

MARY RIVER PROJECT
ENVIRONMENTAL IMPACT STATEMENT

VOLUME 7
FRESHWATER ENVIRONMENT

DOCUMENT STRUCTURE

Volume 1
Main Document

Volume 2
Consultation, Regulatory, Methods
- Consultation
- Regulatory Framework
- Impact Assessment Methodology

Volume 3
Project Description
- Project Description
- Workforce and Human Resources
- Alternatives

Volume 4
Human Environment
- Population Demographics
- Education and Training
- Livelihood and Employment
- Economic Development and Self Reliance
- Human Health and Well Being
- Community Infrastructure and Public Service
- Contracting and Business Opportunities
- Cultural Resources
- Resources and Land Use
- Cultural Well-being
- Benefits, Taxes and Royalties
- Government and Leadership

Volume 5
Atmospheric Environment
- Climate
- Air Quality
- Noise and Vibration

Volume 6
Terrestrial Environment
- Landforms, Soil and Permafrost
- Vegetation
- Birds
- Terrestrial

Volume 7
Freshwater Environment
- Freshwater Quantity
- Freshwater Quality
- Freshwater Biota and Habitat

Volume 8
Marine Environment
- Sea Ice
- Seabed Sediments
- Marine Fish and Invertebrates
- Marine Mammals

Volume 9
Cumulative Effects and Other Assessments
- Cumulative Effects Assessments
- Effects of the Environment on the Project
- Accidents and Malfunctions
- Transboundary Effects Assessment
- Navigable Water Assessment

Volume 10
Environmental, Health and Safety
- Management System
- Individual Management Plans

PROJECT FACE SHEET

Location	• Located at Mary River, North Baffin Island. 1000 km north of Iqaluit, 160km south of Pond Inlet
Reserves	• Comprised of nine known iron ore deposits around Mary River. The current project is focused on Deposit No.1 with known reserves of 365 million tonnes estimated at >64 % iron
Construction Phase	• Construction of the project could commence as early as 2013 • Milne Port will support construction activities, receiving materials during the open water season and moving them to the Mine Site along the existing Tote Road • Construction materials will also be received at Steensby Port • 4 years to complete construction
Operational Phase Open Pit Mine Processing	• Operations will involve mining, ore crushing and screening, rail transport and marine shipping to European markets • Projected production of 18 million tonnes per year for 21 years • No secondary processing required; no tailings produced due to the high grade of ore
Rail Transport and Shipping	• A rail system will be built for year round transfer (~150 km) of ore to Steensby Inlet • A loading port constructed at Steensby Inlet will accommodate cape sized vessels • These specially designed ships will transport to the European market year round • Milne Port will be used to receive construction materials in the open water season and then very rarely to ship, during the open water season, oversized materials
Environment	• Baseline studies have been conducted by Baffinland since 2005 • Inuit Qaujimajatuqangit (traditional knowledge) information collected since 2006 • These baseline studies form the foundation for the environmental impact statement and provide information for the development of mitigation and management plans • Studies cover terrestrial environment, marine environment, freshwater environment, air quality, and resource utilization • Extensive ongoing consultation with communities and agencies • Monitoring during project activities will be important in validating predictions and mitigating potential affects
Social and Economic Benefits	• Mineral royalties will flow to NTI • Taxes will flow to governments of Nunavut and Canada • Baffinland finalizing negotiations with the Qikiqtani Inuit Association (QIA) for an Inuit Impact Benefits Agreement (IIBA) • During the four year construction period employment will peak at 2,700 people • Through the 21 years of operations about 950 people on the payroll each year
Closure and Post-Closure Phase	• Conceptual mine closure planning has been completed • Closure will ensure that the former operational footprint is both physically and chemically stable in the long term for protection of people and the natural environment • Post closure environmental monitoring will continue as long as needed to verify that reclamation has successfully met closure and reclamation objectives

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SECTION 1.0 - REGIONAL FRESHWATER SETTING

1.1 INTRODUCTION

The Mary River Project ("the Project") is a proposed iron ore mine and associated facilities located in northern Baffin Island, in the Qikiqtani Region of Nunavut. The Project involves the Construction, Operation, closure, and reclamation of an 18 million tonne-per-annum (Mt/a) open pit mine that will operate for 21 years. The high-grade iron ore to be mined is suitable for international shipment after only crushing and screening with no chemical processing facilities. A railway system will transport the ore from the mine area to an all-season deep-water port and ship loading facility at Steensby Port, where it will be loaded into carriers for overseas shipment through Foxe Basin by a dedicated fleet of cape-sized ice-breaking ore carriers will be built for the Project. Non-icebreaking ore carriers and conventional ships will be used during the open water season.

Volume 7 of the EIS discusses impacts to the Freshwater Environment, including impacts on water quantity, quality and fish habitat. Sections 1 and 2 describe the baseline hydrologic conditions, potential impacts and mitigation measures and residual effects of activities on the hydrologic system in the Project area. Sections 3 and 4 include similar content related to water quality and aquatic biota and habitat, respectively.

Hydrology deals with the occurrence, circulation, storage and distribution of water in the earth's atmosphere, surface and subsurface. Elements evaluated in a hydrologic assessment include climate and stream flow data in relation to topography, soil type, ground cover, vegetation and permafrost, which are the dominant influences. In the mining environment, safe management of water resources during all phases of work, from Construction to post-closure, is critical. Hydrologic conditions affect how engineering designs will be developed, constructed, and ultimately managed, and it is important to determine the impact of Project activities on existing hydrologic conditions.

1.2 STUDY AREAS

The Project Study Areas for freshwater environment are defined at both local (Local Study Area, LSA) and regional (Regional Study Area, RSA) scales. According to the Nunavut Impact Review Board (NIRB) the RSA "shall be defined as the area within which there exists the potential for direct, indirect, and/or cumulative biophysical and socio-economic effects". These same guidelines state that the LSA shall "be defined as that area where there exists the reasonable potential for immediate impacts due to project activities, ongoing normal activities, or to possible abnormal operating conditions". The freshwater RSA and LSA boundaries are delineated so that all potential impacts from the Project on the freshwater environment will be captured within their boundaries, thereby satisfying the given definitions.

The RSA for freshwater environment was defined as the area extending from Milne Inlet in the north, to Steensby Inlet in the south (Figure 7-1.1) encompassing all Project infrastructure. The RSA boundary was delineated along regional watershed boundaries.

450,000
500,000
550,000
600,000
650,000
700,000
750,000
800,000
8,000,000
7,950,000
7,900,000
7,850,000
7,800,000
7,750,000

ᑲᒪᐸᕼ /ᒪ
PHILLIPS CREEK OUTLET

ᑲᒪᐸᕼ ᒥᓴᓕᓂᖅ
OLIVER GLACIER

H1
H2
H3
H4
H5
H6
H7
H8
H9

ᒪᓂᕐᔾ ᑕᖏᓚᐅᖏᓐᓄᑦ
MARY RIVER AT OUTLET OF MARY LAKE

BR11
BR25
BR96-2
BR137

ᐃᖅᑎᐅᓕᓂᑦ ᐊᖏᓚ ᐃᓐᓇᔪᓐᓇᖅᑐᓂᑦ ᑕᓂᓗᑦ
RAVN RIVER AT OUTLET OF ANGAJURJUALUK LAKE

ᐃᖅᑎᐅᓕᓂᑦ ᐊᖏᓚ
RAVN RIVER OUTLET

ᐃᔾᐱᑦᑐᓴᐊᑦ ᐊᖏᓚ
COCKBURN RIVER OUTLET

ᓴᓐᑦᓂᓴᐊᖏᓐ
STEENSBY INLET

ᐃᓕᑐᑦ ᐊᖏᓚ ᐃᓐᓇᔪᑦ ᑕᓂᓴᓐᓂᑦ
ISORTOQ RIVER AT OUTLET OF ISORTOQ LAKE

ᓴᓐᓂᓴᐊᓕᓐᓄᑦ ᐱᐅᑦᑕᓂᑦ ᐅᑎᐊᓐᓂ
ROWLEY RIVER ABOVE SEPARATION LAKE

ᐊᐅᓚᑲᓕᓐᓄᑦ ᐱᐅᑦᑕᓂᑦ
BARNES ICE CAP

ᑐᑭᓯᐊᖅᑕᐅᓂᖅ/LEGEND:
- ᐃᒥᓴ WATER
- ᓂᓪᓕ GLACIER
- ᑲᔪᓯᐊᓂᖅ/ᐊᖏᓚᔨᓴᓐᓇᖅᑐᖅ RIVER/STREAM/DRAINAGE
- ᒪᓐᓕᐊᓂ ᐃᓐᓇᑎ ᐅᓂᖓᑦᑕᕐᓂᖅ MILNE INLET TOTE ROAD
- ᓄᓇᕗᒻᒥᐅᑦ ᐊᖏᑎᖅᓴᓕ ᓇᓂᓂᐊᓘᓐᓂᖅ PROPOSED RAILWAY ALIGNMENT
- ᐊᑎᒥᒥ ᖃᐅᔨᓴᓂᐅᑦ ᐱᓕᖅᓴ EIS RSA BOUNDARY
- ᐃᓚᒪᑦ ᑲᐃᖅᓴ CATCHMENT BOUNDARY
- ᐃᓚᒥᖅ ᖃᐅᔨᓴᓂᖃᖅ ᑲᓇᑕᒥ WATER SURVEY OF CANADA STATION
- ᐃᓚᓕᓂᐃᑦ HYDROLOGY STATIONS

NOTES
ᖃᐅᔨᓴᕐᓂᐃᑦ:

1. ᓄᓇᕗᑦᓇᐊᖏᑦ ᐊᐃᑦ ᑲᓇᑕᒥ
   BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. ᓂᕆᑐᖅᓂᖅ ᐊᑦᓂᓄᑦᑕᐅᓄᐊ ᐃᓚᓇᐃᓇᓐᓄ 1: ᐊᓯᑎᑎᓄᓪᓚᓂᐊ 50,000 ᐊᓚᓇ ᖃᐅᔨᓴᓄᓂᒪᓇᓐᓄ ᖃᐅᐊᐅᓄᓐᓂᖅ ᑕᒪᓐᓄ ᑭᓪᓗᖅᓄᓂ.
   GLACIER COVERAGE IS TAKEN FROM NTS 1:50,000 SCALE AND IS ONLY SHOWN WITHIN CATCHMENT BOUNDARIES.
3. ᓄᓇᕗᒻᒥᑦ ᑎᑎᕐᓚᓐᓂᖅ ᒪᓕᓐᓄᖅ UTM (NAD83) Zone 17
   COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
4. ᓄᓇᕗᒻᒥᓄᑦ ᐊᓂᐊᓂᓱᖅ Canarail Consultants Inc.
   PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL CONSULTANTS INC. IN AUGUST 2010.
5. ᐃᓚᒥᖅ ᖃᐅᔨᓴᓂᐊᑦ ᑲᓇᑕᒥᑦ ᐊᐸᑎᓕᓂᐊᕐᓇᕐᓂᖅᓂᑦ
   WSC STATIONS PROVIDED BY ENVIRONMENT CANADA.

SCALE 10 5 0 10 20 30 40 50 km

BAFFINLAND IRON MINES CORPORATION

ᓄᓕᒃᑐᓂ ᐅᕙᖅᓯᐅᑦᑐᖅᑎᑦ MARY RIVER PROJECT

ᐃᓚᖅᑲᓂᓕᖅᑐᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᖅ
FRESHWATER REGIONAL STUDY AREA

Knight Piésold CONSULTING

P/A NO. NB102-181/25
REF NO. 12
FIGURE 7-1.1
REV 0

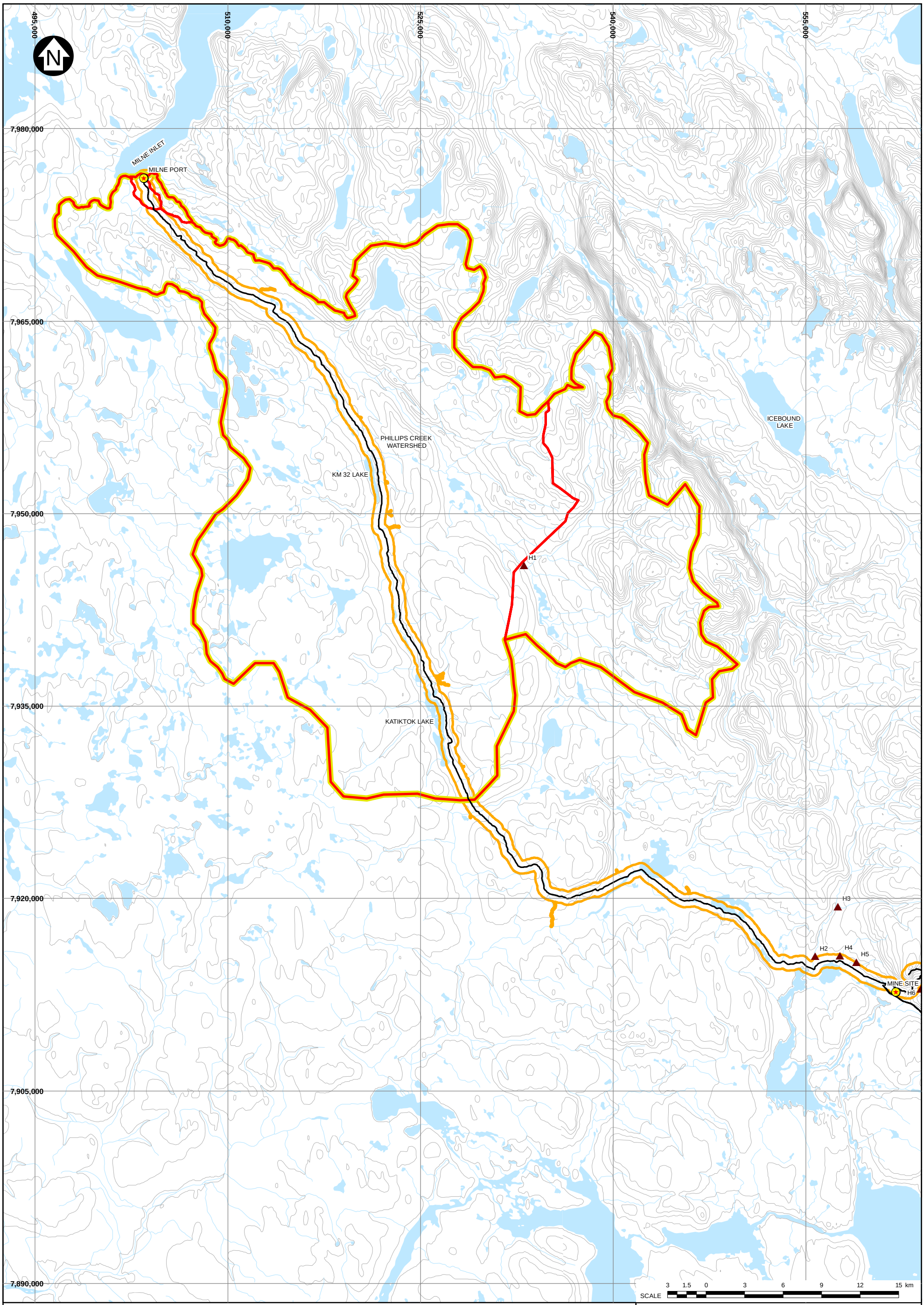
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	16DEC'10	ISSUED WITH REPORT	KT	ASM	KT	RCB

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The primary watershed boundaries that delineate the RSA belong to the Ravn River, Cockburn River, Philips Creek and the Ikpikitturjuaq River, along with a few smaller unnamed watersheds near Milne and Steensby Inlets. The Ravn and Cockburn Rivers general flow in a southerly direction, while Phillips Creek flows to the north. Baseline studies have found that the mean annual unit runoff (MAUR) within the RSA is approximately 9 l/s/km^2, although this will vary locally depending upon watershed characteristics. Streamflow typically occurs between June and September, although the timing of the onset and end of open channel flow can vary by a few weeks within any given watershed, depending upon the year. Watercourses are generally dry or frozen from October through May. All watercourses within the RSA eventually freeze solid during the winter. In spring, early runoff is directed into the stream channels, where it flows on top of the ice that froze in place during winter. Eventually, the channel ice is eroded and melted away. Subsurface flow is limited by permafrost, which melts only to a depth of approximately 1 to 2 m. Essentially no subsurface flow occurs below the active permafrost layer, because permafrost in the region is typically on the order of 500 m in depth. The RSA encompasses all proposed project components (Milne Port, Milne Inlet Tote Road, Mine Site, Railway and Steensby Port), as well as other regional iron ore bodies that have existing and/or possible future activities with the potential for cumulative impacts.

Five LSAs were defined for the freshwater effects assessment. From north to south the LSAs are Milne Port, Milne Inlet Tote Road, Mine Site, Railway and Steensby Port, presented in Figures 7-1.2, 7-1.3 and 7-1.4, respectively. The boundaries of each were defined in a manner best suited for addressing the potential impacts of activities within the LSA. They are described as follows:

- Milne Port: The Milne Port LSA is defined by watershed boundaries, similar to the RSA. It encompasses all Port project infrastructure and activities that have potential effects on freshwater. The largest watercourse and delineated watershed is Phillips Creek; its watershed covers over 900 km^2 and includes both moderate elevation uplands and lower elevation tundra. A baseline monitoring station (H1) located on a tributary of Phillips Creek monitors approximately one quarter of the entire watershed. The long-term MAUR at this station is 7.5 l/s/km^2. The estimated annual distribution of streamflow at this station is presented on Figure 7-1.5. Characteristics of the Phillips Creek watershed and the watershed upstream of monitoring station H1 were modeled using Environment Canada's Green Kenue software. The characteristics were compared, and it was determined that the slightly higher mean watershed elevation and the more inland location of the H1 watershed likely combine to produce a runoff pattern that is similar to the Phillips Creek watershed as a whole. However, in an effort to be conservative, the MAUR for the Phillips Creek watershed was set at 7 l/s/km^2. The streamflow distribution measured at the monitoring station is assumed to apply to the watershed as a whole. However, much smaller watersheds may have a different runoff distribution given that they typically experience considerably less attenuation than in large watersheds. Therefore, the distribution of runoff in some of the small coastal watersheds at Milne Port may be modelled using streamflow distribution more similar to those at stations H4 and H5 in the Mine Site LSA.
- Milne Inlet Tote Road: The Milne Inlet Tote Road LSA extends in a NW-SE alignment, from Milne Port in the north to the Mine Site in the south. It encompasses all Tote Road project infrastructure and activities that have potential effects on freshwater. It is defined using a 500 m buffer on either side of the alignment centre line. For fish-bearing streams, the LSA extends upstream to the extent of fish accessibility and downstream to the nearest major watercourse or potential overwintering waterbody (Figure 7-1.2).



LEGEND:

- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONTOUR
- RIVER/STREAM/DRAINAGE
- WATER
- MILNE CATCHMENT
- MILNE PORT LOCAL STUDY AREA (LSA)
- TOTE ROAD LOCAL STUDY AREA (LSA)
- HYDROLOGY STATIONS

NOTES:

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2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL VARIES. CONTOUR INTERVAL IS IN METRES.
4. PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL (OCT 2010).
5. CATCHMENT BOUNDARIES PRODUCED BY KNIGHT PIESOLD CONSULTING.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	03DEC'10	ISSUED WITH REPORT	KT	ASM	KT	RCB

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE PORT LOCAL STUDY AREA AND MILNE TOTE ROAD LOCAL STUDY AREA

Knight Piésold CONSULTING

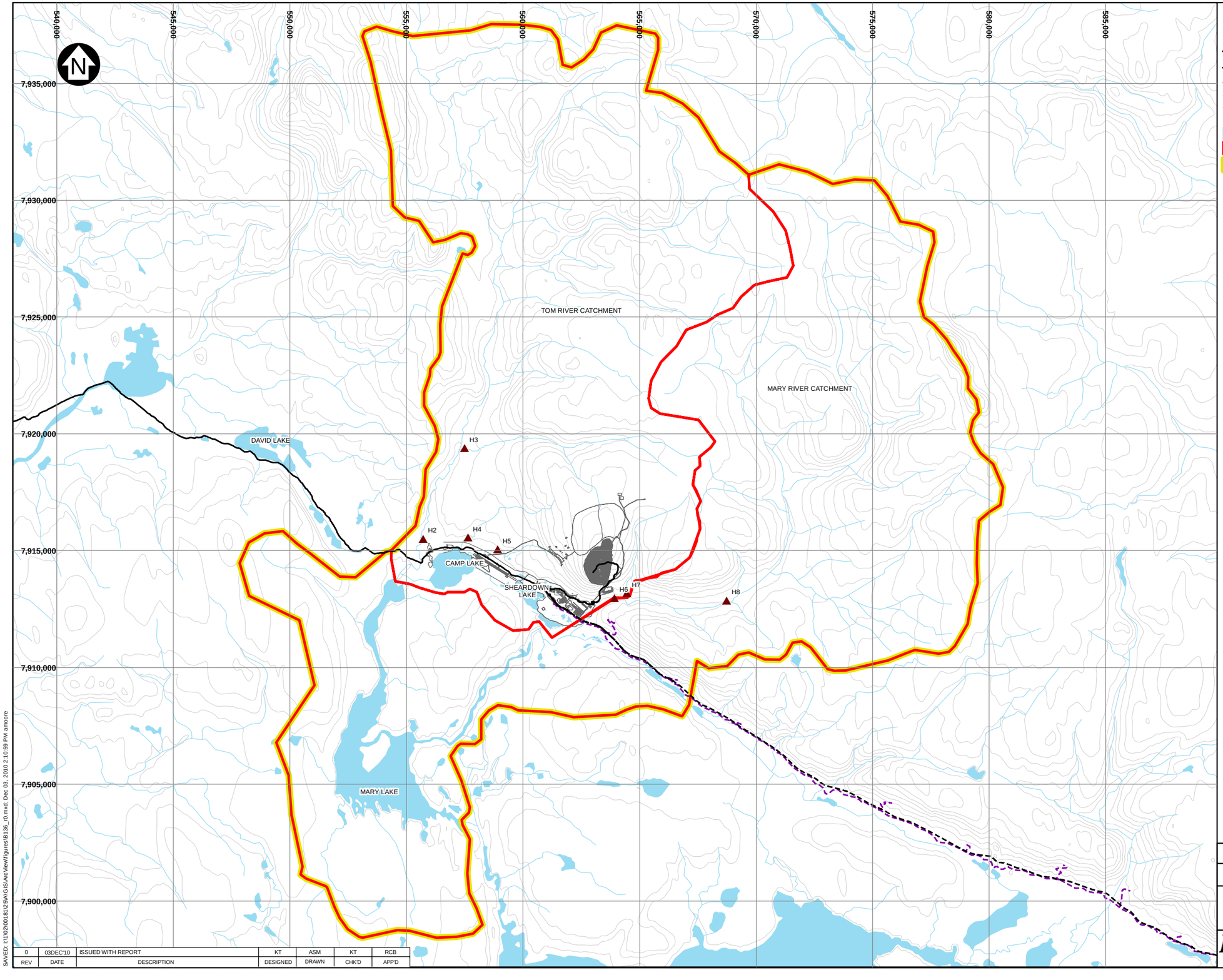
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REF NO. 12

FIGURE 7-1.2

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LEGEND:

- HYDROLOGY STATIONS
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONSTRUCTION ACCESS ROAD
- CONTOUR
- MINE SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- STEENSBY CATCHMENT
- LOCAL STUDY AREA (LSA)

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL IS IN METRES. CONTOUR INTERVAL IS 2.5 METRES.
4. PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL (OCT 2010).
5. CATCHMENT BOUNDARIES PRODUCED BY KNIGHT PIESOLD CONSULTING.

SCALE 1 0.5 0 1 2 3 4 5 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE
LOCAL STUDY AREA

Knight Piésold CONSULTING

P/A NO. NB102-181/25 | REF NO. 12

FIGURE 7-1.3 | REV 0

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N

560,000
580,000
600,000
620,000

7,900,000
7,880,000
7,860,000
7,840,000
7,820,000
7,800,000

H3
H2
H4
H5
MINE SITE
H7
H6
H8

ST-28
ST-22
ST-21
ST-3
ST-20
ST-19
ST-01
ST-4
ST-18
ST-17
ST-16
ST-15
ST-02
ST-6
ST-14
ST-29
ST-25
ST-24
ST-23
ST-26
ST-27
ST-11
ST-5
ST-13
ST-12

SCALE B

STEENSBY PORT

SCALE A 4 2 0 4 8 12 16 20 km

SCALE A 1 0.5 0 1 2 3 4 5 km SCALE B

LEGEND:

- HYDROLOGY STATIONS
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONSTRUCTION ACCESS ROAD
- CONTOUR
- RIVER/STREAM/DRAINAGE
- WATER
- STEENSBY CATCHMENT
- RAILWAY LOCAL STUDY AREA (LSA)
- STEENSBY LOCAL STUDY AREA (LSA)

NOTES:

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2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL VARIES. CONTOUR INTERVAL IS IN METRES.
4. PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL (OCT 2010).
5. CATCHMENT BOUNDARIES PRODUCED BY KNIGHT PIESOLD CONSULTING.

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MARY RIVER PROJECT

RAILWAY CORRIDOR LOCAL STUDY AREA AND STEENSBY PORT LOCAL STUDY AREA

Knight Piésold CONSULTING

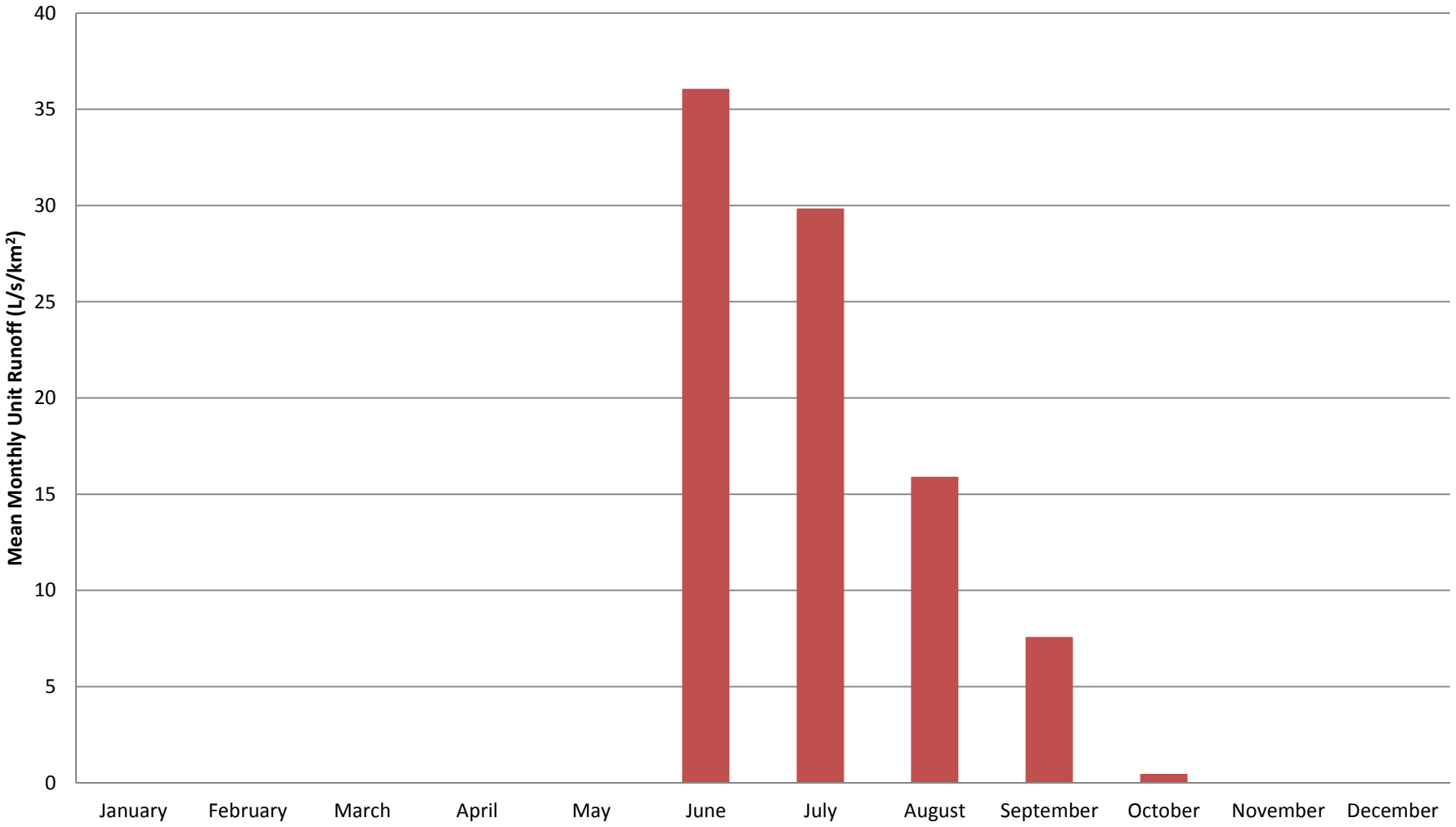
P/A NO. NB102-181/25

REF NO. 12

FIGURE 7-1.4

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE PORT LSA HYDROGRAPH SHAPES
STATION H1

Knight Piésold CONSULTING

P/A NO. NB101-181/30

REF. NO. 3

FIGURE 7-1.5

REV 1

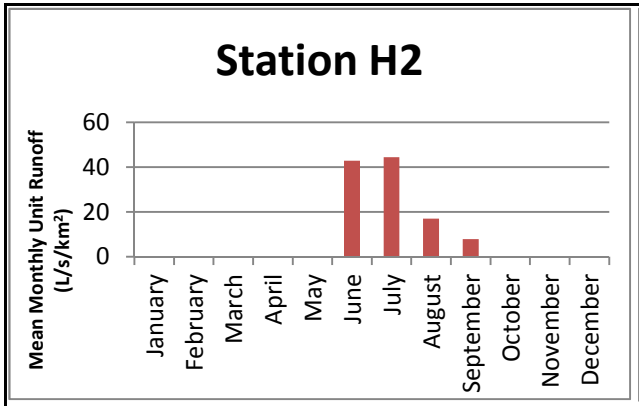
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1	10DEC'11	ISSUED WITH REPORT	KEF	KT	WAN

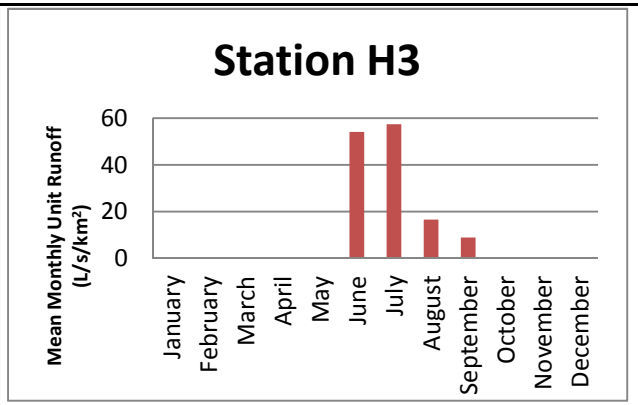
The northern half of the alignment is located within the Phillips Creek watershed, while the southern half is located in the north-western corner of the Ravn River watershed (Figure 7-1.2). The alignment crosses numerous watercourses with varying watershed characteristics and runoff regimes. Baseline streamflow information collected near the mine site and within the Phillips Creek watershed, as well as the characteristics of the monitored watersheds, have been considered when assessing flows in unmonitored watercourses along the Milne Inlet Tote Road.

