to two ponds will collect runoff from the stockpile. The trucking and railway operations will have separate ore stockpiles and runoff collection ponds but will otherwise share common water management facilities and final discharge points.

Mining is expected to begin in the second half of September 2014 beginning with a low-capital trucking operation involving the mining of 3.5 million tonnes per annum (Mt/a) of iron ore that will be transported year-round by truck to Milne Port, with marine shipping to market during the open water season. Ore handling facilities at Milne Port will consist of truck unloading facilities, ore stockpiles and ship-loading facilities at an ore dock. Runoff from the stockpile area at Milne Port will be collected in a pond that will discharge to the marine waters of Milne Inlet. Environment Canada has advised Baffinland that the mine effluent discharge to Milne Inlet will not be subject to the MMER, though the *Fisheries Act* still apply, including Section 36(3) regarding the prohibition of discharges of a deleterious substance in waters frequented by fish (Anne Wilson, pers.comm.)

At some point in the future when the iron ore market and economic conditions for financing capital-intensive projects improves, an 18 Mt/a railway operation will be constructed. This will involve the construction and operation of a 149-km railway to Steensby Port. Steensby Port, once constructed, will be equipped with a railway car dumper and associated conveying equipment, an ore stockpile, and ship-loading facilities to load ore onto ice-breaking ore carriers. Shipping of ore from Steensby Port will take place year-round. Runoff from the ore stockpile at Steensby Port will be collected and discharged to the marine waters in Steensby Inlet. Environment Canada similarly advised that the mine effluent discharge to marine waters from the ore stockpile at Steensby Port would not be subject to the MMER but would otherwise be subject to the *Fisheries Act*.

A number of proven mitigation measures have been included in the Project to reduce potential effects on water quality, freshwater fish, fish habitat, and other aquatic organisms. At each of the ore handling locations, crushers and screens will be installed inside buildings, and conveyors will be covered and equipped with wind ventilation hoods to reduce wind exposure and the potential for dust generation. All ventilation ducts will be routed to dust collectors which will limit dust emissions. Specific Management Plans detail the many ways that water will be protected (Baffinland, 2012).

The operational life of the Project, based on current ore reserves and a production rate of 21.5 Mt/a, is 21 years. The Closure of the facilities is expected to be carried out over a three to five year period and post-closure monitoring will follow for an additional five years. If closure objectives are not met, post closure would extend beyond five years.

2.2 FINAL DISCHARGE POINTS

Mine effluent will be discharged to two watercourses (Figure 1.1):

- Mary River
- Camp Lake Tributary 1

There will be three final discharge points will discharge mine effluent to the Mary River as follows:

- East Pond discharge collecting stormwater from the east side of the waste rock stockpile
- Run-of-mine (ROM) stockpile discharge
- The main ore stockpile at the rail load-out area

There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

2.3 HISTORICAL DATA

In preparation for the MMER regulatory obligations, Baffinland characterized the two exposure areas (Mary River and Camp Lake Tributary 1) and several candidate reference areas in 2013.

The candidate reference areas were characterized to compare the in-situ physical and biological conditions to the conditions of the exposure areas. The candidate reference areas were identified through a series of desktop screenings and ground-truthing activities in 2012 and 2013. At least three candidate reference areas for each receiving watercourse were characterized.

The coordinates of the exposure and candidate reference areas characterized for the study design are shown in Table 2.1. The locations of the proposed exposure areas on the Camp Lake Tributary and Mary River are shown on Figure 1.1, and in greater detail on Figures 2.1 and 2.2. Reference areas for the study are shown on Figure 2.3.