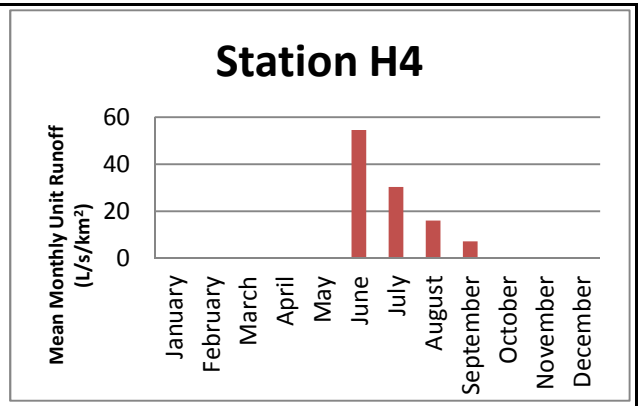
- Mine Site: The Mine Site LSA is defined by watershed boundaries, similar to the RSA (Figure 7-1.3), and encompasses all Mine Site infrastructure and activities that have potential effects on freshwater. The LSA does not extend beyond the outlet of Mary Lake, as quantifiable Project effects on freshwater are not expected to extend further downstream. The Mine Site LSA is located within the Ravn River watershed. It encompasses two major sub-systems, the Mary River and the Tom River, both of which flow from north to south and primarily drain moderate to high elevation plateau regions. Nine hydrologic monitoring stations are located within the LSA, including one at the outlet of Mary Lake. The MAUR at these stations ranges from 7 l/s/km^2 to 12 l/s/km^2, and generally increases with median watershed elevation. The hydrograph shapes of the monitored watersheds are provided on Figure 7-1.6. Typically, the lower elevation watersheds tend to melt and produce runoff earlier in the season than do the higher elevation watersheds.

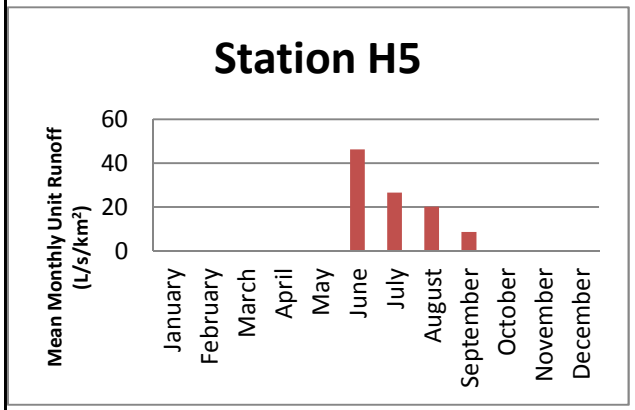
- Railway: The Railway LSA extends in a generally NW-SE alignment, from the Mine Site in the north to Steensby Port in the south, and includes the Railway and Construction Access Road alignments, as well as potential quarry sites and construction camps. It is defined similarly to the Milne Inlet Tote Road LSA: a 500 m buffer on either side of the alignment centre line, with upstream and downstream extensions for fish-bearing streams and the inclusion of construction camp footprints and potentially affected local drainages (Figure 7-1.4). The LSA encompasses all Railway infrastructure and activities that have potential effects on freshwater. The northern half of the alignment is located within the Ravn River watershed, while the southern half is located within the Cockburn River and Ikpikitturjuaq River watersheds, as well as some smaller watersheds near Steensby Port (Figure 7-1.4). The Railway LSA includes portions of five hydrological monitored watersheds. Four of these are limited to one year of baseline data, and therefore long-term MAUR estimates have not yet been developed. The measured hydrograph shapes for all five stations are presented on Figure 7-1.7. The hydrographs for stations BR96-2 and BR137 appear considerably less variable than the other hydrographs. This attenuation of streamflow is a result of the large lake components in these two watersheds. The alignment crosses numerous watercourses with variable watershed characteristics and runoff regimes.

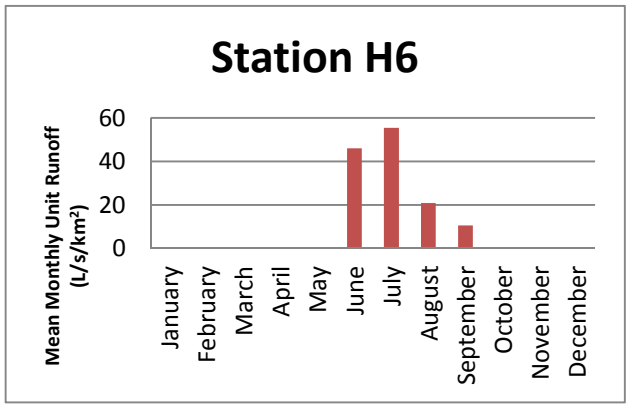
- Steensby Port: The Steensby Port LSA is defined by watershed boundaries similar to the RSA. It encompasses all Steensby Port infrastructure and activities that have potential effects on freshwater. It includes numerous watersheds. The largest is the Ikpikitturjuaq River, which has a drainage area of 323 km^2 and includes ST347 Lake, Steensby Port's primary water source. The only hydrologic monitoring station is BR137, which is located on the Ikpikitturjuaq River at the outlet of 10km Lake, and has a drainage area of 314 km^2. Most of the watersheds in the LSA are low lying and have large lake components.

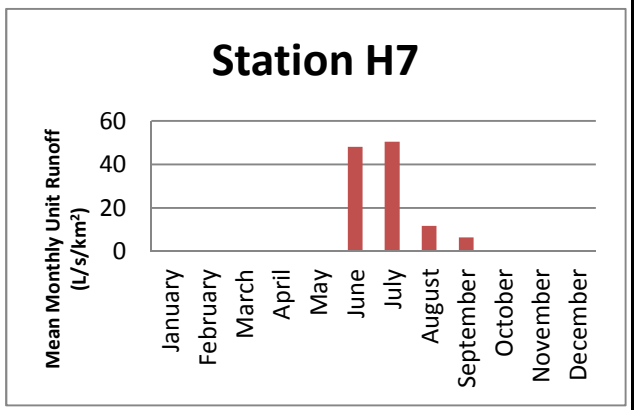


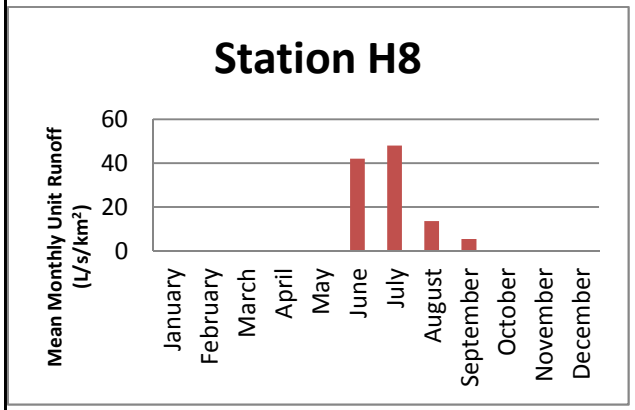












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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE LSA HYDROGRAPH SHAPES STATIONS H2, H3, H4, H5, H6, H7, AND H8

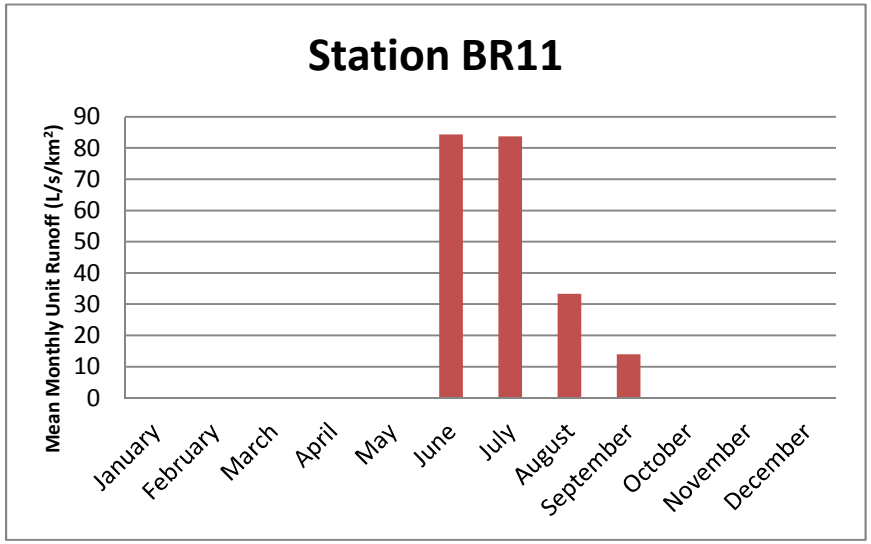
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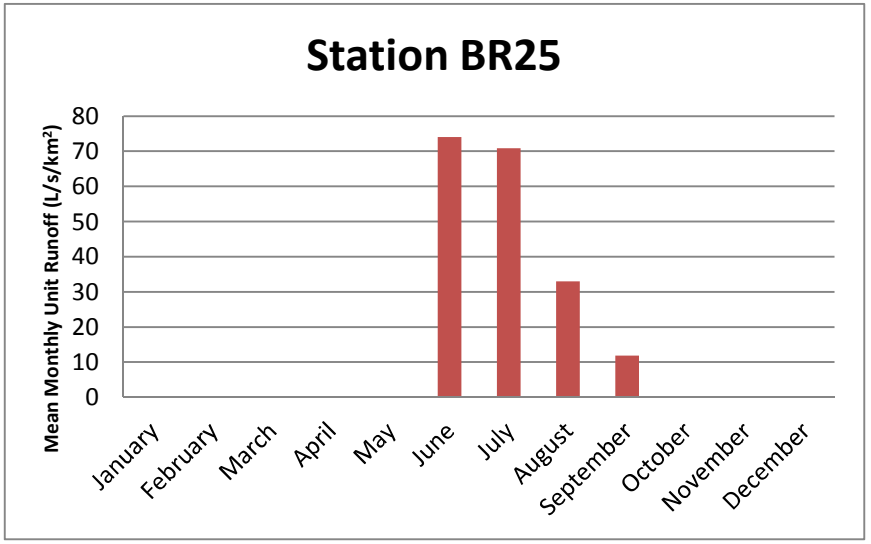
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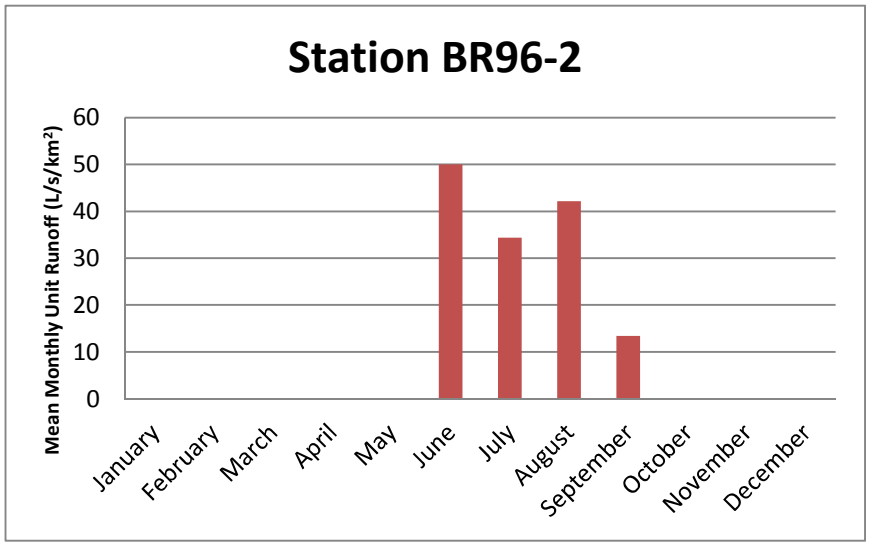
REF. NO. 3

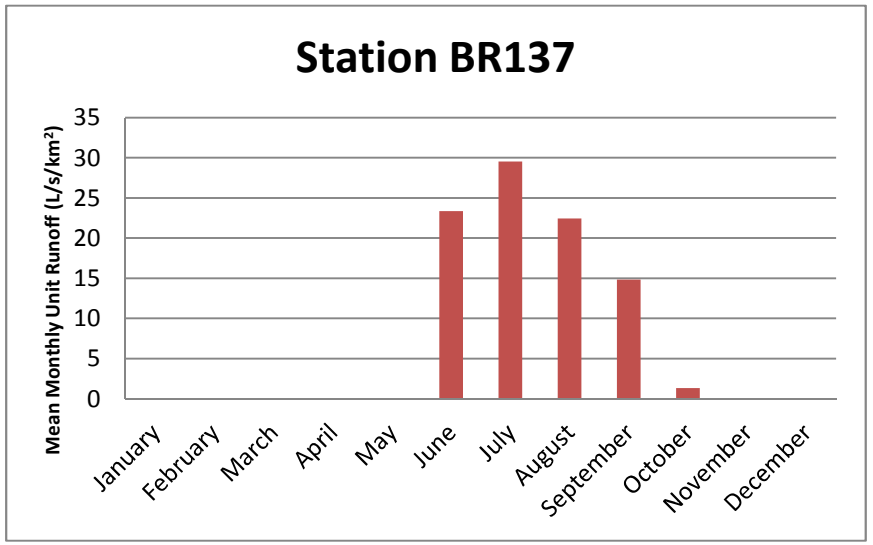
FIGURE 7-1.6

REV 1









BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

RAILWAY CORRIDOR LSA HYDROGRAPH SHAPES

Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF. NO. 3

FIGURE 7-1.7

REV 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	10DEC'11	ISSUED WITH REPORT	KEF	KT	WAN

A long-term MAUR of 7.6 l/s/km2 has been developed for BR137. Because it is the only monitoring station located in the Steensby Port LSA, and its watershed includes numerous lakes similar to most other watersheds within that LSA, the MAUR of 7.6 l/s/km2 was assumed applicable to the entire LSA. Because of its relatively large size, coupled with its large lake component, the BR137 hydrograph exhibits considerable attenuation of flows, resulting in subdued runoff peaks and outflow discharge that extends well into late October. This hydrograph shape is likely not representative of the smaller watersheds within the Steensby LSA, and therefore the mean monthly streamflow distribution from monitoring station H5, a smaller, relatively low elevation station near the Mine Site, was considered more applicable to watersheds less than 100 km2 in area within the Steensby Port LSA. The hydrograph shape of watersheds greater than 100 km2 within the Steensby Port LSA is assumed to be similar to that measured at BR137.

Baffinland will continue to operate a hydrological monitoring program in order to improve the long-term hydrological record as input to the design of future infrastructure.

SECTION 2.0 - FRESHWATER QUANTITY

2.1 BASELINE SUMMARY

2.1.1 Introduction

The Mary River Project (the Project) is located in northern Baffin Island, one of the coldest regions in Canada. The region experiences a mean annual temperature of approximately -15°C, with mean daily temperatures below -20°C from November through April, and above 0°C during June through August. The long period of sub-zero temperatures results in a very short runoff season, typically occurring from June through September. Runoff may extend to late October in systems with large lake components. The frigid temperatures also result in very low precipitation values for northern Baffin Island, from the combined effect of the low moisture-carrying capacity of cold air and the scarcity of liquid water available for evaporation. According to Natural Resources Canada, the region is classified as semi-arid, with mean annual total precipitation ranging from 200 to 400 mm. Regional climate station data suggests that the true value is near the lower end of this range. The amount of water available for runoff is further reduced by evaporation, transpiration and sublimation. The frigid climate and subsequent lack of vegetative cover combine to minimize the volume of water evaporated and transpired. Conversely sublimation, which is the process by which solid water changes phase directly to water vapour, frequently occurs during the winter months, largely as a result of blowing snow transport.

Stream flow regimes in the high Arctic are most strongly influenced by temperature. During winter, persistent sub-zero temperatures cause all watercourses to freeze solid. Snow is frequently redistributed within and between watersheds by wind transport. As temperatures rise above 0°C, stream flow resumes. The majority of annual runoff typically occurs during the nival freshet in late June through July, with runoff decreasing through the late summer, freezing up again at the onset of winter, typically in October. Peak instantaneous flows typically occur during the freshet, but in smaller watersheds peak flow may occur due to rainfall events in July or August. Mean annual discharge per unit area is typically in the order of 5 - 10 l/s/km^2. Differences in elevation, aspect, glacial cover and lake cover between watersheds results in regional variability in the timing and magnitude of runoff. The onset of the spring melt is delayed in higher elevation regions, as well as in north facing watersheds. Higher elevation areas may also receive greater volumes of precipitation as a result of orographic influences. In smaller watersheds, aspect may help determine whether the watershed is a net sink or source for blowing snow transport and deposition. Glacial cover tends to greatly increase the volume of runoff in a watershed, while lakes act to attenuate runoff events and prolong the runoff season. The presence of permafrost, coupled with the lack of vegetative cover, also has a major influence on regional hydrologic systems. Permafrost typically restricts water from infiltrating the ground to any great depth, while the lack of surface vegetation results in little to no impedance or loss of runoff as it flows to the river channels. Therefore, July and August rainfall events tend to produce flashy watercourse flow conditions.

2.1.2 Methods

Eighteen hydrologic monitoring stations and two water level monitoring stations were installed as part of a freshwater baseline studies program designed to assess conditions in the Project area. These data, in addition to regional data, provide the basis for the hydrologic assessment of the Project.

During the 2006 open water season Knight Piésold Ltd. (KP) installed seven hydrologic monitoring stations in the immediate vicinity of the Mine Site, plus one station within the RSA to the north of the Mine Site, and

one station within the RSA to the south of the Mine Site. The Water Survey of Canada (WSC) also concurrently installed four monitoring stations on large river systems to the south of the Mine Site, two of which are within the RSA. In June 2008, KP installed a further five hydrologic monitoring stations and one water level monitoring station along the railway alignment between the Mine Site and Steensby Port. The final station was installed on a tributary of Sheardown Lake during summer 2011. Some stations were discontinued for periods. KP stations were operated during the open water season (June to September, approximately). Data collected at all twenty stations between July 2006 and September 2011 were used to assess hydrologic conditions for the Project. Long-term regional WSC data, in conjunction with the short-term Project data, were used to derive long-term mean annual discharge (MAD) estimates for selected watersheds within the RSA. Ten-year return period mean monthly wet and dry runoff estimates and 7-day low flow estimates were also derived. Peak instantaneous flood estimates for various return periods were also developed using long-term historical peak flow and extreme rainfall data collected by Environment Canada. Further details on methodology can be found in the Baseline Hydrology Report (Knight Piésold, 2011) in Volume 7, Appendix 7A.

2.1.3 Results

The key findings within the Baseline Hydrology Report (Knight Piésold, 2011) pertain to four main hydrometric parameters: timing of runoff, magnitude of runoff, spatial variability of timing and magnitude of runoff, and long-term runoff estimates. Runoff in the vicinity of the Mary River Project are characterised as follows:

- Streamflow typically commences in early to mid-June as temperatures climb above 0 oC, and ends in late September to late October, depending upon watershed characteristics.
- The annual hydrograph is dominated by a nival (snowmelt) freshet, which occurs between late June and the end of July, followed by a period of low baseflows driven by permafrost melt and shallow subsurface flow. Baseflows are punctuated by precipitation events through July to early September.
- Precipitation runoff events are usually quite large and flows increase rapidly as interception, infiltration, and evapotranspiration are minimal due to shallow permafrost, cool temperatures and lack of vegetative cover.

The timing and magnitude of runoff was first estimated from regional analyses and then reassessed with the addition of onsite measurements. Regional data indicated that mean annual unit runoff (MAUR) in the vicinity of Mary River should be slightly less than 10 l/s/km^2. They also suggested that mean annual peak daily unit runoff values likely range from less than 100 l/s/km^2 for watersheds with significant lake volumes, to over 400 l/s/km^2 for smaller watersheds without lakes. The actual measured results generally validate these estimates and are as follows:

- Watersheds H1-H7 operated by KPL had an average MAUR of 9.5 l/s/km^2 for the years of 2007-2008 and 2010-2011. The lowest measured annual mean unit runoff was recorded at H9 in 2007 at 3 l/s/km^2. The highest annual mean unit runoff was 19 l/s/km^2 recorded in 2008 within the Isortoq River watershed, which contains significant glacial cover. The highest mean annual unit runoff measured in a non-glaciated catchment was 18 l/s/km^2 in the BR11 watershed during 2008.
- The annual maximum peak daily unit runoff varied greatly among the sites, and resulted from snowmelt events, precipitation events, as well as combinations of both. The lowest peak daily unit runoff for watersheds with at least one complete year of data was 99 l/s/km^2, measured within the

extensively lake covered BR137 catchment during 2008. The highest annual peak daily unit runoff was recorded in during a July 2006 rain event in the H4 watershed, which registered a unit runoff of 446 l/s/km^2.

As noted above, significant variation was recorded within both the annual hydrograph shape and the volume and intensity of unit runoff. Numerous factors contributed to this variation; the primary factors are listed below:

- The proportion of lakes within a watershed has a significant effect on both the hydrograph shape and unit runoff. Because the lakes are still free of ice and contain attenuated runoff when precipitation begins to fall as snow and permafrost melt ends, rivers fed by lakes typically freeze up approximately a month later than systems that do not include lakes. Lakes attenuate rapid runoff events as well as diurnal fluctuations in runoff, resulting in much lower intensity and longer duration storm event runoff and an overall smoother hydrograph. Lakes also allow larger volumes of water to evaporate than does the surrounding land, therefore lowering the mean annual unit runoff in catchments with large lake components.
- In smaller watersheds, windblown snow deposition may act to increase and/or decrease the mean annual unit runoff depending on whether a net gain or net loss of snow is occurring within the watershed. In larger watersheds, windblown snow is typically less significant as gains tend to balance the losses.
- Runoff from higher elevation areas tends to be greater than from lower elevation areas due to orographic enhancement of precipitation.

Finally, long-term mean discharge values were developed for seven hydrologic stations, as was a methodology for estimating peak return period discharge. Results are summarized as follows:

- The long-term mean annual unit runoff values ranged from 7.5 l/s/km^2 at H1 to 11.5 l/s/km^2 at H3. The average long-term mean annual unit runoff for all stations was 9.5 l/s/km^2.
- The 10-year mean monthly wet and dry return period discharge ranged between 14 % and 229 % of mean monthly discharge.
- For a 200-year return period, peak instantaneous discharge estimates range from a low of 340 l/s/km^2 in the largest monitored watershed (Ravn River) to almost 2500 l/s/km^2 in the smallest monitored watershed (H5).
- The equations developed to calculate instantaneous flood flows for various return periods based upon watershed area are as follows:
  - $Q_2 = 1.1 \times A^{0.79}$
  - $Q_5 = 1.7 \times A^{0.77}$
  - $Q_{10} = 2.0 \times A^{0.76}$
  - $Q_{25} = 2.6 \times A^{0.75}$
  - $Q_{100} = 3.5 \times A^{0.73}$
  - $Q_{200} = 3.9 \times A^{0.73}$

  where

  Q = peak instantaneous flow in m^3/s

  A = drainage area in km^2 (only applicable for watersheds between 0.5 km^2 and 1000 km^2 in size)

The baseline analysis also presented information regarding groundwater discharge and climate change. It was determined that permafrost in the region is on the order of 500 m deep, and that the active layer of the permafrost is approximately 1 m to 2 m deep. As a result, groundwater infiltration and storage is minimal, and transport is limited to shallow subsurface flow. As to climate change, current climate models indicate that temperature, precipitation and runoff will increase throughout the rest of the century in Northern Baffin Island. However, due to the interdependent nature of the physical processes operating within the freshwater RSA, it is extremely difficult to predict the effects such potential changes will have on the hydrology of the region. The baseline report recommends incorporating conservatism in hydrologic designs and impact assessments to account for possible changes due to potential future climate change effects. Further information on climate change in the region is available in Volume 5 Section 1.5, as well as in Volume 9 Section 2.2. Further details regarding the results of the hydrologic assessment can be found in the Baseline Hydrology Report (Appendix 7A).

2.2 ISSUES SCOPING

Information from various sources was collected and reviewed to identify potential issues related to hydrology within the RSA.

2.2.1 Scoping Completed

Scoping activities by the Project team involved the following:

- Literature and data review (baseline conditions) that improved the understanding of hydrologic and hydrometeorologic conditions near the Project, and more specifically within the RSA, were identified and reviewed.
- Discussions with Water Survey of Canada (WSC) personnel were conducted to improve knowledge of hydrology and hydrologic monitoring methods in the region.
- Installation and maintenance of monitoring stations and measurements of discharge at varied flow conditions were conducted by Knight Piésold (KP) and WSC within the RSA.
- Consultation with the communities of (listed in alphabetical order): Arctic Bay, Clyde River, Hall Beach, Igloolik and Pond Inlet, were conducted as described in Volume 2, Section 1.0.
- Inuit knowledge studies were carried out in the same communities listed above.
- A Mary River Project team scoping meeting was held in November 2007.

The above scoping activities contributed to the identification of Valued Ecosystem Components (VECs) and subjects of note, as described below.

Terms specific to the freshwater quantity VEC that require definition were also defined during scoping:

- Lake: a body of freshwater surrounded by land.
- Watercourse: a natural channel through which water flows.
- Waterbody: either a lake or watercourse.
- Runoff: the water from rain, snowmelt or ice melt that flows into streams or other surface waters.
- Unit Runoff: runoff per unit area of watershed.

2.2.2 Valued Ecosystem Components

As described in the Impact Assessment Methodology (Volume 2, Section 3.0), VECs are distinguished as the valued components of the natural biophysical environment, and are identified as those aspects of the

environment considered to be important to a particular region or community. 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 with respect to hydrology. 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.

2.2.3 Subjects of Note and Key Issues

Potential effects of the Project on water quantity will be addressed as either Subjects of Note or as Key Issues. Key Issues, defined as interactions that are of substantial public interest and/or of potentially high environmental importance or consequence, will be carried through the entire assessment. Subjects of Note are defined as less likely to be of notable environmental importance or consequence and will not be carried through the entire assessment. In accordance with the definitions provided in Volume 2, Section 3.5.3, potential interactions have been rated as either Level 1 - Subject of Note or Level 2 - Key Issue. The interactions categorized under each Level are as follows:

Subjects of Note

- Watercourse Crossings
- Railway Alignment Diversions
- South Cockburn Alluvial Fan Channel Diversions
- Stormwater Management

Key Issues

- Withdrawal - withdrawal of water from waterbodies within each LSA
- Diversion - redistribution of water within each LSA
- Discharge - discharge of withdrawn or diverted water

2.2.4 Subjects of Note

Watercourse Crossings

Several bridge and culvert crossing structures are required along the Railway and Railway Access Road. The crossings will be designed to the following criteria to avoid or reduce effects on the hydrologic environment, as well as to the structures themselves.

Table 7-2.1 Watercourse Crossing Design Criteria

Criteria Flood	Return Period
• Design Flood - Main Rail	• 1:200 year
• Fish Passage - Main Rail	• 10-year 3-day peak flow • Average flow • 90 % exceedance flow
• Navigability Flow	• 15 % of 1:2 year average daily peak flow
• Design Flood - Access Road	• 1:10 year

Descriptions of the Criteria Floods are as follows:

- *Design Flood*: Extreme flow event used to determine the hydraulic design capacity of the crossing. During this flood, high water levels (including freeboard) design criteria are met. This event is also used to establish design flow velocities affecting structural loadings on design elements such as piers, and to determine appropriate scour protection measures. This event is associated with a specific return period, i.e. the probability that the event will occur during a given year.
- Fish Passage Flows: A flow condition which incorporates the requirements for fish passage and spawning of local fish species in the hydraulic design of the crossing. This design flow condition applies only to specified fish-bearing watercourses and associated crossings.
- Navigation Flow: a relatively frequent flow condition during which navigational passage of a crossing is to be maintained. General design criteria with respect the vertical and horizontal clearance required under these conditions have been developed in consultation with Transport Canada's Navigable Waters Protection Program. Navigation flows and design criteria apply only to a limited number of crossings that have been deemed to be navigable based on Transport Canada's individual site assessments.

The culverts installed along the rail and road alignments may experience temporary blockage by ice or debris during Construction, Operation and closure. Locations particularly prone to blockage tend to have relatively low gradient culverts, low gradients downstream of the culverts, and/or are prone to snow and ice collection within the culverts or in the downstream drainage ditches. The knowledge gained through operation of the Tote Road will be applied to the Railway, and appropriate mitigation measures will be implemented to reduce the likelihood of blockage. For example, the culverts will be sized to pass the 1:200 year event with the bottom half of the culvert filled with ice and debris (Dillon, 2008). Once the culverts are in place, they will be frequently monitored. Any blockages will be quickly cleared through high pressure wash. During closure and reclamation of the Project, all drainage and crossing structures along the alignments will be removed and natural drainage and water flows will be restored. Further closure details are provided in Volume 3 Section 4.

Railway and Railway Access Road Alignment Diversions

The railway and railway access road alignments are linear features more than 100 km in length. Both structures have the potential to divert considerable amounts of runoff; however, they will be designed to minimize water diversion, especially along the railway alignment. Culverts will be used for smaller rivers and water channels, reducing the potential for water to accumulate on the side of embankments. The alignments will also be designed to keep water and ice from the toe of embankments and limit the embankment exposure to freeze/thaw movements of the soil. Where the railway and access road cross areas of disperse overland flow, water accumulation will be avoided by the use of free draining embankment material, which allows water to continue to flow downhill beneath the alignment (Dillon, 2008). As a result of these standard mitigation measures, the effects of the railway and road alignments on water quantity are expected to be minor.

South Cockburn Alluvial Fan Channel Diversion

Diversion of freshwater will occur near South Cockburn Camp, where the rail alignment crosses an alluvial fan. The fan was created from the depositional action of two watercourses, which both occupy the fan. Both channels braid as they cross the fan, and then converge again into a single channel before entering

Cockburn Lake. The watercourses currently remain separate as they cross the fan; however it has been determined that during high flow events water can spill over low sections of bank, resulting in transfer of water between the braided channels and between the two major watercourses. Study of these channels also shows that they are active and have changed location and size in the recent past. In order to minimize risk to crossing structures on the fan, three containment berms will be constructed to prevent transfer of floodwater between channels and to direct flows to channels with crossings that will be designed to accommodate the extra flow volumes. Several minor braided channels may also be diverted to larger channels with crossings designed to accommodate the extra flow volumes, resulting in a partial or total dewatering of these minor channels below the diversions. These diversions will not affect water quantity within the watersheds under most flow conditions; however, they may result in a minor alteration of water quantity during high flow events, when water would naturally flow between the two major watercourses. This potential alteration is confined to short periods of time during peak discharge. These diversions should not result in a measurable alteration of water quantity within the Railway LSA, and will therefore not be considered further in the Water Quantity effects assessment. However, removal of water from several short channel reaches on the fan may have an effect on fish habitat; this will be considered in Volume 7, Section 4.

Surface Water Management

Non-key components may also affect water quantity. Non-key components are defined as project components not likely to have significant effects to water quantity within the Mary River Freshwater RSA: laydown areas, camps, airstrips and other mine use areas that may intercept water runoff. Water may also be withdrawn from various lakes along the railway alignment and the Tote Road for dust suppression. Management of water in contact with these non-key components will be detailed in the Surface Water, Aquatic Ecosystems, Fish and Fish Habitat Management Plan (Volume 3, Appendix 3B, Attachment 5). However, the plan will manage water in contact with these non-key components in a manner that will avoid or greatly reduce effects on water quantity. For example, locations of dust suppression withdrawal have yet to be identified but potential source waterbodies will be visually assessed prior to withdrawal to mitigate potential effects on water quantity. Consequently, the effects to water quantity that may result from interactions with non-key components will not be assessed for impacts or significance.

2.3 FRESHWATER QUANTITY (KEY INDICATOR)

2.3.1 Assessment Methods

Assessment methods and criteria are discussed in detail in Volume 2, Section 3.0 and are summarized below:

- Regional and local study areas were determined;
- VECs were identified;
- Project activities that could affect hydrological resources and associated issues were identified;
- Project interactions with, and effects on, the freshwater quantity VEC were identified;
- Mitigation measures were identified to avoid or reduce adverse effects during the various phases of work;
- Residual effects were evaluated as to relative significance to the freshwater quantity VEC; and
- Long-term monitoring programs to distinguish Project-related effects from natural changes and to verify effects predictions were developed.

Locations were selected for assessing the magnitude of the water quantity VEC. Standard assessment locations were required because the magnitude of effects on water quantity vary according to the location

on the watercourse where they are assessed. Magnitude assessment locations were selected either by following government guidelines or, when none applied, by selecting an appropriate location for the various Project activities affecting water quantity. These are outlined below in Table 7-2.2.

Table 7-2.2: Magnitude Assessment Locations

Activity	Impact	Magnitude Assessment Location
Water withdrawal from lakes	Reduction in lake volume	Withdrawal waterbody
	Reduction in downstream flow	Outlet of withdrawal waterbody
Point withdrawal of water from a watercourse	Reduction in downstream flow	Point of withdrawal
Diversion of water from a watercourse or watershed	Reduction in discharge downstream of diversion	Downstream extent of the watershed within the LSA or the upstream extent of fish habitat within the watercourse.
Discharge of water to a watercourse	Increase in discharge	Downstream extent of the watershed within the LSA or the upstream extent of fish habitat within the watercourse.

2.3.1.1 Measurable Parameters and Thresholds

Measurable parameters and associated thresholds were defined for the freshwater quantity VEC in accordance with discussion provided in Volume 2, Section 3.0. The freshwater quantity VEC parameters and thresholds are presented below in Table 7-2.3.

Table 7-2.3: Freshwater Quantity VEC Parameters and Thresholds

Measurable Parameters	Thresholds
Volume of water withdrawn from a waterbody under ice conditions.	Withdrawal volume should be less than 10 % of the available water volume beneath 2 m of ice.[1]
Change in flow volume from a waterbody at the point of withdrawal during open water conditions	Change in flow volume should be less than 10 % of the average total monthly volume of flow from the waterbody at the point of withdrawal.[2]
Change in flow volume from a waterbody resulting from the diversion or discharge of water into or out of a watershed.	Change in flow volume should be less than 10 % of the average total monthly volume of flow at a downstream point of interest.[2,3]

NOTE(S):

1. THRESHOLD DERIVED FROM MAXIMUM ALLOWABLE WITHDRAWAL PRESENTED IN THE DFO PROTOCOL FOR WINTER WATER WITHDRAWAL FROM ICE-COVERED WATERBODIES IN THE NORTHWEST TERRITORIES AND NUNAVUT.
2. 10 % EXCEEDANCE OF BASELINE CONDITIONS IS AN OFTEN USED CRITERION FOR ASSESSING HYDROLOGIC EFFECTS. (BOVEE, 1998)
3. DOWNSTREAM POINTS OF INTEREST ARE DEFINED AS EITHER THE NEAREST DOWNSTREAM FISH HABITAT, THE NEAREST DOWNSTREAM WITHDRAWAL WATERBODY, OR THE OUTLET OF THE WATERSHED.

The 10 % exceedance values often used to assess hydrologic effects are a general industry standard and might not be specific to the Project location. The values generally include considerable safety factors, and should therefore be conservative. Residual effects to streamflow volume will be monitored early in Project development to ensure that the 10 % threshold is indeed applicable to the Project.

2.3.1.2 Key Issues and Pathways

Key issues identified in the EIS guidelines for freshwater quantity included:

- Effects of extreme flows on Project design;
- Effects of water diversion at the Mine Site;
- Effects of storm water runoff on receiving waters;
- Effects of Mine facility construction and operation on drainage patterns;
- Effects of modification or redirection of natural flows on terrestrial and aquatic wildlife;
- Effects of ice damming of culverts;
- Effects on navigability at watercourse crossings;
- Effects of water diversions related to the Railway;
- Effects of water withdrawal on source volume; and
- Effects of effluent discharge on natural runoff regime.

The assessment of potential water quantity effects presented below is organized by LSA. All of the above issues and pathways relate to the withdrawal, diversion, or discharge of water within one or more LSA, therefore, the Key Issues and Pathways have been simplified to the following:

- Water Withdrawal;
- Water Diversion; and
- Runoff or Effluent Discharge.

Effects will only be assessed for Key Components within each LSA. Key Components are defined as Project infrastructure features that have a reasonable chance of producing measurable effects on water quantity. Key Components are:

- Ore Stockpiles and Ore Offload Areas;
- Waste Rock Stockpiles;
- Open Pit; and
- Water Source Waterbodies.

The effects on water quantity resulting from other Project components have been discussed as Subjects of Note. Effects of water quantity on terrestrial wildlife will be addressed in Volume 6 of the EIS, while effects to aquatic biota are addressed in Section 4. The effects on navigability at watercourse crossings is discussed in Volume 9. An account of the Project phases during which Key Issues have the potential to affect surface water quantity is provided in Table 7-2.4.

Table 7-2.4 Potential Effects from Key Components per Project Phase for Surface Water Quantity

Issue	Milne Port	Milne Inlet Tote Road	Mine Site	Railway Alignment	Steensby Port
Water Withdrawal	Construction, Operation and Closure	Construction, Operation and Closure	Construction, Operation and Closure	Construction	Construction, Operation and Closure
Water Diversion	N/A	N/A	Operation, Closure and Post-closure	Construction, Operation and Closure	Construction, Operation and Closure
Runoff or Effluent Discharge	N/A	N/A	Construction, Operation and Closure	N/A	N/A

NOTES:
1. N/A INDICATES NO INTERACTIONS ARE EXPECTED.
2. IN THE ABOVE TABLE, CLOSURE REPRESENTS THE DECOMMISSIONING PHASE OF THE PROJECT.
3. IN THE ABOVE TABLE, POST-CLOSURE REPRESENTS THE POST-DECOMMISSIONING PHASE OF THE PROJECT.

The impacts to the Water Quantity VEC are described in greater detail in Section 2.3.2.

Other related freshwater aquatic VECs that may be potentially affected include surface water and sediment quality, and fish and fish habitat, which are discussed in Sections 3 and 4 of Volume 7, respectively.

2.3.2 Potential Effects and Proposed Mitigation

2.3.2.1 General Effects

Water Withdrawal

Withdrawal of water will affect quantity by reducing the volume of the waterbody as well as the downstream flow. Volume reduction is of particular importance during winter when lake surfaces are frozen and water levels are below the outlet; withdrawal will lower the surface elevation, potentially causing dewatering and stranding of fish. In lakes used by Arctic char for spawning, there is a potential for ice to freeze or smother eggs in shallow spawning beds. In spring, outflow will not occur until the lake has refilled and the water surface rises above the outlet. This refilling will delay outflows from the lake. Once it starts, outflow will continue as it would naturally, reduced only by the rate of any summer withdrawals. Reduction in summer outflow may also affect downstream fish biota, including a reduction in fish habitat, through changes to substrate conditions and stranding of previous habitat, a reduction in benthic invertebrate transport, or the prevention of fish passage. Reduction in summer outflow may also affect terrestrial wildlife by depleting their drinking water.

Water Diversion

Water diversion will affect quantity by redistribution within or between watersheds. This redistribution may result in either an increase or decrease in discharge within a watercourse. A reduction in discharge may result in effects to fish, including a reduction in fish habitat, both through changes to substrate conditions and stranding of previous habitat, a reduction in benthic invertebrate transport, or the prevention of fish passage. Reduction in discharge may also affect terrestrial animals relying on these flows for drinking water or other purposes. An increase in discharge may also affect fish biota and terrestrial wildlife. Increased discharge may damage or remove fish habitat, as relatively high flows may be able to transport larger bed

material. Navigation of the watercourse by fish, humans, or terrestrial wildlife may also be impaired by increased discharge.

The Project will require minor water diversions with effects generally below quantifiable limits. These minor water diversions will typically occur around infrastructure, which will act to divert non-channelized runoff around the footprint, but runoff will be otherwise unaffected. Such minor diversions will be discussed within the SWMP and will not be considered within the EIS.

Discharges to Fresh water

Runoff or effluent discharge to fresh water will increase the amount of water within a watercourse. Potential effects are identical to those stated above for discharge of diverted water.

2.3.2.2 General Mitigation

Water Withdrawal

Potential effects from water withdrawal were mitigated for during selection of the withdrawal waterbodies and during the design of the water withdrawal program. Mitigation activities included:

- Desktop assessment of potential withdrawal waterbodies. The assessment considered lake size, upstream watershed area and accessibility during candidate waterbody selection.
- Collection of bathymetric data on the best candidate waterbody identified during the high level review in order to quantify water depths and volumes.
- Volume reduction calculations were conducted using conservative assumptions of water withdrawal volumes to ensure that the guidelines presented in Section Table 7-2.3 were met.

Water Diversion

Potential effects of water diversion were mitigated through the design of the diversion structures. Project infrastructure requiring diversion were located and designed in an effort to minimize downstream effects. Mitigation activities included:

- Desktop assessment of potential infrastructure locations. The assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations.
- Ground truthing of assumptions made during desktop assessment.

Discharge to Freshwater

Potential effects of runoff or discharge to the receiving watercourse were mitigated through the location of the point of discharge. Mitigation activities included:

- Desktop assessment of potential discharge locations. Assessment considered the location of fish habitat, as well as the watercourse length to be affected.
- Ground truthing of assumptions made during desktop assessment.

2.3.2.3 Milne Port LSA Potential Effects Assessment

Freshwater withdrawal is the Key Water Quantity Issue within the Milne Port LSA that will be carried through the effects assessment.

Water will be required for various domestic and industrial activities during Construction, Operation and Closure of the Project within the Milne Port LSA. The domestic and industrial water consumption rates and intake locations are presented below in Table 7-2.5. A more detailed breakdown of individual water use activities and consumption rates is provided in the Milne Port water balance figures presented in Volume 3, Appendix 3B.

Table 7-2.5 Water Consumption within the Milne Port LSA

Use	Intake Location	Project Phase Consumption (m^3/day)	
		Construction	Operation/Closure
Domestic	Phillips Creek (summer); Km 32 Lake (winter)	52.3	13.8
Industrial		15.2	15.2

NOTE(S):
1. CONSUMPTION RATES SOURCED FROM REV B OF THE FRESHWATER SUPPLY, SEWAGE AND WASTEWATER MANAGEMENT PLAN (H337697-4000-10-126-0001) DEVELOPED BY HATCH, DATED NOVEMBER 7, 2011.

During the Operation, Construction and Closure phases, water will be withdrawn from Phillips Creek during the open water season (June - September) and from Km32 Lake during winter (October - May) when Phillips Creek is frozen. Withdrawal locations are presented on Figure 3-2.1. Water will be withdrawn from the source location at a constant rate year-round and will be stored in a freshwater tank. The majority of users will source water from this tank. Water requirements will be greatest during the Construction phase, when camp size and potable water requirements are at their greatest. Withdrawal requirements have not yet been determined for the Closure phase, but they can be assumed to be equal to, or less than, requirements during Operations, and will occur only during decommissioning. No withdrawals will occur post-Closure.

Minor water diversions will occur within the Milne Port LSA, and are addressed as a Subject of Note in Section 2.2.4. Effluent discharge will also occur during the Construction, Operation, and Closure phases of the Project at Milne Port; however it will be pumped directly to the ocean and will therefore have no effect on freshwater quantity.

2.3.2.4 Milne Inlet Tote Road LSA

The only key water quantity issue that will occur within the Milne Inlet Tote Road LSA is the withdrawal of fresh water from Km32 Lake. Water will be required for the Milne Port during winter, when Phillips Creek is frozen; effects of this withdrawal are addressed as part of the Milne Port effects assessment.

2.3.2.5 Mine Site LSA

Key water quantity issues within the Mine Site LSA that will be carried through the effects assessment are:

- Freshwater Withdrawal;
- Freshwater Diversion; and
- Runoff or Effluent Discharge.

Water) will be required for domestic and industrial activities during Construction, Operation and Closure of the Project within the Mine Site LSA. Consumption rates and intake locations are presented below in Table 7-2.6. A more detailed breakdown provided in the Mine Site water balance figures presented in Volume 3, Appendix 3B.

Table 7-2.6: Water Consumption within the Mine Site LSA

Use	Intake Location	Project Phase Consumption (m^3/day)	
		Construction	Operation/Closure
Domestic	Camp Lake	330	169
Industrial		379	34

NOTE(S):
1. CONSUMPTION RATES SOURCED FROM HATCH MINE SITE WATER BALANCE (REV'D JANUARY 9. 2012)

All water needed at the Mine Site LSA will be obtained from Camp Lake during all phases of the Project. Withdrawal locations are presented on Figure 3-2.3. Water will be withdrawn from the source location at a constant rate year-round, and will be stored for use in a freshwater tank. The exploration camp potable water requirements are not included in the assessment as they are existing withdrawals with existing approvals. Water consumption rates will be reduced considerably after Construction when camp sizes are reduced and concrete manufacture ceases. Withdrawal requirements have not yet been determined for the Closure phase, but they can be assumed to be equal to, or less than, requirements during Operations and will only occur during decommissioning. No water withdrawals will occur post-Closure. Potential effects of flow reduction are discussed previously in Section 2.3.2.1.

The diversion of water will occur during Operation, Closure and post-Closure of the Project within the Mine Site LSA. The structures causing the diversions, as well as the distribution of the diversions throughout the phases of the Project, are presented in Table 7-2.7 below.

Table 7-2.7 Diversion Structures within the Mine Site LSA

Diversion Structure	Project Phase		
	Operation	Closure	Post-Closure
Waste Rock Stockpile	1	1	1
Open Pit	1	1	1
Ore Stockpile Platform	1	1	0

NOTES
1. 0 - DIVERSION IS NOT PRESENT DURING THE PROJECT PHASE.
2. 1 - DIVERSION IS PRESENT DURING THE PROJECT PHASE.
3. IN THE ABOVE TABLE, CLOSURE REPRESENTS THE DECOMMISSIONING PHASE OF THE PROJECT.
4. IN THE ABOVE TABLE, POST-CLOSURE REPRESENTS THE POST-DECOMMISSIONING PHASE OF THE PROJECT.

The Waste Rock Stockpile is located above the open pit, as illustrated in Figure 3-2.3. The stockpile is located within sub-watersheds MR-07, MR-08, MR-10 and MR-12. Runoff from the east and west sides will be managed separately. The west side will divert water from watersheds MR-08 and MR-10 into a storage pond (West Pond – SWP1) within watershed MR-10. The runoff from the watershed upslope of the pond and diversion channel will be diverted to the southern portion of the MR-10 watershed. The east side will divert water from watersheds MR-07 and MR-12 into a storage pond (East Pond – SWP2) within watershed MR-12. The diversions and associated water management ponds will remain in place after Closure to allow for ongoing monitoring of water quality.

The Open Pit is located within sub-watersheds MR-08, MR-10, MR-12, and MR-16, as well as the Mary River watershed, as shown on Figure 3-2.3. During Operations, direct precipitation and wind blown snow will deposit in the Open Pit. Much of the snowfall will be removed along with the ore and waste rock, while excess water will be pumped or trucked to the East Pond. For the purpose of this assessment, it is projected that 50 % of annual precipitation will fall as rain, 50 % will be snow. All summer rainfall and 18 % of winter snowfall from the Open Pit is assumed to report to the East Pond, while 32 % of snowfall reports to the West Pond, 25 % of winter snowfall from the Open Pit reports to the Ore Stockpiles, and the remaining 25 % reports to the Run-of-Mine (ROM) Pond. After Closure, the Open Pit will be allowed to fill with water to create a pit lake, a process that will take approximately 85 to 150 years (KP, 2008). Once filled, the pit lake will naturally discharge to the Mary River. Further details regarding closure of the Open Pit are provided in Volume 3 Section 4.

The ROM Stockpile is sited on the hillside above the Mary River, downslope from the Pit. The ROM Stockpile and associated surface water runoff pond will not divert water between watersheds, nor will it store water for any length of time (current assumption is storage for only a few days) and as a result, no measurable effects to water quantity are expected from the diversion of water by the ROM Stockpile.

The Ore Stockpile Platform is located primarily within watershed MR-16, and it will divert water from sub-watersheds SDL Tributary 1, 9 and 12, as well as the Mary River, to its water management pond. The platform will also cause a portion of the SDL Tributary 1 headwaters to be diverted to the Mary River. The Ore Stockpiles and ROM stockpiles will be removed during Closure and natural drainage will be restored if possible. All other potential diversions within the Mine Site LSA are considered within the SWMP, and are discussed as a Subject of Note.

The discharge of effluent will occur during Construction, Operation, Closure and post-Closure of the Project within the Mine Site LSA. The effluent discharge activities are presented in Table 7-2.8 below.

Table 7-2.8 Effluent Discharge Activities within the Mine Site LSA

Diversion Structure	Project Phase			
	Construction	Operation	Closure	Post-Closure
Waste Rock Stockpile Effluent	1	1	1	1
Ore Stockpile Effluent	1	1	1	0
Sewage Effluent	1	1	1	0

NOTES:

1. 0 - EFFLUENT DISCHARGE IS NOT PRESENT DURING THE PROJECT PHASE.
2. 1 - EFFLUENT DISCHARGE IS PRESENT DURING THE PROJECT PHASE.
3. IN THE ABOVE TABLE, CLOSURE REPRESENTS THE DECOMMISSIONING PHASE OF THE PROJECT.
4. IN THE ABOVE TABLE, POST-CLOSURE REPRESENTS THE POST-DECOMMISSIONING PHASE OF THE PROJECT.

An operations effluent discharge scenario that would minimize impacts to water quality was selected for the waste rock ponds and ore stockpile pond. It involves discharge of the West, East and Ore Stockpile Ponds throughout the open water season, at rates that will vary with flow in the channel (more channel flow equals more discharge) so that a constant discharge to natural flow ratio is achieved. After closure, the ore stockpile ponds will be decommissioned, while the waste rock ponds will be allowed to fill and then discharge at natural rates without human imposed storage and discharge cylces. Treated sewage effluent

will be discharged to the Mary River during summer and to a storage tank during winter. Sewage effluent treated and discharged at the Mine Site will include effluent from the Ravn and Mid-rail Camps. It is assumed that effluent will be discharged at a steady rate to the Mary River during July and August. The locations of all discharge points within the Mine Site LSA are presented on Figure 3-2.3. If changes are required to the temporal discharge assumptions stated above, Baffinland will reassess the effects of the corresponding discharges.

The potential effects of water withdrawal, water diversion, and effluent discharge on freshwater quantity are discussed above in Section 2.3.2.1. Measures undertaken to mitigate the potential effects of water withdrawal, water diversion and effluent discharge to freshwater on water quantity are discussed above in Section 2.3.2.2. Residual effects of these activities on water quantity are considered in Section 2.3.3.

2.3.2.6 Railway

Freshwater Withdrawal is the Key Water Quantity Issue within the Railway LSA that will be carried through the effects assessment.

Water will be required for domestic and industrial activities during the Construction Phase within the Railway LSA. Consumption rates and intake locations are presented below in Table 7-2.9. A more detailed breakdown is provided in the Railway water balance figures presented in Volume 3, Appendix 3B.

Table 7-2.9: Water Consumption within the Railway LSA

Camp/Site	Source Location	Use	Project Phase Consumption (m^3/day)
			Construction
Ravn River Area	Ravn Camp Lake	Domestic	132.0
		Industrial	13.2
Mid-Rail Area	Nivek Lake (summer) Ravn Camp Lake (winter)	Domestic	66.0
		Industrial	13.2
Cockburn Lake Tunnels Camp	Cockburn Lake (North Basin)	Domestic	66.0
		Industrial	33.9
Cockburn Lake South Camp	Cockburn Lake (South Basin)	Domestic	99.0
		Industrial	13.2

NOTE(S):

1. CONSUMPTION RATES SOURCED FROM REV B OF THE FRESHWATER SUPPLY, SEWAGE AND WASTEWATER MANAGEMENT PLAN (H337697-4000-10-126-0001) DEVELOPED BY HATCH, DATED NOVEMBER 7, 2011.

The camp and water withdrawal locations presented in Table 7-2.9 are shown graphically on Figures 3-2.4 through 3-2.8. Withdrawal will occur only during the Construction phase within the Railway LSA, after which time the camps will be dismantled and water will no longer be required. Water will be withdrawn from the source locations at a constant rate year-round, unless otherwise specified, and will be stored in a tank at each camp. The majority of water users will then source water from this tank.

Diversion may also occur within the Railway LSA; this may result from the railway alignment inhibiting downslope movement of shallow subsurface flow. Diversion will also occur across an alluvial fan near the South Cockburn Camp, where engineered channels will be required to allow safe construction of the

railway. Effects associated with these diversions are discussed in Section 2.2.4 as Subjects of Note. No other quantifiable fresh water diversions will occur within the Railway LSA.

The discharge of treated sewage effluent will not occur within the Railway LSA. Sewage generated at the Ravn and Mid-Rail camps will be transported to the Mine Site, while sewage generated at the Cockburn camps will be transported to Steensby Port. Sewage discharge at the Mine Site and Steensby Port is discussed in Sections 2.3.2.5 and 2.3.2.7, respectively.

2.3.2.7 Steensby Port LSA

Key Water Quantity Issues within the Steensby Port LSA that will be carried through the effects assessment are:

- Freshwater Withdrawal; and
- Freshwater Diversion.

Water will be required for domestic and industrial activities during Construction, Operation and Closure of the Project within the Steensby Port LSA. Consumption rates and intake locations are presented below in Table 7-2.10. A more detailed breakdown is provided in the Steensby Port water balance figures presented in Volume 3, Appendix 3B.

Table 7-2.10: Water Consumption within the Steensby Port LSA

Use	Intake Location	Project Phase Consumption (m^3/day)	
		Construction	Operation/Closure
Domestic	3km Lake (Early Construction); ST347 Lake (Rest of Construction and Operation)	100.0	100.0
Industrial		325.8	141.6

NOTE(S):
1. CONSUMPTION RATES SOURCED FROM REV B OF THE FRESHWATER SUPPLY, SEWAGE AND WASTEWATER MANAGEMENT PLAN (H337697-4000-10-126-0001) DEVELOPED BY HATCH, DATED NOVEMBER 7, 2011.
2. INTAKE LOCATION SCHEME SOURCED FROM THE PROJECT DESCRIPTION (VOLUME 3 OF THE EIS).

Early in the Construction phase, water will be withdrawn from 3km Lake. As construction proceeds and access is completed, an intake will be constructed at ST347 Lake, from which all water requirements will then be withdrawn from this waterbody. For the purposes of this assessment, it is assumed that at least one full year of water withdrawals occur from 3km Lake. Withdrawal and infrastructure locations at Steensby Port are presented on Figure 3-2.9. Water will be withdrawn at a constant rate year-round, and will be stored in a freshwater tank.

During the Operation phase, industrial activities such as road dust suppression and concrete manufacture will be scaled back or eliminated, reducing the water consumption rate below Construction phase levels. Withdrawal requirements have not yet been determined for the Closure phase, but they are assumed to be equal to or less than requirements during Operations and will occur only during Decommissioning. No water will be required post-Closure.

The diversion of water will occur during Construction and Operation of the Project within the Steensby Port LSA. The structure causing the diversion and the distribution of the diversion throughout the phases of the Project are presented below in Table 7-2.11.

Table 7-2.11 Diversion Activities within the Steensby Port LSA

Diversion Structure	Project Phase		
	Construction	Operation	Closure
Ore Stockpile	1	1	0
Marine Offload and Primary Tank Farm	1	1	0

NOTE(S):
1. 0 - WITHDRAWAL REQUIREMENT IS NOT PRESENT DURING THE PROJECT PHASE.
2. 1 - WITHDRAWAL REQUIREMENT IS PRESENT DURING THE PROJECT PHASE.
3. IN THE ABOVE TABLE, CLOSURE REPRESENTS THE DECOMMISSIONING PHASE OF THE PROJECT.

The Ore Stockpiles are located on an island at Steensby Port (Steensby Island), as shown on Figure 3-2.9. The stockpile footprint covers eight small ponds on the island, diverts water from four watersheds, and represents approximately 22 % of the total area of the island. The flow of water discharging from the stockpiles is also presented on Figure 3-2.9. Runoff will be collected into a drainage pond where it will be treated and then discharged through an engineered outlet channel to the ocean. Runoff from the watersheds above the Ore Stockpiles will be diverted around the stockpile and discharged downslope at a low point in the terrain. Water collecting on the Marine Offload laydown area and Primary Tank Farm will also be diverted to a stormwater management pond where it will be collected, treated and released into a short, natural channel that discharges to Steensby Inlet.

Discharge of effluent to fresh water will not occur within the Steensby LSA, as it will be discharged by pipe directly to the ocean.

The potential effects on water quantity of withdrawal, diversion and effluent discharge to fresh water are discussed above in Section 2.3.2.1. Measures to mitigate the potential effects on water quantity are discussed above in Section 2.3.2.2. Residual effects of these activities on water quantity are considered in Section 2.3.3.

2.3.3 Assessment of Residual Effects of Key Issues

Rating Criteria

Residual effects are those effects that persist after mitigation has been applied. Each potential effect is rated using the VEC-specific criteria described in Table 7-2.12 to assess residual effects.

Table 7-2.12 Ratings for Evaluating Residual Water Quantity Impacts

Criteria	Classification	
Magnitude (Specific to the VEC and the impact)	Level 0	An effect on the Indicator/VEC that is less than quantifiable limits.
	Level I	An effect on the Indicator/VEC that results in a change that is less than threshold value(s)
	Level II	An effect on the Indicator/VEC that results in a change that is greater than threshold value(s)
	Level III	An effect on the Indicator/VEC that results in a change that is five times greater than threshold value(s)

Table 7-2.12 Ratings for Evaluating Residual Water Quantity Impacts (Cont'd)

Criteria	Classification	
Extent The physical extent of the effect, relative to study area boundaries	Level I	The effect applies to less than 1 km of channel or occurs within a watershed less than 10 km^2 in size
	Level II	The effect applies to less than 10 km of channel or occurs in a watershed less than 100 km^2 in size
	Level III	The effect applies to more than 10 km of channel or occurs in a watershed greater than 100 km^2 in size
Duration The length of time over which a Project effect will occur	Level I	Short term (up to the end of construction of the Project, 4 years)
	Level II	Medium term (up to the end of Decommissioning of the Project, 28 years)
	Level III	Long term (beyond the life of the Project) or permanent
Frequency How often the effect occurs	Level I	Infrequent - rarely occurring
	Level II	Frequent - intermittently occurring
	Level III	Continuous
Reversibility The likelihood of the VEC to recover from the effect	Level I	Fully reversible after activity is complete
	Level II	Partially reversible after activity is complete
	Level III	Non-reversible after activity is complete
Qualifiers		
Certainty Limitations in the overall understanding of the ecosystem and ability to predict future conditions	High	Baseline data is comprehensive; predictions are based on quantitative data; effect relationship is well understood
	Medium	Intermediate degree of confidence between high and low
	Low	Baseline data are limited; predictions are based on qualitative data ; effect relationship is not well understood
Probability The likelihood that the predicted impact/residual effect will occur	Unlikely	Less than 20 % likelihood of occurrence
	Moderate	Between 20 and 60 % likelihood of occurrence
	Likely	Over 60 % likelihood of occurrence

Each of the five criteria contributes to the determination of significance. Criteria are categorized into three levels: Level I indicates a negligible or limited potential to contribute to an overall significant adverse environmental effect, Level II represents the intermediate condition and Level III indicates a high potential to contribute to an overall significant adverse environmental effect. Magnitude may also be assessed as Level 0 if the effect is less than quantifiable limits. The quantifiable limit for the two primary water quantity effects are presented below in Table 7-2.13.

Table 7-2.13 Quantifiable Limits

Effect	Quantifiable Limit
Changes to Lake Volume	None
Changes to Discharge	1 % of measured discharge

There is no quantifiable limit for changes in lake volume, as the volume removed is generally easy to measure and is relatively accurate. The quantifiable limit for changes to discharge is 1 % of measured

discharge. Based upon results of measured streamflow data within the Mary River RSA, the least uncertainty associated with the best reasonable measurement methods is +/-5 %. In an effort to be conservative, the quantifiable limit was reduced to 1 % of discharge. Therefore, any changes to discharge that are less than 1 % of background levels are unquantifiable, as the change would be well within the uncertainty of the measurements used to quantify the change.

2.3.3.1 Milne Port LSA Residual Effects Assessment

The following section rates residual effects on Water Quantity in the Milne Port LSA, organized by watershed. The residual effects considered and assessed within the Milne Port LSA are summarized as follows:

Phillips Creek Watershed

1. Water withdrawal - volume reduction
2. Water withdrawal - outflow reduction

The details of the Milne Port LSA residual effects assessment are provided below.

Phillips Creek Watershed

1. Water Withdrawal from Km32 Lake - Reduction in Under-Ice Lake Volume

Residual effects ratings for the reduction in under-ice water volume in Km32 Lake, resulting from water withdrawal in the Milne Port LSA, are summarized in Table 7-2.14.

Magnitude

Water will be withdrawn from Km32 Lake during the winter months. Volumes are presented in Table 7-2.15, along with the resulting overwinter drawdown within Km32 Lake. Withdrawals will be greatest during Construction, and will result in a reduction of approximately 0.03 % of the total under-ice lake volume. This reduction is over two orders of magnitude less than threshold, and is therefore rated as a Level I effect.

Extent

The reduction in under-ice volume will only occur within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from Km32 Lake will occur throughout the Construction, Operation and Closure phases of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Km32 Lake during the winter months. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in under-ice volume will cease once water withdrawal stops. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in Km32 Lake within the Milne Port LSA. The residual effect is ranked as Not Significant (Table 7-2.17).

2. Water Withdrawal from Km32 Lake and Phillips Creek - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge in Phillips Creek, resulting from water withdrawal in Km32 Lake and Phillips Creek, within the Milne Port LSA are summarized in Table 7-2.14.

Magnitude

Water will be withdrawn from Km 32 Lake during winter (November through May) and from Phillips Creek during summer (June through October). Water withdrawal volumes are presented in Table 7-2.16, along with the resulting reduction in monthly discharge. All of the reductions are less than quantifiable limits. The residual effect has therefore been rated as Level 0, and consequently it will no longer be considered within the water quantity effects assessment.

None of the potential residual effects on water quantity within the Milne Port LSA were determined to be significant. No feedback was provided through public consultation or Inuit Knowledge Studies or by regulators as to the perceived significance of these activities.

The Level of Confidence in all significance ratings is high. Confidence ratings are based upon an assessment of the quality of available information used to evaluate the residual effects. The data used to quantify residual effects on water quantity within the Mine Site LSA are:

- Watershed Areas: Values were determined using GIS and AutoCAD.
- Lake Volume and Surface Area: Values were determined from bathymetric surveys.
- Water Withdrawal Volumes: Values were provided by Hatch and are based upon experience with similar mining ventures.
- Mean Monthly Discharge Volumes: Values are based upon four years of data collected within the Mary River RSA.

All of the above data were determined to be of good quality. Effects that made use of only area or volume data, and required zero to minimal assumptions, were rated as having high confidence. Effects that required the application of hydrologic data which were scaled from other watersheds, or the use of potentially large assumptions, were rated as having moderate confidence.

Table 7-2.14 Milne Port LSA Freshwater Quantity Effects Assessment Summary - All Phases

Potential Impacts			Evaluation Criteria				
Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
Water Withdrawal from Km32 Lake	Reduction in Under-Ice Water Volume	Withdrawal waterbody was selected in an effort to meet DFO guidelines	Level I	Level I	Level II	Level III	Level I
	Reduction in Downstream Discharge	Withdrawal waterbody was selected in an effort to limit reductions in downstream flow volume to less than 10% of mean total monthly flow volume	Level 0	-	-	-	-

NOTE:
1. THE ABOVE RATINGS CORRESPOND TO THE RATINGS CRITERIA PRESENTED IN TABLE 7-2.12, WHICH IS LOCATED WITHIN THE TEXT OF THE EIS.

Table 7-2.15 Over-Winter Water Withdrawal Volumes in the Milne Port LSA

Project Phase	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Available Under-Ice Lake Volume (m^3)	Winter Abstraction Volume (m^3)	Total Under-Ice Volume Reduction (%)	Approximate Over-winter Water Level Reduction (m)
Construction	Domestic and Industrial Water Consumption	67.5	Km32 Lake	47,895,000	14,310	0.03%	0.009
Operation		29.0			6,150	0.01%	0.004

NOTES:
1. AVAILABLE UNDER-ICE VOLUME REFERS TO THE VOLUME OF AVAILABLE WATER BENEATH THE ICE SURFACE DURING PERIODS OF MAXIMUM ICE THICKNESS. MAXIMUM ICE THICKNESS WAS ASSUMED TO BE 2 m ACCORDING TO DFO GUIDELINES.
2. THE AVAILABLE UNDER-ICE WATER VOLUME ASSUMES THAT THE LAKE SURFACE WAS AT THE LAKE OUTLET INVERT ELEVATION DURING THE BATHYMETRIC SURVEY.
3. THE WATER LEVEL REDUCTION CALCULATIONS ASSUME THAT THE UNDER-ICE SURFACE AREA IS EQUAL TO THE OPEN WATER SURFACE AREA OF THE LAKE.

Table 7-2.16 Reduction in Flow Downstream of Withdrawal Locations within the Milne Port LSA

Project Phase	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Upstream Drainage Area	Estimated Mean Annual Unit Runoff	Winter Withdrawal Volume (m^3)	Reduction in Mean Monthly Discharge (%)				
							June	July	August	September	October
Construction	Domestic and Industrial Water Consumption	67.5	Km32 Lake	464	7	14,310	-0.04%	-	-	-	-
			Phillips Creek	920			-0.02%	0.00%	-0.01%	-0.01%	-0.25%
Operation		29.0	Km32 Lake	464		6,150	-0.02%	-	-	-	-
			Phillips Creek	920			-0.01%	0.00%	0.00%	-0.01%	-0.11%

NOTES:
1. THE MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT STATION H1, AS DISCUSSED IN VOLUME 7 SECTION 1.
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS ASSUMED EQUAL TO THE 2007-2011 AVERAGE DISTRIBUTION AT MONITORING STATION H1
3. WATER WILL BE WITHDRAWN FROM KM32 LAKE DURING NOV-MAY AND FROM PHILLIPS CREEK NEAR THE MOUTH FROM JUNE - OCTOBER.

Table 7-2.17 Significance of Potential Residual Environmental Effects on Water Quantity in the Milne Port LSA

Watershed - Project Activity	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Km32 Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: 1= Low; 2= Medium; 3=High

2.3.3.2 Mine Site LSA Residual Effects Assessment

This section rates residual effects on Water Quantity within the Mine Site LSA. Residual effects are organized by watershed. The residual effects considered and addressed within the Mine Site LSA are:

Tom River Watershed

- MR-08 Sub-watershed

1. Waste Rock Stockpile Diversion
2. Open Pit Diversion

- MR-10 Sub-watershed

1. West Waste Rock Stockpile Diversion
2. Open Pit Diversion
3. West Waste Rock Stockpile Pond Effluent Discharge
4. Combined Effect of Issues 1-3

Camp Lake Sub-watershed

1. Water withdrawal - volume reduction
2. Water withdrawal - outflow reduction
3. Combined Effect of Water Withdrawal and Upstream Water Quantity Effects

- MR-07 Sub-watershed

1. Waste Rock Stockpile Diversion

- Tom River

1. Net Effect of Upstream Water Quantity Impacts

Mary River Watershed

- MR-12 Sub-watershed

1. East Waste Rock Stockpile Diversion
2. Open Pit Diversion
3. East Waste Rock Stockpile Pond Effluent Discharge
4. Net Effect of Issues 1-3

- SDL Tributary 1 Sub-watershed

1. Open Pit Diversion
2. Ore Stockpile Platform Diversion
3. Combined Effect of Issues 1-2

- SDL Tributary 9 Sub-watershed

1. Ore Stockpile Platform Diversion

- SDL Tributary 12 Sub-watershed

1. Ore Stockpile Platform Diversion

- MR-16 (Sheardown Lake)

1. Open Pit diversion
2. Ore Stockpile Platform diversion
3. Combined Effect of Issues 1-2

- Mary River Watershed

1. Open Pit diversion
2. Waste Rock Stockpile diversion
3. Diversion around Ore Stockpile
4. Ore Stockpile Effluent Discharge
5. Sewage Effluent Discharge
6. Net effects of points 1-5
7. Net effects of points 1-5 and MR-16 Water Quantity Impacts

The details of the Mine Site LSA residual effects assessment are provided below.

Tom River Watershed

MR-08 Sub-watershed

1. West Waste Rock Stockpile Diversions - Reduction in Downstream Discharge:

Residual effects ratings for the reduction in discharge in MR-08, resulting from the diversions around the West Waste Rock Stockpile within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow reduction in MR-08 resulting from the West Waste Rock is presented in Table 7-2.19. The maximum monthly reduction at the upstream extent of fish habitat is 31 %, and occurs during July. The magnitude of the residual effect exceeds threshold and is rated as Level II.

Extent

The reduction in discharge is considered for the MR-08 watershed only. The magnitude of the reduction will remain above threshold at the outlet of the watershed into Camp Lake. Effects downstream of watershed MR-08 will be assessed separately. The MR-08 watershed is approximately 9 km^2 in size, which equates to the maximum extent of the effect. The watershed is less than 10 km^2 in area, and therefore the extent of the residual effect is rated as Level I.

Duration

Water diversion around the Waste Rock Stockpiles will occur during Operation, Closure and post-Closure of the Project. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction of discharge within MR-08, resulting from the Waste Rock Stockpile diversions, will cease once the diversions are removed. The effect is fully reversible and has therefore been rated as Level I.

Table 7-2.18 Mine Site LSA Freshwater Quantity Effects Assessment Summary - All Phases

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
MR-08: West Waste Rock Stockpile Diversion	Reduction in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level II	Level I	Level III	Level III	Level I
MR-08: Open Pit Diversion	Reduction in Downstream Discharge		Level 0	-	-	-	-
MR-10: West Waste Rock Stockpile Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level III	Level I	Level III	Level III	Level I
MR-10: Open Pit Diversion	Reduction in Downstream Discharge		Level II	Level I	Level III	Level III	Level III
MR-10: West Waste Rock Pond Treated Effluent Discharge	Increase in Downstream Discharge	Potential effects of effluent discharge to the receiving watercourse were mitigated through the location of the point of discharge. Mitigation activities included: • Desktop assessment of potential discharge locations. Assessment considered the probable location of fish habitat, as well as the watercourse length to be effected. • Ground truthing of assumptions made during desktop assessment	Level III	Level I	Level III	Level III	Level I
MR-10: Effluent Discharge and West Waste Rock Stockpile and Open Pit Diversions	Combined Change in Discharge	See above MR-10 Mitigation Measures	Level II	Level I	Level III	Level III	Level I

Table 7-2.18 Mine Site LSA Freshwater Quantity Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
Camp Lake: Water Withdrawal	Reduction in Under-Ice Lake Volume	Potential effects from water withdrawal were mitigated for during selection of the withdrawal waterbodies and during the design of the water withdrawal program. Mitigation activities included: • Desktop assessment of potential withdrawal waterbodies near Milne Port. The assessment considered lake size, upstream watershed area and accessibility during candidate waterbody selection. • Collection of bathymetric data on the best candidate waterbody identified during the high level review in order to accurately calculate quantify water depths and volumes. • Volume reduction calculations were conducted using preliminary assumptions of water withdrawal volumes to ensure that the DFO guidelines presented in Section 2.3.1.1 were met.	Level I	Level I	Level II	Level III	Level I
Camp Lake: Water Withdrawal	Reduction in Downstream Discharge		Level I	Level I	Level II	Level III	Level I
Camp Lake: Water Withdrawal and Upstream Water Quantity Effects	Combined Change in Discharge		Level I	Level I	Level III	Level III	Level I
MR-07: Waste Rock Stockpile Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level 0	-	-	-	-
Tom River Watershed: Upstream Effects to Water Quantity	Change in Downstream Discharge		Level 0	-	-	-	-
MR-12: East Waste Rock Stockpile Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level I	Level I	Level III	Level III	Level I
MR-12: Open Pit Diversion	Decrease in Downstream Discharge		Level I	Level I	Level III	Level III	Level III

Table 7-2.18 Mine Site LSA Freshwater Quantity Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
MR-12: East Waste Rock Pond Treated Effluent Discharge	Increase in Downstream Discharge	Potential effects of effluent discharge to the receiving watercourse were mitigated through the location of the point of discharge. Mitigation activities included: • Desktop assessment of potential discharge locations. Assessment considered the probable location of fish habitat, as well as the watercourse length to be effected. • Ground truthing of assumptions made during desktop assessment	Level II	Level II	Level III	Level III	Level I
MR-12: Effluent Discharge and East Waste Rock Stockpile and Open Pit Diversions	Combined Change in Discharge	See above MR-12 Mitigation Measures	Level I	Level II	Level II	Level III	Level I
SDL Tributary 1: Open Pit Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level II	Level I	Level III	Level III	Level III
SDL Tributary 1: Ore Stockpile Platform Diversion	Decrease in Downstream Discharge		Level II	Level I	Level II	Level III	Level I
SDL Tributary 1: Open Pit and Ore Stockpile Platform Diversions	Net Change in Downstream Discharge		Level II	Level I	Level II	Level III	Level I
SDL Tributary 9: Ore Stockpile Platform Diversions	Decrease in Downstream Discharge		Level II	Level I	Level II	Level III	Level I
SDL Tributary 12: Ore Stockpile Platform Diversions	Decrease in Downstream Discharge		Level II	Level I	Level II	Level III	Level I
MR-16: Open Pit Diversion	Decrease in Downstream Discharge		Level II	Level I	Level III	Level III	Level III
MR-16: Ore Stockpile Platform Diversions	Decrease in Downstream Discharge		Level I	Level I	Level II	Level III	Level I
MR-16: Open Pit and Ore Stockpile Platform Diversions	Combined Change in Downstream Discharge		Level II	Level I	Level II	Level II	Level I

Table 7-2.18 Mine Site LSA Freshwater Quantity Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
Mary River Watershed: Open Pit Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level 0	-	-	-	-
Mary River Watershed: Waste Rock Stockpile Diversion	Decrease in Downstream Discharge		Level 0	-	-	-	-
Mary River Watershed: Diversion Around Ore Stockpile	Decrease in Downstream Discharge		Level 0	-	-	-	-
Mary River Watershed: Stockpile Effluent Discharge (Ore, Waste Rock and ROM)	Increase in Downstream Discharge	Potential effects of effluent discharge to the receiving watercourse were mitigated through the location of the point of discharge. Mitigation activities included: • Desktop assessment of potential discharge locations. Assessment considered the probable location of fish habitat, as well as the watercourse length to be effected. • Ground truthing of assumptions made during desktop assessment	Level I	Level I	Level II	Level III	Level I
Mary River Watershed: Treated Sewage Effluent Discharge	Increase in Downstream Discharge in the Mary River		Level 0	-	-	-	-
Mary River Watershed: Upstream Effects to Water Quantity from Open Pit Diversion, Waste Rock Stockpile Diversion, Ore Stockpile Effluent Discharge, and Sewage Effluent Discharge	Change in Downstream Discharge	See above Mary River Watershed Mitigation Measures	Level 0	-	-	-	-

Table 7-2.18 Mine Site LSA Freshwater Quantity Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
Mary River Watershed: Upstream Effects to Water Quantity from Open Pit Diversion, Waste Rock Stockpile Diversion, Ore Stockpile Effluent Discharge, Sewage Effluent Discharge and MR-16 Water Quantity Effects	Change in Downstream Discharge	See above Mary River Watershed Mitigation Measures	Level 0	-	-	-	-

NOTES:
1. THE ABOVE RATINGS CORRESPOND TO THE RATINGS CRITERIA PRESENTED IN TABLE 7-2.12, WHICH IS LOCATED WITHIN THE TEXT OF THE EIS.

Table 7-2.19 Water Quantity Diversion and Discharge within the Mine Site LSA

Watershed	Magnitude Assessment Location	Baseline Upstream Watershed Area (km2)	Watershed Area MAUR (l/s/km2)	Project Phase	Activity	Discharge Scenario	Diverted Upstream Watershed Area (km2)	Diverted Area MAUR (l/s/km2)	Reduction in Mean Monthly Discharge (%)			
									June	July	August	September
MR-07	Outlet of Watershed	31	11.5	Operation, Closure and Post-closure	Waste Rock Stockpile Diversion	-	-0.18	11	-0.6%	-0.6%	-0.5%	-0.5%
MR-08	Fish Barrier	8.3	9.0	Operation, Closure and Post-closure	Waste Rock Stockpile Diversion	-	-1.41	11	-17%	-31%	-15%	-18%
				Operation, Closure and Post-closure	Open Pit Diversion	-	-0.02	10	-0.2%	-0.4%	-0.2%	-0.2%
				Operation, Closure and Post-closure	Total Diversion	-	-	-	-17%	-32%	-15%	-18%
MR-10	Fish Barrier	5.3	8.5	Operation, Closure and Post-closure	Waste Rock Stockpile Diversion	-	-1.50	11/10	-31%	-57%	-19%	-24%
				Operation, Closure and Post-closure	Open Pit Diversion	-	-0.38	10	-8%	-14%	-5%	-6%
				Operation and Closure	West Waste Rock Pond Discharge	Real-time flow matching	-	-	63%	63%	63%	63%
				Post-Closure	West Waste Rock Pond Discharge	Natural discharge	-	-	50%	93%	31%	40%
				Operation and Closure	Total Discharge and Diversion	Real-time flow matching	-	-	25%	-8%	39%	33%
				Post-Closure	Total Discharge and Diversion	Natural discharge	-	-	12%	22%	7%	10%

Table 7-2.19 Water Quantity Diversion and Discharge within the Mine Site LSA (Cont'd)

Watershed	Magnitude Assessment Location	Baseline Upstream Watershed Area (km2)	Watershed Area MAUR (l/s/km2)	Project Phase	Activity	Discharge Scenario	Diverted Upstream Watershed Area (km2)	Diverted Area MAUR (l/s/km2)	Reduction in Mean Monthly Discharge (%)			
									June	July	August	September
MR-12	Outlet of Watershed	15	9.7	Operation, Closure and Post-closure	Waste Rock Stockpile Diversion	-	-1.03	11	-8%	-8%	-8%	-8%
				Operation, Closure and Post-closure	Open Pit Diversion	-	-0.29	10	-2%	-2%	-2%	-2%
				Operation and Closure	East Waste Rock Pond Discharge	Real-time flow matching	-	-	16%	16%	16%	16%
				Post-Closure	East Waste Rock Pond Discharge	Natural discharge	-	-	9%	9%	10%	10%
				Operation and Closure	Total Discharge and Diversion	Real-time flow matching	-	-	6%	6%	5%	5%
				Post-Closure	Total Discharge and Diversion	Natural discharge	-	-	-0.6%	-0.6%	-0.7%	-0.7%
SDL Tributary 1	Outlet of Watershed	3.7	7.0	Operation, Closure and Post-closure	Open Pit Diversion	-	-0.31	10	-11%	-20%	-6%	-8%
				Operation and Closure	Ore Stockpile Diversion	-	-0.64	6	-15%	-15%	-15%	-15%
				-	Total Diversion	-	-	-	-26%	-35%	-21%	-23%
SDL Tributary 9	Upstream Extent of Char Habitat	0.29	6	Operation and Closure	Ore Stockpile Diversion	-	-0.08	6	-29%	-29%	-29%	-29%
SDL Tributary 12	Upstream Extent of Char Habitat	0.31	6	Operation and Closure	Ore Stockpile Diversion	-	-0.05	6	-15%	-15%	-15%	-15%

Table 7-2.19 Water Quantity Diversion and Discharge within the Mine Site LSA (Cont'd)

Watershed	Magnitude Assessment Location	Baseline Upstream Watershed Area (km2)	Watershed Area MAUR (l/s/km2)	Project Phase	Activity	Discharge Scenario	Diverted Upstream Watershed Area (km2)	Diverted Area MAUR (l/s/km2)	Reduction in Mean Monthly Discharge (%)			
									June	July	August	September
MR-16	Outlet of Watershed	8.2	6.5	Operation, Closure and Post-closure	Open Pit Diversion	-	-0.31	10	-5%	-10%	-3%	-4%
				Operation and Closure	Ore Stockpile Diversion	-	-0.64	6	-9%	-9%	-9%	-9%
				-	Total Diversion	-	-	-	-14%	-19%	-12%	-12%
Mary River	Effluent Discharge Location	240	11.1	Operation, Closure and Post-closure	Waste Rock Stockpile Diversion	-	-1.03	11	-0.5%	-0.4%	-0.3%	-0.3%
				Operation, Closure and Post-closure	Open Pit Diversion	-	-0.97	10	-0.4%	-0.4%	-0.3%	-0.3%
				Operation and Closure	Ore Stockpile Diversion	-	0.41	8.5	0.2%	0.1%	0.1%	0.1%
				Operation and Closure	East Waste Rock, Ore Stockpile and ROM Pond Discharge	Real-time flow matching	-	-	1%	1%	1%	1%
				Post-Closure	East Waste Rock Pond Discharge	Natural discharge	-	-	0.6%	0.5%	0.3%	0.4%
				Construction	Sewage Effluent Discharge	-	-	-	0.0%	0.1%	0.4%	0.2%
				Operation		-			0.0%	0.1%	0.2%	0.1%

NOTES:
1. THE MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT VARIOUS LOCATIONS WITHIN THE FRESHWATER RSA, AS DISCUSSED IN VOLUME 7 SECTION 1.
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS DETERMINED USING THE 2007-2011 AVERAGE DISTRIBUTION AT VARIOUS MONITORING STATIONS WITHIN THE RSA.

Significance

The magnitude of the Waste Rock Stockpile diversions on water quantity in the MR-08 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered within the MR-08 watershed, which has a drainage area of 9 km^2. This area can be equated to the maximum possible extent of the effect within the watershed. The MR-08 watershed comprises approximately 1 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, water diversion by the Waste Rock Stockpile out of watershed MR-08 is not expected to result in a significant change in water quantity within the Mine Site LSA as a whole. Furthermore, the total water quantity within the LSA will not be changed, only redistributed. Therefore, the residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Open Pit Diversion - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge within the MR-08 watershed, resulting water diversion by the Open Pit, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow reduction in MR-08 resulting from the Open Pit diversion is presented in Table 7-2.19. Reductions are less than quantifiable limits at the upstream extent of fish habitat. The residual effect has therefore been rated as Level 0, and consequently it will no longer be considered within the water quantity effects assessment.

MR-10 Sub-watershed

1. West Waste Rock Stockpile Diversion - Decrease in Downstream Discharge

Residual effects ratings for the increase in discharge within the MR-10 watershed, resulting from the West Waste Rock Stockpile diversions within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-10 resulting from diversion of water around the West Waste Rock Stockpile and into and around the West Waste Rock Management Pond is presented in Table 7-2.19. The maximum monthly reduction at the upstream extent of fish habitat is 57 %, and occurs during July. The magnitude of the residual effect exceeds five times threshold and is rated as Level III.

Extent

The decrease in discharge is considered only within the MR-10 watershed; downstream effects will be assessed separately. The MR-10 watershed is approximately 8.4 km^2, which equates to the maximum extent of the effect. As it is <10 km^2 in area, the extent of the residual effect is rated as Level I.

Duration

Water diversion around the Waste Rock Stockpiles will occur during Operation, Closure and post-Closure of the Project. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the diversions. The frequency of the effect has therefore been rated as Level III.

Reversibility

The decrease in water quantity within MR-10 will cease once the Waste Rock Stockpile diversions are removed. The effect is fully reversible has therefore been rated as Level I.

Significance

The magnitude of the West Waste Rock Stockpile diversions on water quantity in the MR-10 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered within the MR-10 watershed, which has a drainage area of 8.4 km^2. This area can be equated to the maximum possible extent of the effect within the watershed. The MR-10 watershed comprises approximately 1 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, water diversion by the Waste Rock Stockpile from watershed MR-10 is not expected to result in a major change in water quantity within the Mine Site LSA as a whole. The total water quantity will not be changed, only redistributed. Therefore, the residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Open Pit Diversion - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge within the MR-10 watershed, resulting from diversion of water by the Open Pit, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-10 resulting from the Open Pit diversions is presented in Table 7-2.19. The maximum monthly reduction at the upstream extent of fish habitat is 14 %, and occurs during July. The magnitude of the residual effect exceeds threshold and is rated as Level II.

Extent

The decrease in discharge is considered only within the MR-10 watershed; downstream effects will be assessed separately. The magnitude of the effect is below threshold at the outlet of the watershed into Camp Lake. The MR-10 watershed is approximately 8.4 km^2 in size, which equates to the maximum extent of the effect. The watershed is less than 10 km^2 in area, and therefore the extent of the residual effect is rated as Level I.

Duration

Water diversion from watershed MR-10 by the Open pit will be permanent. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction of discharge within MR-10 caused by the Open Pit diversion is irreversible. The effect has therefore been rated as Level III.

Significance

The magnitude of the Open Pit diversion on water quantity in the MR-10 watershed exceeds threshold; however, the effect is minor in areal extent and water volume compared to the Mine Site LSA. The

MR-10 watershed has a drainage area of 8.4 km^2, which can be equated to the maximum possible extent of the effect. The watershed comprises approximately 1 % of the watershed area within the LSA, so this diversion is not expected to result in a major change in water quantity within the Mine Site LSA as a whole. The total water quantity will not be changed, only redistributed. The residual effect is ranked as Not Significant (Table 7-2.23).

3. West Waste Rock Stockpile Pond Treated Effluent Discharge - Increase in Downstream Discharge

Residual effects ratings for the increase in discharge within the MR-10 watershed, resulting from treated effluent discharge collect from the West Waste Rock Stockpile, are summarized in Table 7-2.18.

Magnitude

Treated effluent will be discharged throughout the open water season at variable rates designed to match natural discharge patterns during the period of mine operation. The result of this flow matching is a mean discharge to natural flow mixing ratio at the upstream extent of fish habitat of 63 %. The mean magnitude of the streamflow increase in MR-10 resulting from the discharge will therefore also be 63 % (see Table 7-2.19). After closure, the ponds will be allowed to discharge naturally, resulting in a maximum mean monthly discharge increase of 93 % during July. The magnitude of the operations and closure residual effects are both greater than five times threshold, and are rated as Level III.

Extent

The increase in discharge is considered only within MR-10 watershed; downstream effects are considered separately. The magnitude of the increase exceeds five times threshold at the upstream extent of fish habitat in MR-10, and also at the outlet of the watershed. The MR-10 watershed is approximately 8.4 km^2, which can be equated to the maximum possible extent of the effect within the watershed. The watershed is less than the Level I threshold of 10 km^2, and therefore the extent of the residual effect is rated as Level I.

Duration

Treated effluent discharge from the Waste Rock Stockpiles will occur during Operation, Closure and post-Closure of the Project. A Level III rating has therefore been assigned.

Frequency

Discharge will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The increase in discharge within the MR-10 watershed will cease once the Stockpiles and ponds are decommissioned. The effect is fully reversible and has therefore been rated as Level I.

Significance

The magnitude of the West Waste Rock Stockpile effluent discharge on water quantity in the MR-10 watershed exceeds five times threshold (10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered within the MR-10 watershed, which has a drainage area of 8.4 km^2. This area can be equated to the maximum possible extent of the effect within the watershed. The MR-10 watershed comprises only about 1 % of the watershed area within the LSA.

Based on the extent of the residual effect relative to the entire LSA, effluent discharge to watershed MR-10 is not expected to result in a major change in water quantity within the Mine Site LSA as a whole. The total water quantity within the LSA will not be changed, only temporally redistributed. Therefore, the residual effect is ranked as *Not Significant* (Table 7-2.23).

4. Effluent Discharge and West Waste Rock Stockpile and Open Pit Diversions - Combined Change in Discharge

The residual effects ratings for the change in discharge in watercourse MR-10, resulting from effluent discharge and water diversion, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow in MR-10 resulting from the combined effects of water diversion and effluent discharge is presented in Table 7-2.19. The overall change in streamflow during the period of Operations has a maximum decrease of 8 % during July, and a maximum increase of 39 % during August, at the upstream extent of fish habitat. After closure the change in mean discharge is positive in all months, with the largest increase of 22 % occurring in July. The magnitude of the residual effect exceeds threshold (+/- 10 %), and is therefore rated as Level II.

Extent

The change in discharge is considered only within the MR-10 watershed; downstream effects are considered separately. The magnitude of the decrease will remain above threshold at the outlet of the watershed into Camp Lake. The MR-10 watershed is approximately 8.4 km^2 in size, which can be equated to the maximum extent of the effect within the watershed. The watershed is less than 10 km^2, and therefore the extent of the residual effect is rated as Level I.

Duration

All three activities will occur concurrently during the Operation, Closure and post-Closure phases of the Project. A Level III rating has therefore been assigned.

Frequency

All activities will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The change in discharge in MR-10 resulting from both water diversion and effluent discharge will cease once the diversions are removed. The combined residual effect is fully reversible and has therefore been rated as Level I.

Significance

The magnitude of water diversion and effluent discharge on water quantity in the MR-10 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The combined effect is considered only within the MR-10 watershed, which has a drainage area of 8.4 km^2. This area can be equated to the maximum possible extent of the effect within the watershed. The MR-10 watershed comprises only about 1 % of the watershed area within the LSA. Based on the extent of the combined residual effect relative to the entire LSA, the effect is not expected to result in a major change in water quantity within the Mine Site LSA as a whole. The

total water quantity within the LSA will not be changed, only redistributed. Therefore, the net residual effect is ranked as *Not Significant* (Table 7-2.23).

Camp Lake Sub-watershed

1. Water Withdrawal - Reduction in Under-Ice Lake Volume

Residual effects ratings for the reduction in under-ice water volume in Camp Lake, resulting from water withdrawal in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

All water requirements within the Mine Site LSA will be withdrawn from Camp Lake. Withdrawal rates are presented in Table 7-2.20, along with the resulting overwinter drawdown. Withdrawals will be greatest during Construction, and will result in a reduction of approximately 0.8 % of the total under-ice lake volume. This reduction is considerably less than threshold, and is therefore rated as a Level I residual effect.

Extent

The reduction in under-ice volume will occur only within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from Camp Lake will occur during the Construction, Operation, and Closure phases of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Camp Lake throughout the year. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in under-ice volume associated with water withdrawal will cease once water is no longer withdrawn from the waterbody. The effect is fully reversible, and has therefore been rated as Level I.

Table 7-2.20 Over-Winter Water Withdrawal Volumes in the Mine Site LSA

Project Phase	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Available Under-Ice Lake Volume (m^3)	Winter Abstraction Volume (m^3)	Total Under-Ice Volume Reduction (%)	Approximate Over-winter Water Level Reduction (m)
Construction	Domestic and Industrial Water Consumption	710	Camp Lake	22,606,000	172,430	0.8%	0.08
Operation		135			49,220	0.2%	0.02

NOTES:
1. AVAILABLE UNDER-ICE VOLUME REFERS TO THE VOLUME OF AVAILABLE WATER BENEATH THE ICE SURFACE DURING PERIODS OF MAXIMUM ICE THICKNESS. MAXIMUM ICE THICKNESS WAS ASSUMED TO BE 2 m ACCORDING TO DFO GUIDELINES.
2. THE AVAILABLE UNDER-ICE WATER VOLUME ASSUMES THAT THE LAKE SURFACE WAS AT THE LAKE OUTLET INVERT ELEVATION DURING THE BATHYMETRIC SURVEY.
3. THE WATER LEVEL REDUCTION CALCULATIONS ASSUME THAT THE UNDER-ICE SURFACE AREA IS EQUAL TO THE OPEN WATER SURFACE AREA OF THE LAKE.
4. THE WATER VOLUMES WERE CACULATED USING THE WATER BALANCE DIAGRAMS DEVELOPED BY HATCH AND PRESENTED IN THE SURFACE WATER AND AQUATIC ECOSYSTEMS MANAGEMENT PLAN. THE WATER VOLUMES ALSO DO NOT INCLUDE USAGE BY THE EXPLORATION CAMP, AS THIS CAMP IS NOT DIRECTLY PART OF THE PROJECT.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in Camp Lake. The residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge from Camp Lake, resulting from water withdrawal within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of streamflow reduction downstream of Camp Lake resulting from water withdrawal is presented in Table 7-2.21. Outflow reductions are less than threshold for all open water months during the Construction and Operation phases of the Project. Therefore, the magnitude of the residual effect is rated as Level I.

Extent

The magnitude of the discharge reductions is less than threshold at the outlet of Camp Lake, which is also the source location for the effect. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal will occur during the Construction, Operation, and Closure phases of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Camp Lake throughout the year. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in discharge from Camp Lake will cease once withdrawal stops. The residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction to discharge downstream of Camp Lake, in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

Table 7-2.21 Reduction in Flow Downstream of Withdrawal Locations within the Mine Site LSA

Description	Project Phase	Withdrawal Rate (m^3/day)	Withdrawal Source	Upstream Drainage Area	Estimated Mean Annual Unit Runoff	Winter Withdrawal Volume (m^3)	Reduction in Mean Monthly Discharge (%)			
							June	July	August	September
Domestic and Industrial Water Consumption	Construction	710	Camp Lake	25	8.5	172,430	-6%	-1%	-1%	-4%
	Operation	135				49,220	-2%	-0.4%	-0.4%	-1%

NOTES:
1. MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT STATIONS H4 AND H5, AS DISCUSSED IN VOLUME 7 SECTION 1.
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS ASSUMED EQUAL TO THE AVERAGE 2007-2011 MEAN DISTRIBUTION AT MONITORING STATIONS H4 AND H5.

3. Water Withdrawal and Upstream Water Quantity Effects - Combined Change in Discharge

The residual effects ratings for the change in discharge downstream from Camp Lake, resulting from water withdrawal and water quantity effects in the upstream watersheds of MR-08 and MR-10, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow downstream of Camp Lake resulting from the combined water quantity effects is presented in Table 7-2.22. During Operations, the overall change to water quantity at the outlet of Camp Lake ranges from a decrease of 9 % in July to an increase of 4 % in August. After closure the only net loss of water from the Camp Lake watershed will result from diversion by the open pit, resulting in a maximum mean monthly flow reduction of 3 % in July. The magnitude of the residual effect is less than threshold (+/- 10 %) during both Operation and after closure, and is therefore rated as Level I.

Extent

The change in discharge is considered only at the outlet of the Camp Lake watershed. Downstream effects will be considered separately. The magnitude of the decrease is less than threshold at the outlet of Camp Lake. Because the lake outlet is essentially the source location for the combined effects of upstream impacts, the extent of the residual effect is rated as Level I.

Duration

Upstream activities will occur concurrently during the Operation, Closure and post-Closure phases of the Project. A Level III rating has therefore been assigned.

Frequency

All activities will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The change in discharge at the outlet of Camp Lake resulting from combined water quantity effects will cease after Decommissioning. The combined residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, net upstream effects are not expected to result in an adverse change to discharge downstream of Camp Lake, in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

Table 7-2.22 Changes to Water Quantity in the Mine Site LSA Resulting from a Combination of Key Issues

Project Phase	Source	Watershed	Assessment Location	Upstream Drainage Area (km^2)	Discharge Scenario	Change in Mean Monthly Discharge (%)			
						June	July	August	September
Operation/ Closure	Combined Effect of West Waste Rock and Open Pit Diversions, West Waste Rock Stockpile Pond Discharge and Camp Lake Water Withdrawals	Camp Lake	Outlet of Camp Lake	25	Real-time flow matching	-1%	-9%	4%	3%
		Tom River	Confluence of Camp Lake Watershed and the Tom River	240		-0.2%	-0.7%	0.2%	0.0%
	Combined Effect of East Waste Rock Stockpile and Open Pit Diversions, East Waste Rock, Ore Stockpile and ROM Pond Discharge, and Sewage Effluent Discharge	Mary River	Effluent Discharge Location	240	Real-time flow matching; July and August sewage discharge	0.5%	0.4%	0.8%	0.6%
			Confluence of MR-16 and the Mary River	270		0.1%	0.1%	0.5%	0.3%
Post-Closure	Combined Effect of West Waste Rock and Open Pit Diversions and West Waste Rock Stockpile Pond Discharge	Camp Lake	Outlet of Camp Lake	25	Natural discharge	-2%	-3%	-1%	-1%
		Tom River	Confluence of Camp Lake Watershed and the Tom River	240		-0.3%	-0.3%	-0.1%	0.0%
	Combined Effect of East Waste Rock Stockpile and Open Pit Diversions and East Waste Rock Stockpile Pond Discharge	Mary River	Effluent Discharge Location	240	Natural discharge	-0.3%	-0.3%	-0.2%	-0.2%
			Confluence of MR-16 and the Mary River	270		-0.7%	-0.5%	-0.5%	-0.5%

NOTES:
1. THE MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT VARIOUS LOCATIONS WITHIN THE FRESHWATER RSA, AS DISCUSSED IN VOLUME 7 SECTION 1.
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS DETERMINED USING THE 2007-2011 AVERAGE DISTRIBUTION AT VARIOUS MONITORING STATIONS WITHIN THE RSA.

MR-07 Sub-watershed

1. Waste Rock Stockpile Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within the MR-07 watershed, resulting from the diversion of water around the Waste Rock Stockpile within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of streamflow reduction in the MR-07 watershed, at the confluence of with the Tom River, is less than quantifiable limits, as presented in Table 7-2.19. The residual effect has therefore been rated as Level 0, and consequently it will no longer be considered within the water quantity effects assessment.

Tom River Watershed

1. Upstream Effects to Water Quantity - Change in Downstream Discharge

Residual effects ratings for the reduction in discharge in the Tom River, resulting from upstream water quantity effects within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of streamflow reduction in the Tom River below the confluence of the Camp Lake watershed is less than quantifiable limits during both Operations and after Closure, as presented in Table 7-2.22. The residual effect has therefore been rated as Level 0; consequently it will be given no further consideration.

Mary River Watershed

MR-12 Sub-watershed

1. Waste Rock Stockpile Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within the MR-12 watershed, resulting from the Waste Rock Stockpile diversion in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-12 resulting from the Waste Rock Stockpile diversions is presented in Table 7-2.19. The decrease is approximately 8 % at the confluence of MR-12 with the Mary River. The magnitude of the residual effect is less than threshold and is rated as Level I.

Extent

The magnitude of the discharge reduction is less than threshold at the outlet of the MR-12 watershed. However, the magnitude of the effect would exceed threshold in greater than 10 km^2 of the watershed area, and therefore the extent is rated as Level II.

Duration

Water diversion around the Waste Rock Stockpiles will occur during Operation, Closure and post-Closure of the Project. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the diversions. The frequency of the effect has therefore been rated as Level III.

Reversibility

The decrease in water quantity within MR-12 will cease once the Waste Rock Stockpile diversions are removed. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, net upstream effects are not expected to result in an adverse change to discharge from the MR-12 watershed, within the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Open Pit Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within the MR-12 watershed, resulting from water diversion by the Open Pit, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-12 resulting from water diversion by the Open Pit is presented in Table 7-2.19. The decrease is approximately 2 % at the confluence of MR-12 with the Mary River. The magnitude of the residual effect is rated as Level I.

Extent

The magnitude of the discharge reduction is less than threshold at the outlet of the MR-12 watershed. The magnitude could be above threshold within less than 4 km^2 of the watershed. Therefore, the extent is rated as Level I.

Duration

Water diversion by the Open Pit will be permanent. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Open Pit will be permanent and irreversible. A Level III rating has therefore been assigned.

Significance

Based on the ratings criteria described above, water diversion by the Open Pit is not expected to result in an adverse decrease in discharge within the MR-12 watershed in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

3. East Waste Rock Stockpile Pond Treated Effluent Discharge - Increase in Downstream Discharge

Residual effects ratings for the increase in discharge within the MR-12 watershed, resulting from treated effluent discharge collected from the East Waste Rock Stockpile and Open Pit, are summarized in Table 7-2.18.

Magnitude

During Operations, treated effluent will be discharged throughout the open water season at variable rates designed to match natural discharge patterns. The result of this flow matching is a mean discharge to natural flow mixing ratio at the outlet of the watershed of 16 %. The mean magnitude of the streamflow increase in MR-12 resulting from the discharge will therefore also be 16 %, as presented in Table 7-2.19. After closure, water from the open pit will no longer be directed to the East Waste Rock Pond and discharge will no longer need to managed to match downstream discharge, resulting in a maximum mean monthly discharge increase of 10 % during August and September. The magnitude of the residual effect is greater than threshold during Operations and after closure, and is therefore rated as Level II.

Extent

The increase in discharge is considered only within MR-12 watershed; downstream effects are considered separately. The magnitude of the increase exceeds threshold at the outlet of the watershed. The MR-12 watershed is approximately 15 km^2, which can be equated to the maximum possible extent of the effect within the watershed. The watershed is less than the Level II threshold of 100 km^2, and therefore the extent of the residual effect is rated as Level II.

Duration

Waste Rock Stockpile Pond effluent discharge will occur during Operation, closure and post-closure of the Project. A Level III rating has therefore been assigned.

Frequency

Discharge will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The increase in discharge within MR-12 caused by the effluent discharge will cease once the Stockpiles and ponds are decommissioned. The effect is fully reversible and has therefore been rated as Level I.

Significance

The magnitude of the East Waste Rock Stockpile effluent discharge on water quantity in the MR-12 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered within the MR-12 watershed, which has a drainage area of 15 km^2 the maximum possible extent of the effect. This watershed comprises less than 3 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, effluent discharge to watershed MR-12 is not expected to result in a major change in water quantity within the Mine Site LSA as a whole. The total water quantity within the LSA will not be changed, only spatially and temporally redistributed. Therefore, the residual effect is ranked as *Not Significant* (Table 7-2.23).

4. Effluent Discharge and East Waste Rock Stockpile and Open Pit Diversions - Combined Change in Discharge

The residual effects ratings for the change in discharge in watercourse MR-12, resulting from effluent discharge and water diversion, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow in MR-12 resulting from the combined effects of water diversion and effluent discharge are presented in Table 7-2.22. The maximum change in streamflow during Operations is an increase of 6 % during June and July, at the outlet of the watershed. After closure, the maximum change in streamflow is less than quantifiable limits, and will therefore not be considered further in this assessment. The magnitude of the residual effect is less than threshold (+/-10 %) in all months during Operations, and is therefore rated as Level I.

Extent

The change in discharge is considered only within the MR-12 watershed; downstream effects are considered separately. The magnitude of change is less than threshold at the outlet of the MR-12 watershed, and would exceed threshold in less than 10 km^2. Therefore, the extent of the residual effect is rated as Level I.

Duration

All three activities will occur concurrently, and produce quantifiable effects, during the Operation and Closure phases of the Project. A Level II rating has therefore been assigned.

Frequency

All three activities will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The change in discharge in MR-12 resulting from both water diversion and effluent discharge will cease once the diversions are removed. The combined residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, the combined effects of water diversion and effluent discharge within watershed MR-12 are not expected to result in an adverse decrease in discharge. The residual effect is therefore ranked as *Not Significant* (Table 7-2.23).

SDL Tributary 1 Sub-watershed

1. Open Pit Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within SDL Tributary 1, resulting from water diversion by the Open Pit, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease is presented in Table 7-2.19. The maximum monthly decrease is approximately 20 % at the outlet of the watershed during July. Therefore, the magnitude of the residual effect is rated at Level II.

Extent

The change in discharge is considered only within the SDL Tributary 1 watershed; downstream effects are considered separately. The magnitude of the change exceeds threshold at the outlet of the SDL Tributary

1 watershed, approximately 3.7 km^2 ,size, which can be equated to the maximum extent of the effect within the watershed. The watershed is less than 10 km^2, and therefore the extent of the residual effect is rated as Level I.

Duration

Water diversion by the Open Pit will be permanent. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Open Pit will be permanent and irreversible. A Level III rating has therefore been assigned.

Significance

The magnitude of the Open Pit diversions on water quantity in the SDL Tributary 1 watershed exceeds threshold (10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the context of the SDL Tributary 1 watershed, a drainage area of 3.7 km^2, the maximum possible extent of the effect. The SDL Tributary 1 watershed comprises less than 1 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, diversion of water from SDL Tributary 1 by the Open Pit is not expected to result in a major change in water quantity within the Mine Site LSA. Therefore, the net residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Ore Stockpile Platform Diversions - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within SDL Tributary 1, resulting from water diversion by the Ore Stockpile Platform diversions within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in SDL Tributary 1 is presented in Table 7-2.19. The decrease is approximately 15 % at the outlet of the watercourse. The magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reduction is above threshold at the outlet of SDL Tributary 1. The residual effects from the Ore Stockpile Platform diversions outside of the SDL Tributary 1 watershed will be addressed in sections to follow. Therefore, the extent will only be considered within the SDL Tributary 1 watershed, which is 3.7 km^2 in area. The extent has therefore been rated as Level I.

Duration

Water diversion by the Ore Stockpile Platform will occur during Construction, Operation and Closure of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Ore Stockpile Platform. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Ore Stockpile Platform will cease once the structure is decommissioned. The effects are completely reversible and have been rated as Level I.

Significance

The magnitude of the Ore Stockpile Platform diversions on water quantity in the SDL Tributary 1 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the SDL Tributary 1 watershed, which has a drainage area of 3.7 km^2. This area can be equated to the maximum possible extent of the effect. The SDL Tributary 1 watershed comprises less than 1 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, diversion is not expected to result in a major change in water quantity within the Mine Site LSA. The total water quantity within the LSA will not be changed, only redistributed. Therefore, the net residual effect is ranked as *Not Significant* (Table 7-2.23).

3. Open Pit and Ore Stockpile Platform Diversions - Net Change in Downstream Discharge

Residual effects ratings for the net change in water quantity within SDL Tributary 1, resulting from water diversion by the Open Pit and Ore Stockpile Platform within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the net change in water quantity in SDL Tributary 1 resulting from water diversion by the Open Pit and Ore Stockpile Platform is presented in Table 7-2.19. The change in water quantity has a maximum monthly decrease of approximately 35 % at the outlet of the watercourse. The effect is even greater at some of the upstream Arctic Char habitat locations. The magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reduction is above threshold at the outlet of SDL Tributary 1. The residual effects from the Open Pit and Ore Stockpile Platform diversions outside of the SDL Tributary 1 watershed will be addressed in sections to follow. The extent will be considered only within the SDL Tributary 1 watershed, which is 3.7 km^2 in area. The extent has therefore been rated as Level I.

Duration

Water diversion by the Ore Stockpile Platform and Open Pit will occur concurrently during Operation and Closure. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit and Ore Stockpile Platform. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Ore Stockpile Platform will cease once the structure is decommissioned. The net diversion effects are therefore completely reversible and have been rated as Level I.

Significance

The magnitude of the Ore Stockpile Platform and Open Pit diversions on water quantity in the SDL Tributary 1 watershed exceeds threshold (10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the SDL Tributary 1 watershed; the drainage area of 3.7 km^2 can be equated to the maximum possible extent of the effect. The SDL Tributary 1 watershed comprises less than 1 % of the watershed area within the LSA. Based on the extent of the net residual effect relative to the entire LSA, diversion of water from SDL Tributary 1 by the Ore Stockpile Platform and Open Pit is not expected to result in a major change in water quantity within the Mine Site LSA. Therefore, the net residual effect is ranked as *Not Significant* (Table 7-2.23).

SDL Tributary 9

Ore Stockpile Platform Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within SDL Tributary 9, resulting from water diversion by the Ore Stockpile Platform within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in SDL Tributary 9 resulting from water diversion by the Ore Stockpile Platform is presented in Table 7-2.19. The decrease is approximately 29 % at the upstream extent of fish habitat. The magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reduction remains above threshold at the outlet of SDL Tributary 9. The residual effects from the Ore Stockpile Platform diversions outside of the SDL Tributary 9 watershed will be addressed in sections to follow. Therefore, the extent will only be considered within the SDL Tributary 9 watershed, which is 0.33 km^2 in area. The extent has therefore been rated as Level I.

Duration

Water diversion by the Ore Stockpile Platform will occur during Construction, Operation and Closure of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Ore Stockpile Platform. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Ore Stockpile Platform will cease once the structure is decommissioned. The effects are completely reversible and have been rated as Level I.

Significance

The magnitude of the Ore Stockpile Platform diversions on water quantity in the SDL Tributary 9 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the SDL Tributary 9 watershed; its drainage area of 0.33 km^2.can be equated to the maximum possible extent of the effect. The SDL Tributary 9 watershed comprises less than 0.1 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, diversion of water from SDL Tributary 9 by the Ore Stockpile Platform is not expected to result in a major change in water quantity within the Mine Site LSA. The total water quantity within the LSA will not be changed, only redistributed. The net residual effect is ranked as *Not Significant* (Table 7-2.23).

SDL Tributary 12

1. Ore Stockpile Platform Diversions - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within SDL Tributary 12, resulting from water diversion by the Ore Stockpile Platform within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in SDL Tributary 12 resulting from water diversion by the Ore Stockpile Platform is presented in Table 7-2.19. The decrease is approximately 15 % at the upstream extent of fish habitat in the watercourse. The magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reduction remains above threshold at the outlet of SDL Tributary 12. The residual effects from the Ore Stockpile Platform diversions outside of the SDL Tributary 12 watershed will be addressed in sections to follow. Therefore, the extent will only be considered within the SDL Tributary 12 watershed, which is 0.32 km^2 in area. The extent has therefore been rated as Level I.

Duration

Water diversion by the Ore Stockpile Platform will occur during Construction, Operation and Closure of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Ore Stockpile Platform. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Ore Stockpile Platform will cease once the structure is decommissioned. The effects are completely reversible and have been rated as Level I.

Significance

The magnitude of the Ore Stockpile Platform diversions on water quantity in the SDL Tributary 12 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the SDL Tributary 12 watershed; the drainage area of 0.32 km^2 is the maximum possible extent of the effect. The SDL Tributary 12 watershed comprises less than 0.1 % of the watershed area within the LSA. Based on the

extent of the residual effect relative to the entire LSA, diversion of water from SDL Tributary 12 by the Ore Stockpile Platform is not expected to result in a major change in water quantity within the Mine Site LSA. Furthermore, total water quantity within the LSA will not be changed, only redistributed. The net residual effect is ranked as *Not Significant* (Table 7-2.23).

MR-16 (Sheardown Lake)

Residual effects for MR-16 assume that the contributing area is 8.2 km^2; however, during freshet the current configuration of the Mary River results in MR-16 being backwatered, greatly increasing its effective watershed area. In an effort to be conservative, the residual effects presented below do not consider this backwatering, as this would act to reduce the magnitude of residual effects.

1. Open Pit Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within MR-16, resulting from water diversion by the Open Pit, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-16 resulting from water diversion by the Open Pit is presented in Table 7-2.19. The maximum monthly decrease is approximately 10 % at the outlet of the watershed during July. Therefore, the magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reduction remains above threshold at the outlet of MR-16. The residual effects from the Open Pit diversions downstream of the MR-16 watershed will be addressed separately in sections to follow. Therefore, the extent will only be considered within the MR-16 watershed, which has a drainage area of 8.2 km^2. The extent has therefore been rated as Level I.

Duration

Water diversion by the Open Pit will be permanent. A Level III rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Open Pit will be permanent and irreversible. A Level III rating has therefore been assigned.

Significance

The magnitude of the Open Pit diversion on water quantity in the MR-16 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered only within the MR-16 watershed, a drainage area of 8.2 km^2, and this can be equated to the maximum possible extent of the effect. The MR-16 watershed comprises less than 2 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, diversion of water from MR-16 by the Ore Stockpile Platform is not expected to result in a major change in water quantity within the Mine Site LSA. Total water quantity within

the LSA will not be changed, only redistributed. The net residual effect is ranked as *Not Significant* (Table 7-2.23).

2. Ore Stockpile Platform Diversions - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge within MR-16, resulting from water diversion by the Ore Stockpile Platform within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the streamflow decrease in MR-16 resulting from water diversion by the Ore Stockpile Platform is presented in Table 7-2.19. The decrease is approximately 9 % at the outlet of the watercourse. The magnitude of the residual effect is rated at Level I.

Extent

The magnitude of the discharge reduction is below threshold at the outlet of MR-16. The watershed area of MR-16 is 8.2 km^2, and therefore extent has been rated as Level I.

Duration

Water diversion by the Ore Stockpile Platform will occur during Construction, Operation and Closure of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Ore Stockpile Platform. The frequency of the effect has therefore been rated as Level III.

Reversibility

Water diversion by the Ore Stockpile Platform will cease once the structure is decommissioned. The effects are completely reversible and have been rated as Level I.

Significance

Based on the ratings criteria described above, water diversion by the Ore Stockpile Platform is not expected to result in an adverse reduction in water quantity within MR-16 in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

3. Open Pit and Ore Stockpile Platform Diversions - Combined Change in Downstream Discharge

Residual effects ratings for the change in water quantity in MR-16, resulting from water diversion within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow from MR-16 resulting from water diversion is presented in Table 7-2.19. The maximum monthly net decrease in water quantity is 19 % during July. Effect magnitude is the same for both Construction and Operations, and was assessed at the outlet of the watercourse. The magnitude of the residual effect is greater than threshold and is rated at Level II.

Extent

The change in discharge is considered only within MR-16 watershed. Downstream effects will be considered separately. The magnitude of the increase is above threshold (+/- 10 %) at the outlet of the

watershed. The MR-16 watershed is approximately 8.2 km^2, the maximum possible extent of the effect. The watershed is less than the Level I threshold of 10 km^2, and therefore the extent of the residual effect is rated as Level I.

Duration

Concurrent water diversion will occur during Operation and Closure of the Project. A Level II rating has therefore been assigned.

Frequency

Water will be diverted continuously by the Open Pit and Ore Stockpile Platform. The combined effect will also occur continuously, and has therefore been rated as Level III.

Reversibility

Concurrent water diversion will cease after closure when the Ore Stockpiles are decommissioned. The combined effects are completely reversible and have been rated as Level I.

Significance

The magnitude of the water quantity reduction in the MR-16 watershed exceeds threshold (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Mine Site LSA. The effect is considered within the MR-16 watershed, whose drainage area of 8.2 km^2 can be equated to the maximum possible extent of the effect. The MR-16 watershed comprises less than 2 % of the watershed area within the LSA. Based on the extent of the residual effect relative to the entire LSA, changes to water quantity within MR-16 from water diversion are not expected to result in a major change in water quantity within the Mine Site LSA. The net residual effect is ranked as *Not Significant* (Table 7-2.23).

Mary River Watershed

1. Open Pit Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge in the Mary River, resulting from withdrawal of water by the Open Pit in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

Water from the Open Pit will end up in the Waste Rock Stockpile, the Ore Stockpile, or the ROM pond; discharge will be assessed separately. The magnitude of removal of water by the open pit is presented in Table 7-2.19. The maximum reduction in discharge in the Mary River is 0.5 %, less than quantifiable limits during June. The residual effect has been rated as Level 0, and consequently it is given no further consideration.

2. Waste Rock Stockpile Diversion - Decrease in Downstream Discharge

Residual effects ratings for the decrease in discharge in the Mary River, resulting from the diversion of water by the Waste Rock Stockpile in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The decrease in discharge in the Mary River associated with diversion of water by the Waste Rock Stockpile is less than quantifiable limits during Operations and after closure, as presented in Table 7-2.19. The residual effect has been rated as Level 0 and is thus given no further consideration.

3. Diversion Around Ore Stockpile - Increase in Downstream Discharge

Residual effects ratings for the increase in discharge in the Mary River, resulting from the diversion of water by the Waste Rock Stockpile in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The increase in discharge in the Mary River associated with diversion of water around the Ore Stockpiles is less than quantifiable limits, as presented in Table 7-2.19. The residual effect has been rated as Level 0 and is thus given no further consideration.

4. Stockpile Effluent Discharge - Increase in Downstream Discharge

Residual effects ratings for the increase in discharge within the Mary River, resulting from Waste Rock Stockpile, Run-of-Mine Stockpile and Ore Stockpile effluent discharge in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

During Operations, treated stockpile effluent will be discharged throughout the open water season at variable rates designed to match natural discharge patterns. The ROM pond, however, will have little storage and will discharge in natural runoff patterns. The result of this flow matching is a mean discharge to natural flow mixing ratio at the outlet of the watershed of 1 %. The mean magnitude of the streamflow increase in the Mary River resulting from the discharge will therefore also be 1 %, as presented in Table 7-2.19. During closure, changes to streamflow resulting from the waste rock pond discharge will be less than quantifiable limits, and will therefore not be considered further in this assessment. The magnitude of the residual effect is less than threshold during Operations and is therefore rated as Level I.

Extent

The magnitude of the discharge changes are less than threshold at the Mary River effluent discharge location, which equates to the location of maximum effect magnitude in the Mary River. The effect was therefore rated as Level I in extent.

Duration

Concurrent upstream effects will occur, and may result in quantifiable effects, during the Operation and Closure phases of the Project. A Level II rating has therefore been assigned.

Frequency

Discharge will occur continuously each year during the open water season. The combined effect is therefore continuous, and has been rated as Level III.

Reversibility

The net change in discharge in the Mary River will cease after Decommissioning of the Project. The residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, upstream water quantity effects are not expected to result in an adverse reduction to discharge in the Mary River, within the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-2.23).

5. Sewage Effluent Discharge - Increase in Downstream Discharge in the Mary River

Residual effects ratings for the increase in discharge in the Mary River, resulting from effluent discharge in the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

Treated sewage effluent will be discharged to the Mary River during summer and to a storage tank during winter. For this assessment, it is assumed that treated sewage effluent will be discharged at a continuous rate from the treatment plant and the storage pond annually during July and August. Sewage effluent discharge will result in an increase in the mean total monthly discharge in the Mary River during the open water season that is less than quantifiable limits, as presented in Table 7-2.19. Therefore, the residual effect has been rated as Level 0 and consequently it will be given no further consideration.

6. Upstream Effects to Water Quantity - Change in Downstream Discharge

Residual effects ratings for the change in water quantity in the Mary River, resulting from upstream water diversion and effluent discharge within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow in the Mary River resulting from upstream water diversion and effluent discharge is presented in Table 7-2.22. Magnitude is assessed at the proposed effluent discharge location, east of the Ore Stockpiles, with a drainage area of approximately 240 km^2. Changes to water quantity will be less than quantifiable limits during Operations and after closure; therefore, the net residual effect has been rated as Level 0 and will be given no further consideration.

7. Upstream Effects to Water Quantity - Change in Downstream Discharge

Residual effects ratings for the change in discharge in the Mary River, resulting from upstream water quantity effects within the Mine Site LSA, are summarized in Table 7-2.18.

Magnitude

The magnitude of the change in streamflow in the Mary River resulting from upstream water diversion and effluent discharge is presented in Table 7-2.22. Magnitude is assessed immediately downstream of the confluence of MR-16 with the Mary River. The drainage area at this location is approximately 270 km^2. Changes to water quantity will be less than quantifiable limits during Operations and after closure; the net residual effect has been rated as Level 0 and will be given no further consideration.

Summary of Significance

The significance of residual effects of Project activities on water quantity within the Mine Site LSA are summarized below in Table 7-2.23.

Table 7-2.23 Significance of Potential Residual Environmental Effects on Water Quantity in the Mine Site LSA

Watershed - Project Activity	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
MR-08: Waste Rock Stockpile Diversion	N	3	N/A	N/A
MR-10: Waste Rock Stockpile Diversion	N	3	N/A	N/A
MR-10: Open Pit Diversion	N	3	N/A	N/A
MR-10: Effluent Discharge	N	2	N/A	N/A
MR-10: Diversion and Discharge	N	2	N/A	N/A
Camp Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A
Camp Lake: Water Withdrawal (Outflow Reduction)	N	3	N/A	N/A
Camp Lake: Upstream Water Quantity Effects	N	2	N/A	N/A
MR-12: Waste Rock Stockpile Diversion	N	3	N/A	N/A
MR-12: Open Pit Diversion	N	3	N/A	N/A
MR-12: Effluent Discharge	N	2	N/A	N/A
MR-12: Diversion and Discharge	N	2	N/A	N/A
SDL Tributary 1: Open Pit Diversion	N	3	N/A	N/A
SDL Tributary 1: Ore Stockpile Platform Diversion	N	3	N/A	N/A
SDL Tributary 1: Total Diversions	N	3	N/A	N/A
SDL Tributary 9: Ore Stockpile Platform Diversion	N	3	N/A	N/A
SDL Tributary 12: Ore Stockpile Platform Diversion	N	3	N/A	N/A
MR-16: Open Pit Diversion	N	3	N/A	N/A
MR-16: Ore Stockpile Platform Diversion	N	3	N/A	N/A
MR-16: Net Diversion	N	3	N/A	N/A
Mary River: Stockpile Effluent Discharge	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: 1= Low; 2= Medium; 3=High

None of the potential residual effects on water quantity within the Mine Site LSA were determined to be significant. No feedback on the perceived significance of the above activities was provided through public consultation or Inuit Knowledge Studies or by regulators.

The Level of Confidence in all significance ratings is either moderate or high. Confidence is rated based upon an assessment of the quality of available information used to evaluate the residual effects. The data used to quantify residual effects on water quantity within the Mine Site LSA are:

- Watershed and Facility Footprint Areas: Values were determined using GIS and AutoCAD.
- Lake Volume and Surface Area: Values were determined from bathymetric surveys.
- Water Withdrawal Volumes: Values were provided by Hatch and are based upon experience with similar mining ventures.
- Mean Monthly Discharge Volumes: Values are based upon four years of data collected within various watersheds within the Mine Site LSA.

Confidence was generally rated as high if the magnitude of the effect was derived from area or volume calculations, from hydrologic information collected within the subject watershed or from an adjacent watershed, or if minimal assumptions were used to define the effect. Confidence was generally rated as moderate if several or important assumptions were used to define the effect, or if the effect is close to threshold and involved the compilation of multiple upstream effects.

2.3.3.3 Railway LSA Residual Effects Assessment

The following section rates residual effects on Water Quantity in the Railway LSA. Residual effects are organized by watershed. The residual effects considered and addressed within the Railway LSA are:

Ravn River Watershed

- Ravn Camp Lake Sub-watershed
  - Water Withdrawal - Volume reduction
  - Water Withdrawal - Discharge reduction
- Nivek Lake Sub-watershed
  - Water Withdrawal - Volume reduction
  - Water Withdrawal - Discharge reduction

Cockburn River Watershed

- Cockburn Lake North Basin
  - Water withdrawal - Volume reduction
  - Water withdrawal - Discharge reduction
- Cockburn Lake South Basin
  - Water withdrawal - Volume reduction
  - Water withdrawal - Discharge reduction
- Combined North and South Basin Effects - Discharge reduction

The details of the Railway LSA residual effects assessment are provided below.

Ravn River Watershed

Ravn Camp Lake Sub-watershed

1. Water Withdrawal - Reduction in Ravn Camp Lake under-ice water volume

Residual effects ratings for the reduction in under-ice water volume, resulting from water withdrawal from Ravn Camp Lake in the Railway LSA, are summarized in Table 7-2.24.

Magnitude

All water requirements for Ravn Camp and all winter water requirements for Mid-rail Camp will be withdrawn from Ravn Camp Lake. Winter water withdrawal rates are presented in Table 7-2.25, along with the resulting overwinter drawdown from Ravn Camp Lake. Withdrawals will result in a reduction of approximately 0.2 % in the total under-ice lake volume. This reduction is more than an order of magnitude less than threshold, and is therefore rated as a Level I residual effect.

Extent

The reduction in under-ice volume will occur only within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from Ravn Camp Lake will occur only during the Construction phase of the Project. A Level I rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Ravn Camp Lake throughout the year, so reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in under-ice volume associated with water withdrawal will cease once water is no longer being withdrawn from the waterbody. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in Ravn Camp Lake. The residual effect is rated as *Not Significant* (Table 7-2.27).

Table 7-2.24 Railway LSA Freshwater Quantity Effects Assessment Summary - Construction Phase

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
Ravn Camp Lake: Water Withdrawal	Reduction in Ravn Camp Lake under-ice water volume	Potential effects from water withdrawal were mitigated for during selection of the withdrawal waterbodies and during the design of the water withdrawal program. Mitigation activities included: • Desktop assessment of potential withdrawal waterbodies near Milne Port. The assessment considered lake size, upstream watershed area and accessibility during candidate waterbody selection. • Collection of bathymetric data on the best candidate waterbody identified during the high level review in order to accurately calculate quantify water depths and volumes. • Volume reduction calculations were conducted using preliminary assumptions of water withdrawal volumes to ensure that the DFO guidelines presented in Section 2.3.1.1 were met.	Level I	Level I	Level I	Level III	Level I
	Reduction in downstream discharge		Level I	Level I	Level I	Level III	Level I
Nivek Lake: Water Withdrawal	Reduction in downstream discharge		Level I	Level I	Level I	Level III	Level I
Cockburn Lake: Water Withdrawal	Reduction in Cockburn Lake North Basin under-ice water volume		Level I	Level I	Level I	Level III	Level I
	Reduction in Cockburn Lake North Basin downstream discharge		Level 0	-	-	-	-
	Reduction in Cockburn Lake South Basin under-ice water volume		Level I	Level I	Level I	Level III	Level I
	Reduction in Cockburn Lake South Basin downstream discharge		Level 0	-	-	-	-
	Reduction in Cockburn Lake downstream discharge from the combination of both north and south basin effects		Level 0	-	-	-	-

Table 7.2-25 Over-Winter Water Withdrawal Volumes in the Railway LSA

Camp	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Available Under-Ice Lake Volume (m^3)	Winter Abstraction Volume (m^3)	Total Under-Ice Volume Reduction (%)	Approximate Over-winter Water Level Reduction (m)
Ravn and Mid-Rail Camps	Domestic and Industrial Water Consumption	224.4	Ravn Camp Lake	23,715,000	54,530	0.2%	0.03
Cockburn Tunnels Camp	Domestic and Industrial Water Consumption	99.9	Cockburn Lake - North Basin	1,692,875,000	21,180	0.001%	0.001
South Cockburn Camp	Domestic and Industrial Water Consumption	112.2	Cockburn Lake - South Basin	135,179,000	23,790	0.02%	0.003

NOTES:
1. AVAILABLE UNDER-ICE VOLUME REFERS TO THE VOLUME OF AVAILABLE WATER BENEATH THE ICE SURFACE DURING PERIODS OF MAXIMUM ICE THICKNESS. MAXIMUM ICE THICKNESS WAS ASSUMED TO BE 2 m ACCORDING TO DFO GUIDELINES.
2. THE AVAILABLE UNDER-ICE WATER VOLUME ASSUMES THAT THE LAKE SURFACE WAS AT THE LAKE OUTLET INVERT ELEVATION DURING THE BATHYMETRIC SURVEY.
3. THE WATER LEVEL REDUCTION CALCULATIONS ASSUME THAT THE UNDER-ICE SURFACE AREA IS EQUAL TO THE OPEN WATER SURFACE AREA OF THE LAKE.

Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge from Ravn Camp Lake, resulting from water withdrawal in the Railway LSA, are summarized in Table 7-2.24.

Magnitude

The magnitude of streamflow reduction downstream of Ravn Camp Lake resulting from water withdrawal is presented in Table 7-2.26. Outflow reductions are less than threshold for all open water months. Therefore, the magnitude of the residual effect is rated at Level I.

Extent

The magnitude of the discharge reduction is less than threshold at the outlet of Ravn Camp Lake, which is also the source location of the effect. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal will only occur during the Construction phase of the Project. A Level I rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Ravn Camp Lake throughout the year. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in downstream discharge from Ravn Camp Lake will cease once withdrawal stops. The residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in discharge downstream of Ravn Camp Lake. The residual effect is rated as *Not Significant* (Table 7-2.27).

Nivek Lake Sub-watershed

Residual effects ratings for the reduction in discharge from Nivek Lake, resulting from water withdrawal in the Railway LSA, are summarized in Table 7-2.24.

Magnitude

The magnitude of streamflow reduction downstream of Nivek Lake resulting from water withdrawal is presented in Table 7-2.26. Outflow reductions are less than threshold for all open water months. Therefore, the magnitude of the residual effect is rated at Level I.

Extent

The magnitude of the discharge reduction is less than threshold at the outlet of Nivek Lake, which is also the source location of the effect. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal will occur only during the Construction phase of the Project. A Level I rating has been assigned.

Table 7-2.26 Reduction in Flow Downstream of Withdrawal Locations within the Railway LSA – Construction Phase Only

Camp / Location	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Upstream Drainage Area (km^2)	Estimated Mean Annual Unit Runoff (l/s/km^2)	Winter Withdrawal Volume (m^3)	Reduction in Mean Monthly Discharge (%)				
							June	July	August	September	October
Ravn Camp	Domestic and Industrial Water Consumption	145.2	Ravn Camp Lake	68	10	54,530	-0.71%	-0.05%	-0.18%	-0.31%	-
Mid-Rail Camp	Domestic and Industrial Water Consumption	79.2	Nivek Lake	5.4	6	-	-0.53%	-0.98%	-1.2%	-2.6%	
Cockburn Tunnels Camp	Domestic and Industrial Water Consumption	99.9	Cockburn Lake - North Basin	1900	8	21,180	-0.02%	0.00%	0.00%	0.00%	-0.04%
South Cockburn Camp	Domestic and Industrial Water Consumption	112.2	Cockburn Lake - South Basin	1945	8	23,790	-0.02%	0.00%	0.00%	0.00%	-0.04%
Cockburn Camps - Combined	Domestic and Industrial Water Consumption	212.1	Cockburn Lake	1945	8	44,970	-0.04%	0.00%	-0.01%	-0.01%	-0.08%

NOTES:
1. THE MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT VARIOUS LOCATIONS WITHIN THE FRESHWATER RSA, AS DISCUSSED IN VOLUME 7 SECTION 1
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS DETERMINED USING THE 2007-2011 AVERAGE DISTRIBUTION AT VARIOUS MONITORING STATIONS WITHIN THE RSA.
3. WATER WILL ONLY BE WITHDRAWN FROM NIVEK LAKE BETWEEN JUNE AND SEPTEMBER. MID-RAIL CAMP WATER REQUIREMENTS WILL BE SOURCED FROM RAVN CAMP LAKE DURING THE WINTER

Frequency

Water will be withdrawn more or less continuously from Nivek Lake throughout the open water season (June – September). The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in downstream discharge from Nivek Lake will cease once withdrawal stops. The residual effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in discharge downstream of Nivek Lake. The residual effect is rated as *Not Significant* (Table 7-2.27).

Cockburn River Watershed

Cockburn Lake – North Basin

1. Water Withdrawal - Reduction in Cockburn Lake North Basin under-ice water volume

Residual effects ratings for the reduction in under-ice water volume, resulting from water withdrawal from the north basin of Cockburn Lake in the Railway LSA, are summarized in Table 7-2.24.

Magnitude

All water requirements for the Cockburn Tunnels Camp will be withdrawn from the north basin. Winter withdrawal rates are presented in Table 7-2.25, along with the overwinter drawdown from the north basin. Withdrawals will result in a reduction of approximately 0.001 % of the total under-ice lake volume. This reduction is considerably less than threshold, and is therefore rated as a Level I residual effect.

Extent

The reduction in under-ice volume will only occur within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from Cockburn Lake – North Basin will occur only during the Construction phase of the Project. A Level I rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Cockburn Lake – North Basin throughout the year. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in under-ice volume associated with water withdrawal will cease once water is no longer being withdrawn from the waterbody. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in the north basin of Cockburn Lake. The residual effect is rated as *Not Significant*.

2. Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge from Cockburn Lake – North Basin, resulting from water withdrawal, are summarized in Table 7-2.24.

Magnitude

The magnitude of streamflow reduction downstream of Cockburn Lake – North Basin resulting from water withdrawal is presented in Table 7-2.26. Outflow reductions are much less than quantifiable limits. The magnitude of the residual effect is rated at Level 0 and consequently it will not be given further consideration.

Cockburn Lake – South Basin

1. Water Withdrawal - Reduction in Cockburn Lake South Basin under-ice water volume

Residual effects ratings for the reduction in under-ice water volume, resulting from water withdrawal from the south basin of Cockburn Lake in the Railway LSA, are summarized in Table 7-2.24.

Magnitude

All water requirements for the South Cockburn Camp will be withdrawn from the south basin of Cockburn Lake. Winter water withdrawal rates are presented in Table 7-2.25, along with the resulting overwinter drawdown within the south basin of Cockburn Lake. Withdrawals will result in a reduction of approximately 0.02 % of the total under-ice lake volume, considerably less than threshold, and is therefore rated as a Level I residual effect.

Extent

The reduction in under-ice volume will only occur within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from Cockburn Lake – South Basin will occur only during the Construction phase of the Project. A Level I rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from Cockburn Lake – South Basin throughout the year. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Reversibility

The reduction in under-ice volume associated with water withdrawal will cease once water is no longer being withdrawn from the waterbody. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in the south basin of Cockburn Lake. The residual effect is rated as *Not Significant* (Table 7-2.27).

2. Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge from Cockburn Lake – South Basin, resulting from water withdrawal, are summarized in Table 7-2.24.

Magnitude

The magnitude of streamflow reduction downstream of Cockburn Lake – South Basin resulting from water withdrawal is presented in Table 7-2.26. Outflow reductions are much less than quantifiable limits. Therefore, the magnitude of the residual effect is rated at Level 0 and consequently it will not be given further consideration.

Cockburn Lake – Combined

Residual effects ratings for the reduction in discharge from Cockburn Lake, resulting from water withdrawal in both the north and south basins, are summarized in Table 7-2.24.

Magnitude

The magnitude of streamflow reduction downstream of Cockburn Lake resulting from water withdrawal in both the north and south basins is presented in Table 7-2.26. Outflow reductions are much less than quantifiable limits. Therefore, the magnitude of the residual effect is rated at Level 0 and will not be given further consideration.

Summary of Significance

The significance of residual effects of Project activities on water quantity within the Railway LSA is summarized below in Table 7-2.27.

Table 7-2.27 Significance of Potential Residual Environmental Effects on Water Quantity in the Railway LSA

Watershed - Project Activity	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Ravn Camp Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A
Ravn Camp Lake: Water Withdrawal (Outflow Reduction)	N	2	N/A	N/A
Nivek Lake: Water Withdrawal (Outflow Reduction)	N	2	N/A	N/A
Cockburn Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: 1= Low; 2= Medium; 3=High

None of the potential residual effects on water quantity within the Railway LSA were determined to be significant. No feedback on the perceived significance of the above activities was provided through public consultation or Inuit Knowledge Studies or by regulators.

The Level of Confidence in the significance ratings is either moderate or high. Confidence ratings are based upon an assessment of the quality of available information used to evaluate the residual effects. The data used to quantify residual effects on water quantity within the Railway LSA are:

- Watershed and Facility Footprint Areas: Values were determined using GIS and AutoCAD.
- Lake Volume and Surface Area: Values were determined from bathymetric surveys.
- Water Withdrawal Volumes: Values were provided by Hatch and are based upon experience with similar mining ventures.
- Mean Monthly Discharge Volumes: Values are based upon data collected at representative monitoring stations within the freshwater RSA.

All of the above data were determined to be of good quality, based upon measurement techniques and/or location of the measured data. This determination resulted in the rating of confidence as high for all effects assessed using area calculations, and medium for all effects assessed by scaling hydrologic information.

2.3.3.4 Steensby Port LSA Residual Effects Assessment

The following section rates residual effects on Water Quantity in the Steensby Port LSA. Residual effects are organized by watershed. The residual effects considered and addressed within the Steensby Port LSA are summarized as follows:

3km Lake Watershed

- Water Withdrawal - Volume Reduction
- Water Withdrawal - Discharge Reduction

ST347 Lake Watershed

- Water Withdrawal - Volume Reduction
- Water Withdrawal - Discharge Reduction

ST-1 Watershed

- Ore Offload Area Water Diversion

ST-2 Watershed

- Ore Offload Area Water Diversion

ST-15 Watershed

- Ore Offload Area Water Diversion

ST-16 Watershed

- Ore Offload Area Water Diversion

Ore Stockpile Island Watershed

- ST-23 Watershed
    - Ore Stockpile
- ST-24 Watershed
    - Ore Stockpile

- ST-26 Watershed
    - Ore Stockpile
- ST-27 Watershed
    - Ore Stockpile

The details of the Steensby Port LSA residual effects assessment are provided below.

3km Lake Watershed

1. Water Withdrawal - Reduction in under-ice water volume

Residual effects ratings for the reduction in under-ice water volume in 3km Lake, resulting from water withdrawal within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

While access to ST347 Lake is being constructed, water requirements for Steensby Port will be withdrawn from 3km Lake. Winter water withdrawal rates are presented in Table 7-2.29, along with the resulting overwinter drawdown within 3km Lake. Withdrawals will result in a reduction of approximately 5.4 % of the total under-ice lake volume. This reduction is less than threshold, and is therefore rated as a Level I residual effect.

Extent

The reduction in under-ice volume will only occur within the waterbody. The effect was therefore rated as Level I in extent.

Duration

Water withdrawal from 3km Lake will occur only during the early Construction phase of the Project. A Level I rating has therefore been assigned.

Frequency

Water will be withdrawn more or less continuously from 3km Lake throughout the year. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of the effect has therefore been rated as Level III.

Table 7-2.28 Steensby Port LSA Freshwater Quantity Effects Assessment Summary - All Phases

Potential Impacts			Evaluation Criteria				
Watershed - Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Extent**	**Duration**	**Frequency**	**Reversibility**
3km Lake: Water Withdrawal	Reduction of Under-Ice Water Volume	Potential effects from water withdrawal were mitigated for during selection of the withdrawal waterbodies and during the design of the water withdrawal program. Mitigation activities included: • Desktop assessment of potential withdrawal waterbodies near Milne Port. The assessment considered lake size, upstream watershed area and accessibility during candidate waterbody selection. • Collection of bathymetric data on the best candidate waterbody identified during the high level review in order to accurately calculate quantify water depths and volumes. • Volume reduction calculations were conducted using preliminary assumptions of water withdrawal volumes to ensure that the DFO guidelines presented in Section 2.3.1.1 were met.	Level I	Level I	Level I	Level III	Level I
	Reduction in Downstream Discharge		Level II	Level II	Level I	Level III	Level I
ST347 Lake: Water Withdrawal	Reduction of Under-Ice Water Volume		Level I	Level I	Level II	Level III	Level I
	Reduction in Downstream Discharge		Level I	Level I	Level I	Level III	Level I
ST-1: Ore Offload Diversion	Decrease in Downstream Discharge	Potential effects from water diversion were mitigated through the design of the water diversion structures. Project infrastructure requiring water diversion were located and designed in an effort to minimize downstream impacts. Mitigation activities included: • Desktop assessment of potential infrastructure locations. Assessment considered configuration of infrastructure, access to infrastructure, footprint overlap with watercourses and nearby diversion discharge locations • Ground truthing of assumptions made during desktop assessment	Level I	Level I	Level II	Level III	Level I
ST-2: Ore Stockpile Diversion	Decrease in Downstream Discharge		Level I	Level I	Level II	Level III	Level I
ST-15: Ore Stockpile Diversion	Decrease in Downstream Discharge		Level III	Level I	Level II	Level III	Level I
ST-16: Ore Stockpile Diversion	Change in Downstream Discharge		Level III	Level I	Level II	Level III	Level I
Ore Stockpile Island Watershed: Ore Stockpile Diversion	Change in Downstream Discharge		Level 0	-	-	-	-

NOTES:
1. THE ABOVE RATINGS CORRESPOND TO THE RATINGS CRITERIA PRESENTED IN TABLE 7-2.12, WHICH IS LOCATED WITHIN THE TEXT OF THE EIS.

Reversibility

The reduction in under-ice volume will cease once water is no longer being withdrawn. The effect is fully reversible and has therefore been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in 3 km Lake. The residual effect is rated as *Not Significant* (Table 7-2.32).

2. Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in discharge from 3km Lake, resulting from water withdrawal within the Steensby LSA, are summarized in Table 7-2.28.

Magnitude

The magnitude of streamflow reduction downstream of 3 km Lake resulting from water withdrawal is presented in Table 7-2.30. Outflow reductions exceed threshold during June and September. The magnitude of the residual effect is rated at Level II.

Extent

The magnitude of the discharge reductions is greater than threshold at the outlet of 3km Lake. The magnitude will remain above threshold almost to the outlet of the watershed, 2 km downstream of the outlet of 3km Lake. The effect was rated as Level II.

Duration

Water withdrawal will only occur early in the Construction phase of the Project. The duration was rated as Level I.

Frequency

Water will be withdrawn more or less continuously from 3km Lake throughout the year. The effect has therefore been rated as Level III.

Reversibility

The reduction in discharge downstream of 3 km Lake will cease once withdrawal stops. The residual effect is fully reversible and has been rated as Level I.

Significance

The magnitude of the discharge reduction from 3km Lake, resulting from water withdrawal, exceeds threshold during the months of June and September (a 10 % change from natural discharge). However, the effect is minor in both areal extent and water volume with respect to the Steensby Port LSA. The effect is confined to the 2 km channel downstream of 3km Lake. The Steensby LSA contains hundreds of kilometres of watercourses. The flow reduction downstream of 3km Lake affects only a small fraction of the total watercourses in the Steensby Port LSA. Therefore, the reduction in water quantity downstream of 3km Lake is not expected to result in a major change in water quantity within the Steensby Port LSA and consequently, the net residual effect is ranked as *Not Significant* (Table 7-2.32).

Table 7-2.29 Over-Winter Water Withdrawal Volumes in the Steensby Port LSA

Project Phase	Withdrawal Source	Description	Withdrawal Rate (m^3/day)	Available Under-Ice Lake Volume (m^3)	Winter Abstraction Volume (m^3)	Total Under-Ice Volume Reduction (%)	Approximate Over-winter Water Level Reduction (m)
Construction	3km Lake	Domestic and Industrial Water Consumption	425.8	1,901,000	103,470	5.4%	0.18
	ST347 Lake			20,969,000	90,270	0.4%	0.03
Operation	ST347 Lake	Domestic and Industrial Water Consumption	241.6	20,969,000	51,220	0.2%	0.02

NOTES:
1. AVAILABLE UNDER-ICE VOLUME REFERS TO THE VOLUME OF AVAILABLE WATER BENEATH THE ICE SURFACE DURING PERIODS OF MAXIMUM ICE THICKNESS. MAXIMUM ICE THICKNESS WAS ASSUMED TO BE 2 m ACCORDING TO DFO GUIDELINES.
2. THE AVAILABLE UNDER-ICE WATER VOLUME ASSUMES THAT THE LAKE SURFACE WAS AT THE LAKE OUTLET INVERT ELEVATION DURING THE BATHYMETRIC SURVEY.
3. THE WATER LEVEL REDUCTION CALCULATIONS ASSUME THAT THE UNDER-ICE SURFACE AREA IS EQUAL TO THE OPEN WATER SURFACE AREA OF THE LAKE.
4. THE WINTER WITHDRAWAL PERIOD IS ASSUMED TO BE JUNE-SEPTEMBER FOR 3KM LAKE AND JUNE-OCTOBER FOR ST347 LAKE. THE DIFFERENT PERIODS RESULT FROM THE MUCH LARGER DRAINAGE AREA AND LAKE VOLUME OF THE ST347 WATERSHED, RESULTING IN CONSISTENT LAKE OUTFLOWS DURING OCTOBER.

Table 7-2.30 Reduction in Flow Downstream of Withdrawal Locations within the Steensby Port LSA

Project Phase	Description	Withdrawal Rate (m^3/day)	Withdrawal Source	Upstream Drainage Area	Estimated Mean Annual Unit Runoff	Winter Withdrawal Volume (m^3)	Reduction in Mean Monthly Discharge (%)				
							June	July	August	September	October
Construction	Domestic and Industrial Water Consumption	425.8	3km Lake	4.7	7.6	103,470	-23%	-5%	-6%	-14%	-
			ST347 Lake	323		90,270	-0.5%	-0.05%	-0.07%	-0.10%	-1.2%
Operation		241.6	ST347 Lake	323		51,220	-0.3%	-0.03%	-0.04%	-0.06%	-0.7%

NOTES:
1. THE MEAN ANNUAL UNIT RUNOFF WAS ESTIMATED FROM MEASURED DATA COLLECTED AT STATION BR137, AS DISCUSSED IN VOLUME 7 SECTION 1.
2. THE ANNUAL DISTRIBUTION OF STREAMFLOW WAS ASSUMED EQUAL TO THE 2007-2011 AVERAGE DISTRIBUTION AT MONITORING STATION H5 OR BR137.
3. WATER WILL BE WITHDRAWN FROM 3KM LAKE ONLY UNTIL ACCESS AND AN INTAKE CAN BE ESTABLISHED AT ST347 LAKE.

Table 7-2.31 Change in Flow Downstream of Diversion and Discharge Locations within the Steensby Port LSA

Watershed	Magnitude Assessment Location	Baseline Upstream Watershed Area (km2)	Diverted Upstream Watershed Area (km2)	Reduction in Mean Monthly Discharge (%)			
				June	July	August	September
ST-1	Outlet of Watershed	1.8	-0.05	-3%	-3%	-3%	-3%
ST-2	Outlet of Watershed	7.3	-0.24	-3%	-3%	-3%	-3%
ST-15	Outlet of Watershed	0.28	-0.18	-64%	-64%	-64%	-64%
ST-16	Outlet of Watershed	0.26	-0.14	-54%	181%	-54%	-54%
Ore Stockpile Island	Island	1.7	-0.47	-19%	54%	-19%	-19%

NOTES:
1. CONSIDERING THE SMALL SIZE AND ELEVATION RANGE WITHIN THESE WATERSHED, UNIT RUNOFF WAS ASSUMED CONSTANT THROUGOUT THE WATERSHEDS AND THEREFORE CHANGE IN FLOW IS EQUIVALENT TO THE CHANGE IN WATERSHED AREA.

ST347 Lake Watershed

1. Water Withdrawal - Reduction in under-ice water volume

Residual effects ratings for the reduction in under-ice water volume in ST347 Lake, resulting from water withdrawal from within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

Water requirements for Steensby Port will be withdrawn from ST347 Lake once access has been constructed. Winter withdrawal rates are presented in Table 7-2.29, along with the resulting overwinter drawdown within ST347 Lake. Withdrawals will result in a maximum reduction of approximately 0.4 % of the total under-ice lake volume during Construction. This reduction is considerably less than threshold, and is therefore rated as Level I.

Extent

The reduction in under-ice volume will only occur within the waterbody. The effect was therefore rated as Level I.

Duration

Water withdrawal from ST347 Lake will occur during Construction, Operation and Closure of the Project. The duration is rated as Level II.

Frequency

Water will be withdrawn more or less continuously from ST347 Lake throughout the year. As a result, the reduction of under-ice water volume will also occur continuously throughout the winter. The frequency of effect has been rated as Level III.

Reversibility

The reduction in under-ice volume associated with water withdrawal will cease once water is no longer being withdrawn from the waterbody. The effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in under-ice water volume in ST347 Lake. The residual effect is ranked as *Not Significant* (Table 7-2.32).

2. Water Withdrawal - Reduction in Downstream Discharge

Residual effects ratings for the reduction in downstream discharge from ST347 Lake, resulting from water withdrawal in the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

The magnitude of streamflow reduction downstream of ST347 Lake resulting from water withdrawal is presented in Table 7-2.30. Outflow reductions exceed quantifiable limits only in October during the Construction phase. The magnitude of the residual effect is rated at Level I.

Extent

The magnitude of the discharge reductions is less than threshold at the outlet of ST347 Lake, which is also the source location of the effect. The effect was therefore rated as Level I.

Duration

Water withdrawal exceeding quantifiable limits will only occur during the Construction phase of the Project. The duration is rated as Level I.

Frequency

Water will be withdrawn more or less continuously from ST347 Lake throughout the year. The frequency of the effect is rated as Level III.

Reversibility

The quantifiable reduction in discharge downstream of ST347 Lake will cease after the Construction phase of the Project. The residual effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water withdrawals are not expected to result in an adverse reduction in discharge downstream of ST347 Lake. The residual effect is ranked as *Not Significant* (Table 7-2.32).

ST-1 Watershed

1. Ore Offload Area Water Diversion

Residual effects ratings for the diversion of water within the ST-1 watershed, resulting from water management of the Ore Offload Area within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

Construction of the Steensby Port Ore Offload will result in the diversion of water from approximately 0.05 km^2 of the contributing area to a water management pond. Accordingly, discharge from the ST-1 watershed will be reduced by approximately 3 %, as presented in Table 7-2.31. This reduction is less than threshold, and is rated as Level I.

Extent

Considering the magnitude of the reduction, it would only exceed threshold (10 %) in less than 1 km^2 of the ST-1 watershed. The effect is rated as Level I.

Duration

The diversion will be functional during Operation and Decommissioning of the Project. The effect is rated as Level II.

Frequency

Water will be diverted continuously throughout the year. The frequency of the effect has been rated as Level III.

Reversibility

The diversion of water will cease once the diversion ditches are decommissioned. The effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water diversion is not expected to result in an adverse reduction of discharge within the ST-1 watershed. The residual effect is ranked as *Not Significant* (Table 7-2.32).

ST-2 Watershed

1. Ore Offload Area Water Diversion

Residual effects ratings for the diversion of water within the ST-2 watershed, resulting from water management of the Ore Offload Area within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

Construction of the Steensby Port Ore Offload will result in the diversion of water from approximately 0.24 km^2 of the contributing area within the ST-2 watershed to a water management pond. Accordingly, discharge from the ST-2 watershed will be reduced by approximately 3 %, as presented in Table 7-2.31. This reduction is less than threshold, and is rated as a Level I residual effect.

Extent

Considering the magnitude of the reduction, it would only exceed threshold (10 %) in less than 10 km^2 of the ST-2 watershed. The effect was rated as Level I.

Duration

The diversion will be functional during Operation and Closure of the Project. The effect was rated as Level II.

Frequency

Water will be diverted continuously throughout the year. The frequency of the effect has been rated as Level III.

Reversibility

The diversion of water will cease once the diversion ditches are decommissioned. The effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water diversion is not expected to result in an adverse reduction discharge within the ST-2 watershed. The residual effect is ranked as *Not Significant* (Table 7-2.32).

ST-15 Watershed

1. Ore Offload Area Water Diversion

Residual effects ratings for the diversion of water within the ST-15 watershed, resulting from water management of the Ore Offload Area within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

Construction of the Steensby Port Ore Offload will result in the diversion of water from approximately 0.18 km^2 of the contributing area within the ST-15 watershed to a water management pond. Accordingly, discharge from the watershed will be reduced by approximately 64 %, as presented in Table 7-2.31. This reduction is exceeds five times threshold, and is rated as a Level III residual effect.

Extent

The magnitude of the effect does not extend beyond the ST-15 watershed, as it discharges directly to the ocean. The maximum extend of the effect is 0.28 km^2. The effect was rated as Level I.

Duration

The diversion will be functional during Operation and Closure of the Project. The effect is rated as Level II.

Frequency

Water will be diverted continuously throughout the year. The frequency of the effect has been rated as Level III.

Reversibility

The diversion of water will cease once the diversion ditches are decommissioned. The effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water diversion is expected to result in an adverse reduction in discharge within the ST-15 watershed. However, the effect is restricted to the ST-15 watershed, an area of only 0.28 km^2. Considering that there are hundreds of square kilometres of watershed area within the Steensby Port LSA, the diversion is not expected to result in an adverse reduction in water quantity within the LSA as a whole. The residual effect is ranked as *Not Significant* (Table 7-2.32).

ST-16 Watershed

1. Ore Offload Area Water Diversion and Discharge

Residual effects ratings for the diversion and discharge of water within the ST-16 watershed, resulting from water management of the Ore Offload Area within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

Construction of the Steensby Port Ore Offload will result in the diversion of water from approximately 0.14 km^2 of the contributing area within the ST-16 watershed to a water management pond. Accordingly, discharge from the ST-16 watershed will be reduced by approximately 54 %, as presented in Table 7-2.31. Furthermore, water diverted from ST-16 as well as ST-1, ST-2 and ST-15 will be discharged from the management pond into the ST-16 watershed, most probably in July. This discharge will result in an increase in mean July discharge of approximately 181 %. Both residual effects exceed five times threshold, and are therefore rated as a Level III.

Extent

The magnitude of the effect does not extend beyond the ST-16 watershed as it discharges directly to the ocean. Therefore, the maximum extent of the effect is 0.26 km^2; hence the effect was rated as Level .

Duration

The diversion will be functional during Operation and Closure of the Project. The duration has been rated as Level II.

Frequency

Water will be diverted continuously throughout the year and discharged annually. The frequency of the effect has been rated as Level III.

Reversibility

The diversion and discharge of water will cease once the diversion ditches are decommissioned. The effect is fully reversible and has been rated as Level I.

Significance

Based on the ratings criteria described above, water diversion and discharge is expected to result in an adverse reduction and an increase in discharge within the watershed. However, the effect is restricted to the ST-16 watershed, which is only 0.26 km^2 in size. Considering that there are hundreds of square kilometres of watershed area within the Steensby Port LSA, the diversion is not expected to result in an adverse change to water quantity within the LSA as a whole. Therefore, the residual effect is ranked as *Not Significant* (Table 7-2.32).

Ore Stockpile Island Watershed

1. Ore Stockpile Diversion and Discharge - Change in Downstream Discharge

Residual effects ratings for the change in discharge from the Ore Stockpile Island Watershed, resulting from water diversion and discharge from the Ore Stockpile and Management Pond within the Steensby Port LSA, are summarized in Table 7-2.28.

Magnitude

The magnitude of the streamflow change from the Ore Stockpile Island watershed resulting from water diversion and discharge from the Ore Stockpile and Management Pond is presented in Table 7-2.31. There will be a decrease in flow within natural channels of approximately 19 % within the Ore Stockpile Island watershed, and an increase in discharge of 54 % downstream of the Management Pond. The Management Pond discharge is assumed to occur during July. The diverted water will flow from the Ore Stockpile Island into Steensby Inlet, only it will issue from different outlets and potentially at different times than under natural conditions. The result will be no net change in annual discharge from the Ore Stockpile Island watershed. The magnitude of the residual effect is rated at Level 0, and will not be considered further within the water quantity effects assessment.

Summary of Significance

The significance of residual effects of Project activities on Water Quantity within the Steensby Port LSA is summarized below in Table 7-2.32. The significance of affects on Water Quality and Fish and Fish Habitat will be addressed in Sections 3 and 4 of this volume.

Table 7-2.32 Significance of Potential Residual Environmental Effects on Water Quantity in the Steensby Port LSA

Watershed - Project Activity	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
3km Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A
3km Lake: Water Withdrawal (Outflow Reduction)	N	2	N/A	N/A
ST347 Lake: Water Withdrawal (Volume Reduction)	N	3	N/A	N/A
ST347 Lake: Water Withdrawal (Volume Reduction)	N	2	N/A	N/A
ST-1: Ore Offload Diversion	N	3	N/A	N/A
ST-2: Ore Offload Diversion	N	3	N/A	N/A
ST-15: Ore Offload Diversion	N	3	N/A	N/A
ST-16: Ore Offload Diversion and Discharge	N	2	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: 1= Low; 2= Medium; 3=High

None of the potential residual effects on Water Quantity within the Steensby Port LSA were determined to be significant. No feedback as to the perceived significance of the above activities was provided through public consultation or Inuit Knowledge Studies or by regulators.

The Level of Confidence in the significance ratings is either moderate or high, based on an assessment of the quality of available information used to evaluate the residual effects. The data used to quantify residual effects on water quantity within the Mine Site LSA are:

- Watershed and Facility Footprint Areas: Values were determined using GIS and AutoCAD.
- Lake Volume and Surface Area: Values were determined from bathymetric surveys.
- Water Withdrawal Volumes: Values were provided by AMEC and are based upon experience with similar mining ventures.
- Mean Monthly Discharge Volumes: Values are based upon data collected at a monitoring station on the Ikpikiturjjuaq River, at the outlet of 10km Lake, and at monitoring station H5. Values were then scaled by drainage area to the various watersheds.

All of the data were determined to be of good quality, based upon measurement techniques and/or location. This determination resulted in the rating of confidence as high for all effects assessed using area calculations, and medium for all effects assessed by scaling hydrologic information.

2.3.4 Prediction Confidence

Prediction confidence has been discussed for each LSA within the preceding Section. In summary, the Level of Confidence in all Water Quantity significance ratings is either moderate or high, based on an assessment of the quality of available information used to evaluate the residual effects. The data used to quantify residual effects on water quantity within the Mary River RSA are:

- Watershed and Facility Footprint Areas: Values were determined using GIS and AutoCAD.
- Lake Volume and Surface Area: Values were determined from bathymetric surveys.
- Water Withdrawal Volumes: Values were provided by AMEC and are based upon experience with similar mining ventures.
- Mean Monthly Discharge Volumes: Values are based upon three to four years of data collected within watersheds various watersheds within the Milne Port, Mine Site and Steensby LSAs.

Confidence was generally rated as high if the magnitude of the effect was derived from area or volume calculations, from hydrologic information collected within the subject watershed or from an adjacent watershed, or if minimal assumptions were used to define the effect. Confidence was rated as moderate if several or important assumptions were used to define the effect, or if the effect is close to threshold and involved the compilation of multiple upstream effects.

2.3.5 Follow Up

Some adaptive management of Water Quantity will be required for the Mary River Project. Most notably, the magnitude threshold of 10 % change to baseline conditions should be confirmed to ensure that no significant Water Quantity effects occur below this threshold. Specific details regarding adaptive management, mitigation and monitoring of Water Quantity for Mary River are presented in the Mary River Site Water Management Plan.

2.4 IMPACT STATEMENT

Impact Statement for Key Issue 1 - Water Withdrawal (Volume Reduction)

The Project will not have significant adverse residual effects on the under-ice water volume of water. All withdrawals meet DFO guidelines for the Regional Study Area.

Impact Statement for Key Issue 1 - Water Withdrawal (Outflow Reduction)

Withdrawal will not have significant adverse residual effects on the outflow of water from waterbodies. Magnitude threshold will be exceeded at only one location, 3km Lake within the Steensby LSA, during June and September; however, the extent of the effect is minor relative to the entire LSA and will occur only while access is being established to ST347 Lake, the permanent water source for the Steensby Port. All withdrawals are within thresholds.

Impact Statement for Key Issue 2 - Water Diversion

The Project will not have significant adverse residual effects on water quantity resulting from water diversion. Magnitude threshold will be exceeded in several cases within the Mine Site and Steensby Port LSAs; however in all cases the extent of the effects is minor relative to the applicable LSA. The majority of these diversions do not alter total water quantity; they merely redistribute the water.

Impact Statement for Key Issue 3 - Effluent Discharge

The Project will not have significant adverse residual effects on water quantity resulting from effluent discharge. Magnitude threshold will be exceeded in several cases within the Mine Site LSA; however, in all

cases the extent of the effects is minor relative to the applicable LSA. The majority of these discharges do not alter total water quantity; instead, they redistribute during it.

Impact Statement for Combined Effects of Key Issues 1-3

The Project will not have significant adverse residual effects on Water Quantity resulting from combining the Key Issues of Water Withdrawal, Diversion and Discharge. Magnitude threshold will be exceeded in several cases within the Mine Site LSA. In all cases the relative extent of the effects is minor as they redistribute rather than alter the total quantity.

2.5 AUTHORS

This impact statement was prepared by Kyle Terry, B.Sc., Water Resource Scientist with Knight Piésold Ltd. (KPL), with support from Ryan Stinson (Senior Scientist, KPL) and Richard Cook (Senior Environmental Scientist, KPL). The technical review was provided by Toby Perkins (Senior Engineer, KPL).

SECTION 3.0 - WATER AND SEDIMENT QUALITY

3.1 INTRODUCTION

As defined by the EIS Guidelines developed for the Project, the objective of the baseline study was to provide a description of physical and chemical characteristics of surface water and sediment quality. The objectives of the impact assessment were to identify potential effects on surface water and sediment quality in surrounding lakes and rivers from the following Project components and/or activities:

- Surface runoff and traffic on Project roads
- Discharges of Project wastewater treatment facilities (WWTFs)
- Acid rock drainage (ARD) and meals leaching (ML) resulting from waste rock piles, ore stockpiles, open pit dewatering, construction fills, embankment of roads and railway and open quarries
- Nutrient input from blasting activities and chemical leaching from rail sleeper coatings (non-treated wooden ties will be used)
- Suspended sediment due to construction of Project facilities, Milne Inlet Tote Road, the railway and associated water crossings
- Runoff at fuel storage facilities, including fuel spills and malfunctions
- Waste management activities including storage, handling and landfilling of waste, landfarming of contaminated ice/snow/soil, the management of historically contaminated material and sewage effluent discharges
- Construction and operation of camps
- Erosion and sediment transport due to vegetation removal, cuts/fills and other disturbances
- Dust deposition, and
- Drilling water withdrawals and returns.

The background characteristics and potential effects on surface water and sediment quality and proposed mitigation measures are described in this section. The Project area has a well developed river/stream and lake network, described in Section 1.0 and illustrated in Figure 7-1.1 for which baseline surface water and sediment quality data was obtained.

The baseline investigation was designed and completed to establish a suitable characterization of surface water and sediment quality prior to the Project and to provide a basis for quantitative and qualitative assessment of effects during its duration. The bulk sampling program and associated infrastructure (Milne Inlet Tote road, camp, wastewater treatment and discharge, water abstraction) was being conducted concurrent to the baseline sampling program, so the data do not reflect pre-disturbance conditions. Thus baseline data were relied on to reflect baseline conditions.

The assessment of predicted effects is conducted on the basis that design and mitigation are aimed at avoiding or reducing adverse effects on surface water and sediment quality by meeting applicable criteria outlined in the following legislation and guidance documents:

- Federal *Fisheries Act* and Metal Mining Effluent Regulation (MMER)
- Nunavut Land Claim Agreement, Article 20 Inuit Water Rights
- Nunavut Land Claim Agreement, Article 13 Water Management
- Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic Life
- Health Canada Canadian Drinking Water Guidelines
- CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, and
- Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.

A comprehensive description of the regional freshwater environment is provided in Section 1 and the supporting baseline summary reports (i.e., Appendix 7A – Hydrology; Appendix 7B-1 – Water and Sediment Quality; and Appendix 7C – Freshwater Aquatic Habitat and Fish).

3.1.1 Study Areas

The Freshwater RSA and five LSAs identified for the water and sediment quality assessment are described in Section 1.2 and illustrated on Figures 7-1.1 through 7-1.7.

3.2 BASELINE SUMMARY

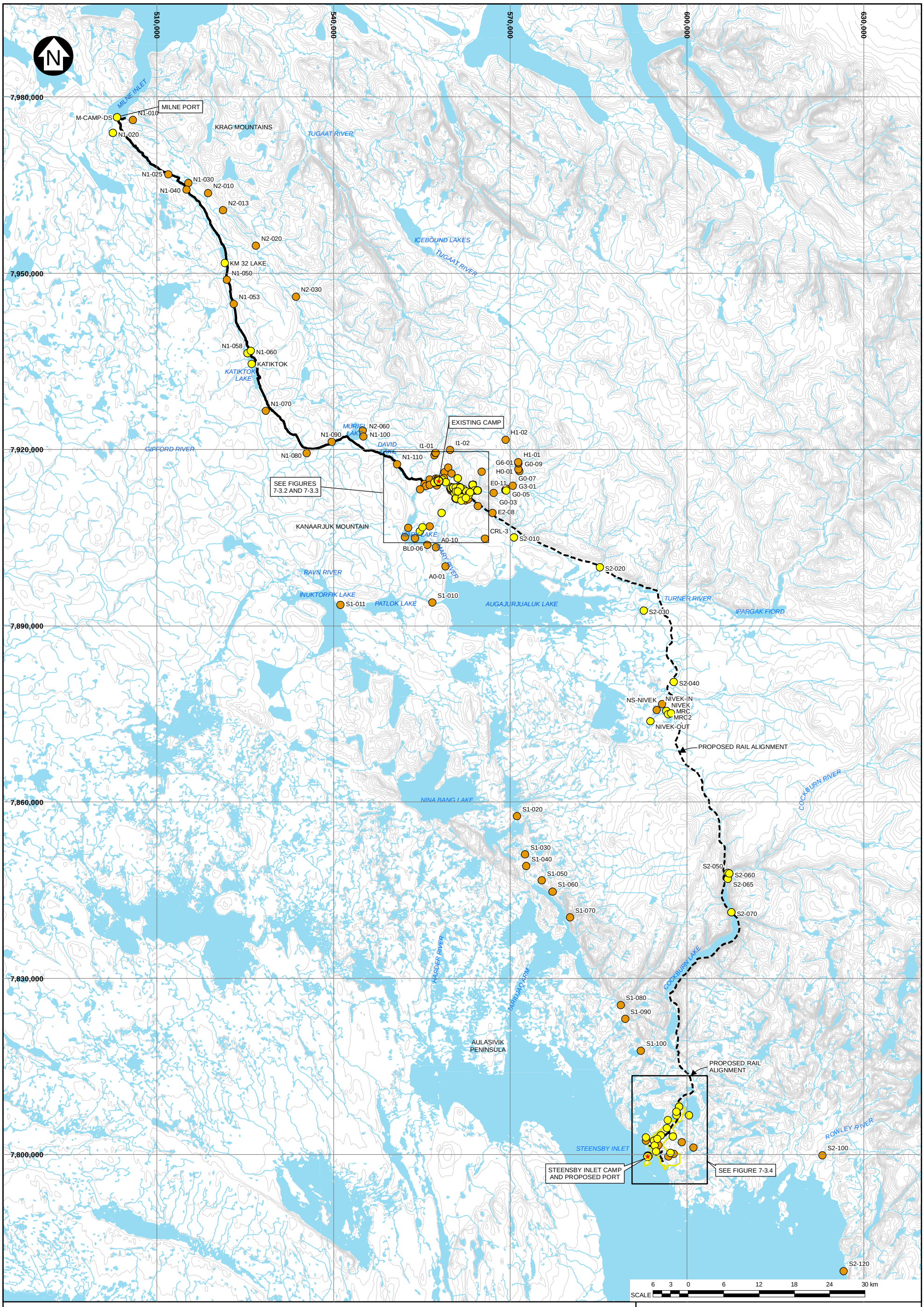
3.2.1 Introduction

The baseline water quality program was carried out over the period of 2005 through 2008 by Knight Piésold as part of a larger aquatic program carried out jointly by Knight Piésold and North/South Consultants Inc. (North/South). The surface water quality program included up to 74 surface water sampling sites distributed throughout the RSA and five LSAs. Three lakes in the vicinity of the Mine Site with the potential to be affected by Project-related components and activities were sampled in 2006 through 2007: Camp Lake, Sheardown Lake and Mary Lake. In 2008, lake water sampling extended to the Steensby Inlet area, the Rail Camp area, and the current railway alignment. A follow-up water and sediment quality monitoring program was carried out in summer 2011 to update the dataset and to obtain water and sediment quality data from candidate long-term water monitoring locations.

Sediment samples were collected from various lake, stream, and river locations within the five freshwater LSAs. The 2005, 2006 and 2011 sampling programs were conducted by Knight Piésold and the 2007 sampling program was conducted by North/South Consultants Inc. The complete water and sediment quality baseline data are provided in the Surface Water and Sediment Baseline Report (Knight Piésold, 2011a, Appendix 7B-1)

3.2.2 Sampling Locations

All surface water and sediment quality sites that were sampled from 2005 up to 2011 are illustrated on Figures 7-3.1 through and 7-3.7. All locations were organized into sampling groups to simplify data analysis, interpretation and reporting. Justification for the selected sample group locations is provided in Table 7-3.1.



LEGEND:

- 2011 WATER QUALITY SAMPLE LOCATION
- HISTORIC WATER QUALITY SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA

NOTES:

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2. COORDINATE GRID IS UTM NAD83 ZONE 17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM AND LAKE WATER QUALITY SAMPLE LOCATIONS IN THE FRESHWATER RSA

Knight Piésold CONSULTING

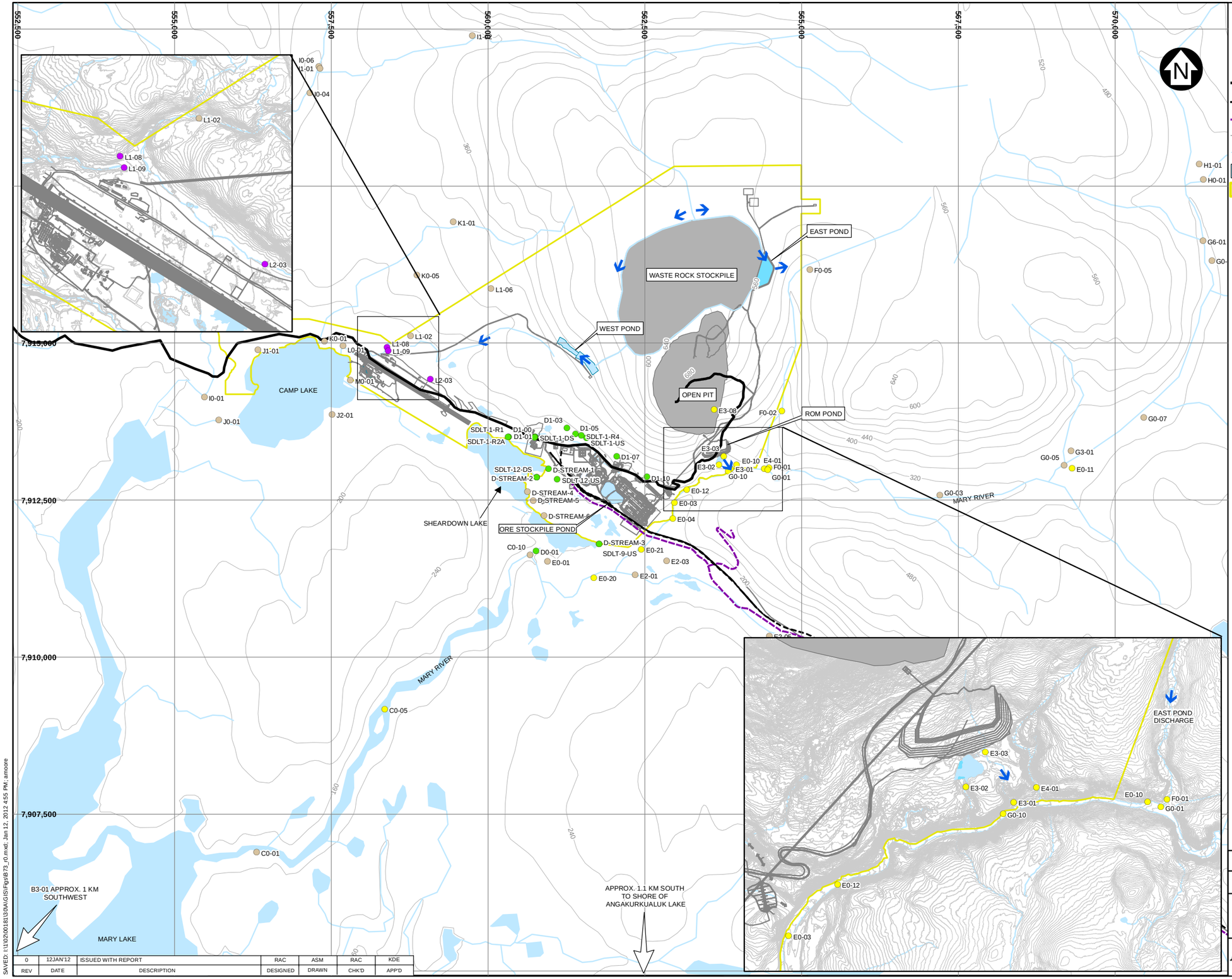
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FIGURE 7-3.1

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LEGEND:

- DOWNSTREAM OF DEPOSITS
- TRIBUTARIES OF SHEARDOWN LAKE
- TRIBUTARIES OF CAMP LAKE
- HISTORIC STREAM WATER SAMPLE LOCATIONS
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)

NOTES:

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3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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

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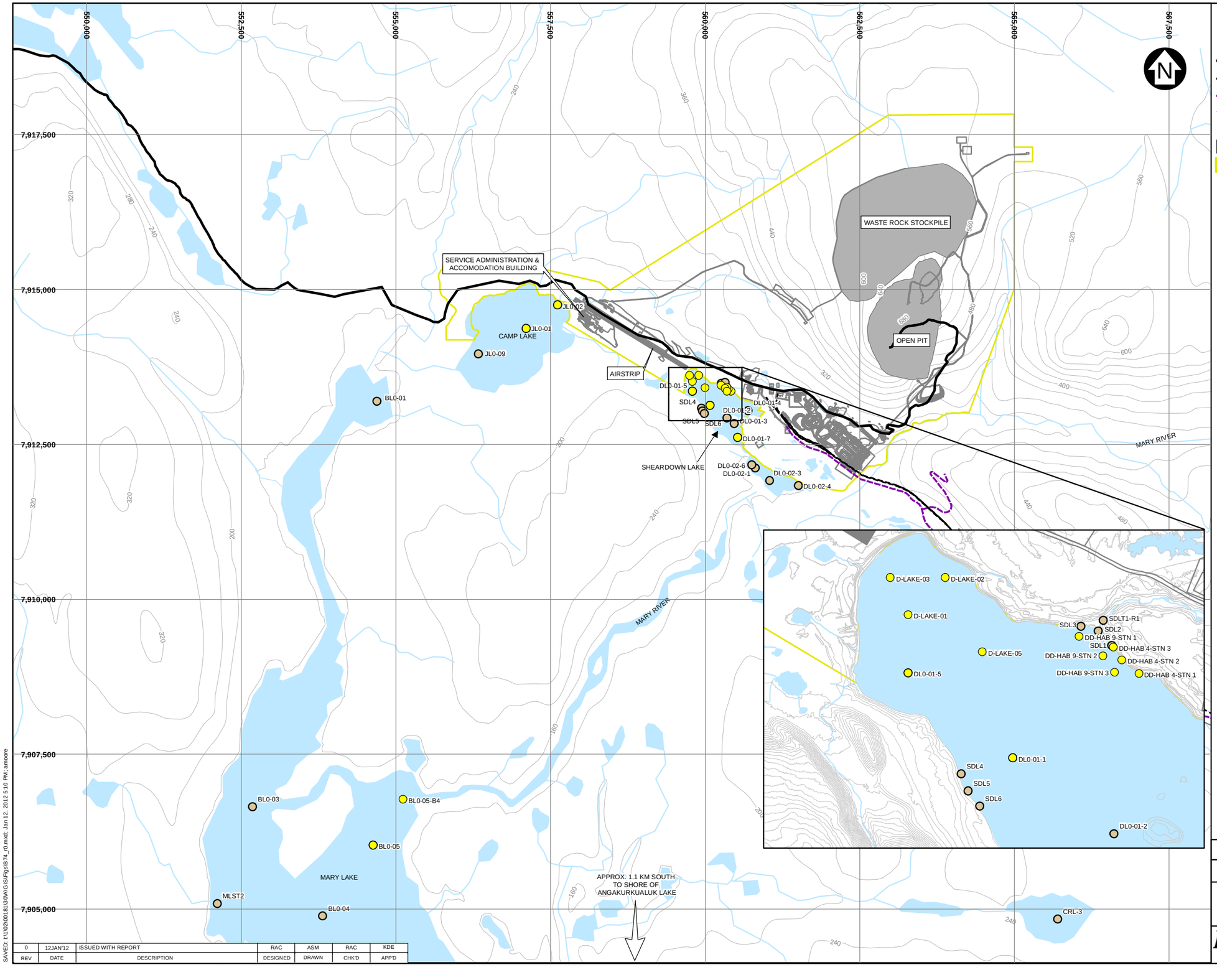
MARY RIVER PROJECT

STREAM WATER QUALITY SAMPLE LOCATIONS MINE SITE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	3

FIGURE 7-3.2 REV 0



LEGEND:

- 2011 WATER QUALITY SAMPLE LOCATION
- HISTORIC WATER QUALITY SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)

NOTES:

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3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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

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MARY RIVER PROJECT

LAKE WATER QUALITY SAMPLE LOCATIONS MINE SITE

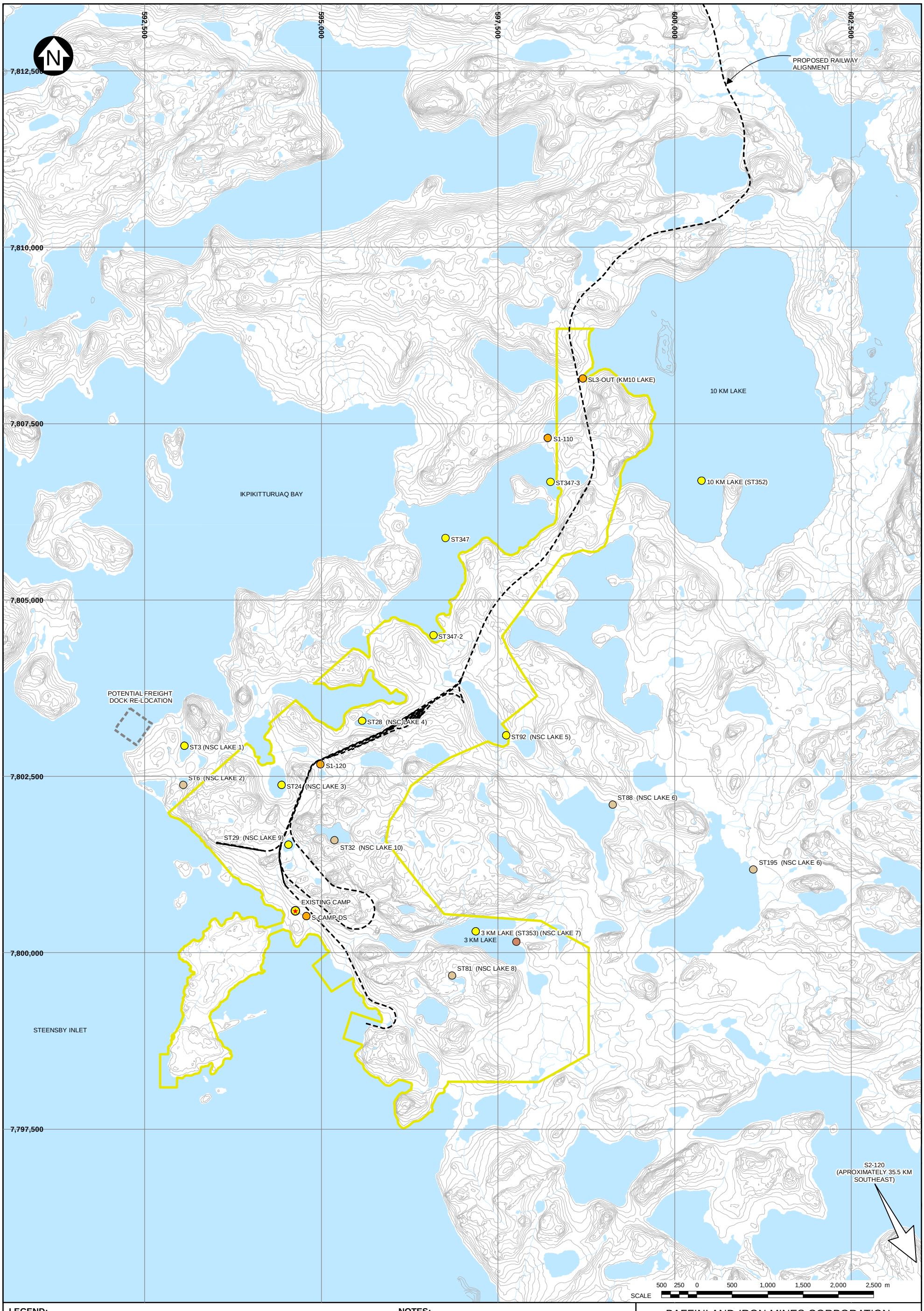
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FIGURE 7-3.3 | REV 0

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LEGEND:

- 2011 LAKE SAMPLE LOCATION
- 2011 STREAM SAMPLE LOCATION
- HISTORIC LAKE SAMPLE LOCATION
- HISTORIC STREAM SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONTOUR
- RIVER/STREAM/DRAINAGE
- POTENTIAL DEVELOPMENT AREA (PDA)
- WATER

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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MARY RIVER PROJECT

STREAM AND LAKE WATER QUALITY SAMPLE LOCATIONS STEENSBY PORT

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FIGURE 7-3.4

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510,000
540,000
570,000
600,000
630,000
7,980,000
7,950,000
7,920,000
7,890,000
7,860,000
7,830,000
7,800,000
N
MILNE INLET
MILNE PORT
KRAG MOUNTAINS
TUGAAT RIVER
ICEBOUND LAKES
TUGAAT RIVER
KATIKTOK LAKE
MURIEL LAKE
DAVID LAKE
GIFFORD RIVER
EXISTING CAMP
SEE FIGURES 7-3.6
G0-09
H0-01
G0-03 SED
KANAARJUK MOUNTAIN
MARY LAKE
MARY RIVER
BL0-06 SED
A0-01 (SED)
RAVN RIVER
INUKTORFIK LAKE
PATLOK LAKE
AUGAJURJUALUK LAKE
TURNER RIVER
IPARGAK FIORD
PROPOSED RAIL ALIGNMENT
COCKBURN RIVER
NINA BANG LAKE
HARDER RIVER
TARIUAQ ARM
COCKBURN LAKE
AULASIVIK PENINSULA
PROPOSED RAIL ALIGNMENT
ROWLEY RIVER
STEENSBY INLET
STEENSBY INLET CAMP AND PROPOSED PORT
SEE FIGURE 7-3.7
6 3 0 6 12 18 24 30 km
SCALE

LEGEND:

- 2011 WATER QUALITY SAMPLE LOCATION
- HISTORIC WATER QUALITY SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA

NOTES:

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4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS IN THE FRESHWATER RSA

Knight Piésold CONSULTING

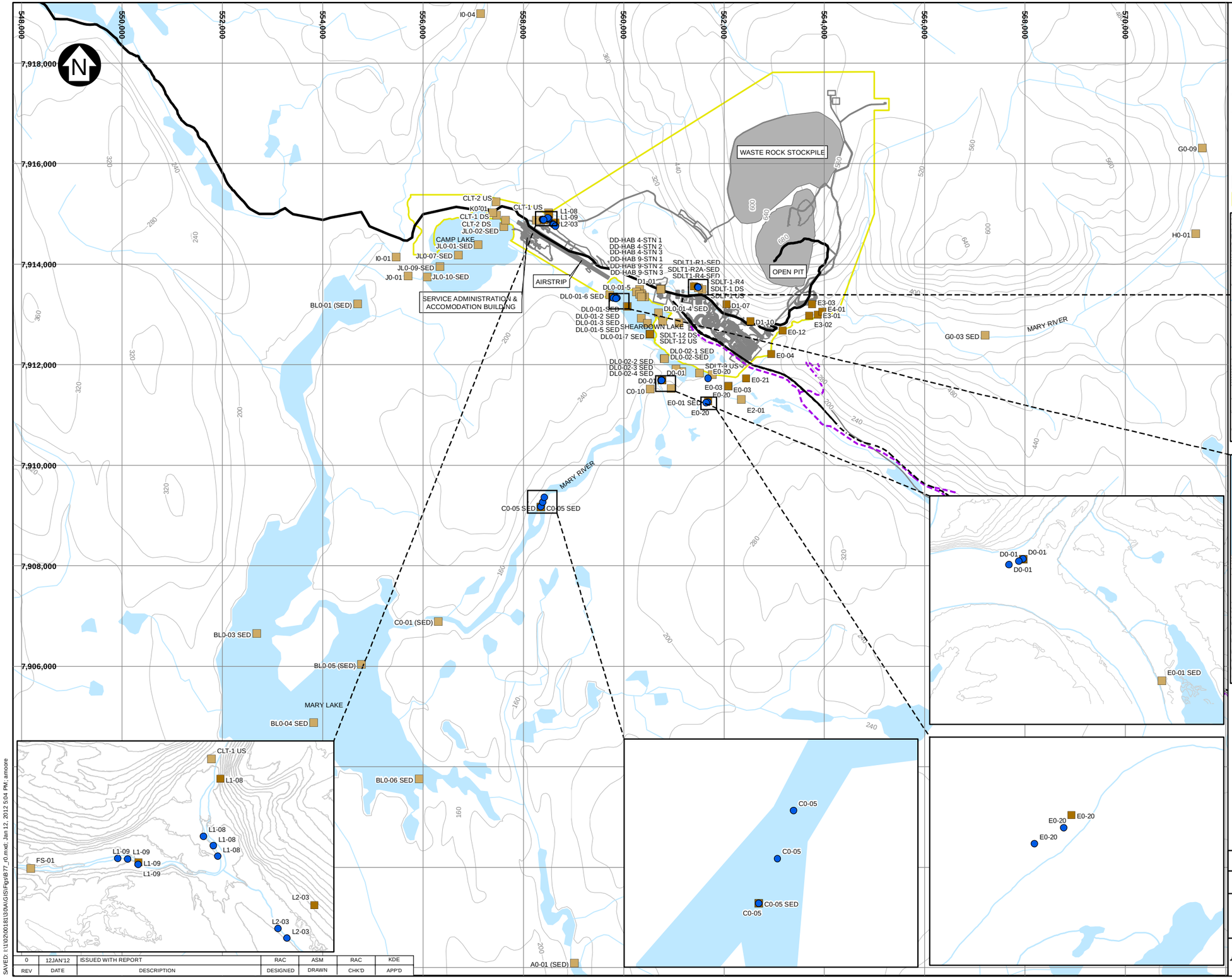
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FIGURE 7-3.5

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LEGEND:

- BENTHIC SITE
- SEDIMENT SAMPLE SITE (2011)
- HISTORIC SEDIMENT SAMPLE SITE
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)

NOTES:

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2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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

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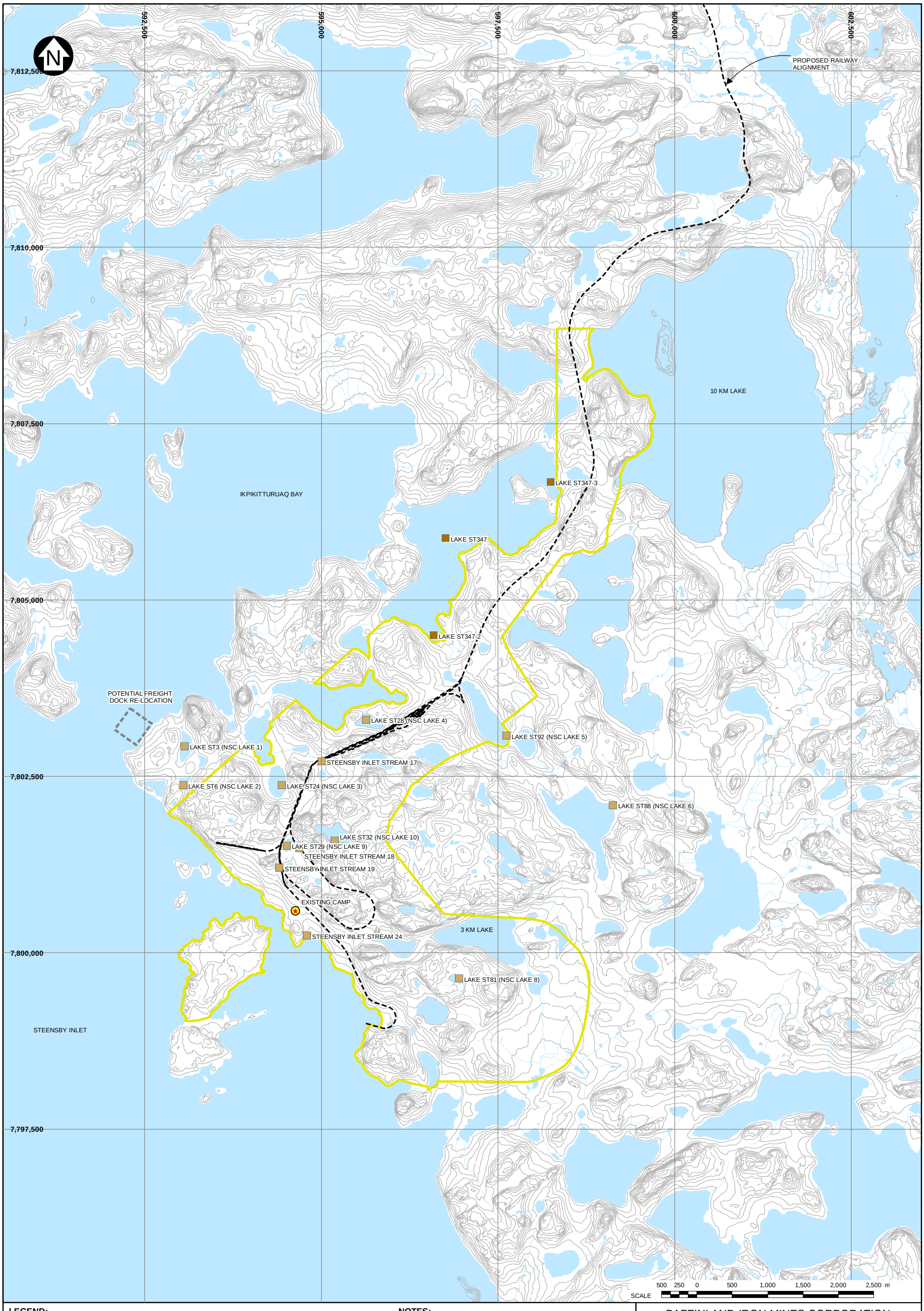
MARY RIVER PROJECT

SEDIMENT AND BENTHIC INVERTEBRATES SAMPLE LOCATIONS MINE SITE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	3

FIGURE 7-3.6 REV 0



LEGEND:

- SEDIMENT SAMPLE LOCATION (2011)
- HISTORIC SEDIMENT SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONTOUR
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.

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MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS STEENSBY PORT

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REF NO. 3

FIGURE 7-3.7

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Table 7-3.1 Water and Sediment Quality Sampling Group Justification

Sample Group (LSA)	Sample Type(s)	Justification
Milne Inlet Area (Milne Port and Milne Inlet Tote Road LSAs)	Surface Water	Downstream receiving environment for Project components/activities associated with Milne Port and Milne Inlet Tote Road.
Upstream of Deposits (Mine Site LSA)	Surface Water Sediment	Upstream environment for Project components/activities associated with the Mine Site and Railway Alignment.
Downstream of Deposits (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site and Railway Alignment.
Drainages off Deposits (Mine Site LSA)	Surface Water	Downstream receiving environment for Project components/activities associated with the Mine Site.
Tom River Area (Mine Site LSA)	Surface Water Sediment	Upstream environment for Project components/activities associated with Milne Inlet Tote Road and Mine Site.
Tributaries of Sheardown Lake (Mine Site LSA)	Surface Water Sediment	Upstream environment for Project components/activities associated with the Mine Site and Railway Alignment.
Sheardown Lake N.W. (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site and Railway Alignment.
Sheardown Lake S.E. (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site and Railway Alignment.
Tributaries of Camp Lake (Mine Site LSA)	Surface Water Sediment	Upstream environment for Project components/activities associated with the Mine Site and Milne Inlet Tote Road.
Camp Lake (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site and Milne Inlet Tote Road.
Background Tributary to Mary River (Mine Site LSA)	Surface Water Sediment	Upstream environment for Project components/activities associated with the Mine Site, Railway Alignment, and Milne Inlet Tote Road.
Mary Lake (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site, Railway Alignment, and Milne Inlet Tote Road.
Mary River Downstream of Mary Lake (Mine Site LSA)	Surface Water Sediment	Downstream receiving environment for Project components/activities associated with the Mine Site, Railway Alignment, and Milne Inlet Tote Road.
Ravn River Upstream of Angajurjualuk Lake (Mine Site LSA)	Surface Water	Downstream receiving environment for Project components/activities associated with the Mine Site, Railway Alignment, and Milne Inlet Tote Road.
Cockburn Area (Railway Alignment LSA)	Surface Water	Downstream receiving environment for Project components/activities associated with the Mine Site, Railway Alignment, and Milne Inlet Tote Road.
Rowley River (Railway Alignment LSA)	Surface Water	Upstream environment for Project components/activities associated with the Railway Alignment.
Steensby Port Area (Steensby Port LSA)	Surface Water	Downstream receiving environment for Project components/activities associated with Steensby Port and Railway Alignment.

3.2.3 Sampling Methodology

3.2.3.1 Water Quality

Water quality sampling methods are described in the water and sediment quality report (Appendix 7B-1). Sampling of watercourses and lakes was undertaken in spring (June), summer (mid-July to mid-August) and fall (late August to mid-September). Winter sampling was carried out only on lakes in late winter (May), as rivers in the Project area are frozen solid. A summary of surface water sampling areas and years of investigation are provided in Table 7-3.2.

Table 7-3.2 Surface Water Sampling Programs by Year

Year	General Sampling Areas
2005	Mine Site LSA Milne Inlet Tote Road LSA Railway Alignment LSA
2006	Mine Site LSA Milne Inlet Tote Road LSA Railway Alignment LSA
2007	Mine Site LSA Railway Alignment LSA
2008	Mine Site LSA Railway Alignment LSA Steensby Port LSA Milne Port LSA
2011	Mine Site LSA – including future MMER monitoring locations Railway Alignment LSA Steensby Port LSA Milne Port LSA

A detailed description of surface water sampling methods and specific sampling locations and timing are provided in the baseline report (Appendix 7B-1).

3.2.3.2 Sediment

Sediment sampling was conducted following generally accepted methodologies. Ten sediment samples were collected from each sampling location in August 2005. Six sediment samples were collected in 2006 from new locations that were chosen as candidate monitoring sites in accordance with anticipated MMER requirements. On the Mary River, site G0-09 is located upstream of Deposits No. 1, 2, and 3; site C0-10 is located immediately downstream of the deposits and the proposed facilities. These locations are paired with reference locations on the Tom River, where I0-04 is the upstream reference location and I0-01 is the downstream reference location. Two sampling locations were selected in Mary Lake to characterize the depositional habitat.

Three lake locations were sampled in May 2007 and 39 lake, river and stream locations were sampled in August and September 2007. Several were the same locations sampled in 2005 or 2006, providing a baseline characterization of sediment quality through the seasons over consecutive years. A summary sediment sampling areas and years of investigation are provided in Table 7-3.3.

Table 7-3.3 Sediment Sampling Programs by Year

Year	Sediment Samples Collected
2005	10 (at each river/stream location in Mine Site LSA, Milne Inlet Tote Road LSA and Railway Alignment LSA)
2006	6 (at each river/stream location in Mine Site LSA, Milne Inlet Tote Road LSA and Railway Alignment LSA)
2007	3 (at each lake location - 5/07) 39 (at each lake, river/stream location in Mine Site LSA and Railway Alignment LSA)
2011	17 stream locations within the Mine Site 6 lake samples (3 in Sheardown Lake and 3 in ST-347)

A detailed description of sediment sampling methodologies, locations and timing is provided in Tables 2-1 through 2-5 of the Surface Water and Sediment Quality Baseline Report included in Appendix 7B-1 of this volume.

3.2.4 Results

3.2.4.1 Water Quality

The water quality data collected to date for river/stream and lake water sampling sites are summarized in Tables 3-1 to 3-3 in Appendix 7B-1, respectively.

Rivers

In general, surface water quality measured in rivers and streams throughout the study area was nutrient-poor, with low conductivity and anion concentrations (Tables 3-1 and 3-2, Appendix 7B-1). Turbidity was generally low, but observed to be naturally elevated in some areas based on inputs from adjacent landforms, snow-melt, and precipitation. Metal concentrations were also generally low, with the exception of total aluminum, iron, and copper concentrations, which had levels greater than the applicable CCME guidelines. These exceedances are discussed in further detail in the following paragraphs, but in all cases the mean concentration of the analyzed metals over the course of the baseline sampling program was within the applicable CCME guideline value.

Total aluminum concentrations have exceeded the CCME guideline on several occasions at the Mine Site as well as in the Ravn River and Cockburn areas. Total aluminum concentrations exceeded the CCME guideline at all of the general locations listed in Table 3-3 in Appendix 7B-1, and ranged from 0.0013 to 2.97 milligrams per litre (mg/L) with the mean concentration for the Mary River Site between 2005 and 2007 being 0.0724 mg/L, which is within the guideline (0.1 mg/L as determined by pH). The mean aluminum concentration for sites in the Ravn River and Cockburn areas (0.0495 mg/L) was also within the CCME guideline value.

At the Mine Site, total copper concentrations above the CCME guideline of 0.002 - 0.004 mg/L (guideline is dependent on water hardness) occurred in Mary River downstream of Mary Lake, in the tributaries of Sheardown Lake, downstream of the deposits, drainages off Deposit No. 1, and in a tributary of Camp Lake. Measured total copper concentrations between 2005 and 2007 ranged from 0.00042 to 0.00310 mg/L, with a mean concentration of 0.0012 mg/L, all within the CCME guideline of 0.002 mg/L. Considering the relative hardness of the water, the potential copper toxicity is likely to be reduced.

Total iron concentrations greater than the CCME guideline of 0.3 mg/L occurred in a tributary of Sheardown Lake, downstream of the deposits, drainages off Deposit No. 1, upstream of the deposits, and in Mary River downstream of Mary Lake. Between 2005 and 2007, the measured total iron concentrations ranged from <0.02 (below method detection limits) to 2.96 mg/L, with a mean concentration of 0.0871 mg/L, which is within the CCME guideline value of 0.3 mg/L.

Between 2005 and 2007 nine other parameters (lead, silver, dissolved oxygen, phenols, pH, cadmium, arsenic, selenium and zinc) have all shown a minimum of one exceedance of the applicable CCME guideline values within Mary River, and for pH in the Cockburn area. These concentrations reflect natural fluctuations, based on the mineralogy of the ore body (Volume 6, Section 2.1.3).

To assess the general characteristics of mean surface water quality and relative sensitivity in each individual rivers/streams or group of rivers/streams, the descriptors included in Table 7-3.4 were applied:

Table 7-3.4 Qualitative Characterization of River Systems

General Characteristic	Parameter
pH Scale	pH
Acidic	< 6
Neutral	6 - 8
Basic	> 8
Hardness Scale[1]	Calcium Carbonate (mg/L)
Very Soft	<30
Soft	31-60
Moderately Soft	61-120
Hard	121-180
Very Hard	>180
Acid Sensitivity Scale[2]	Alkalinity (CaCO3 in mg/L)
Acidic	<0
Highly Sensitive	0-2.5
Sensitive	2.6-10
Not Sensitive	>10
Nutrient Scale[3]	Total Phosphorous (mg/L)
Very Nutrient Poor (VNP)	<0.004
Nutrient Poor (NP)	0.004-0.01
Moderate Nutrients (MN)	0.01 - 0.02
High Nutrients (HN)	0.02 - 0.035
Nutrient Rich (NR)	0.035 - 0.1
Very Nutrient Rich (VNR)	>0.1

NOTE(S):
1. DERIVED FROM MCNEELY *et al.* (1979).
2. DERIVED FROM BOWARD *et al.* (1999).
3. DERIVED FROM ENVIRONMENT CANADA (2004).

Table 7-3.5 presents a summary of general mean surface water characteristics important to the prediction of potential effects for each of the rivers/streams.

Table 7-3.5 Characterization of River Systems in the Project Area

Sample Group	Hardness	Acid Sensitivity	Nutrient Level[1]	pH
Upstream of Deposits	Soft	Not Sensitive	Nutrient Poor	Basic
Downstream of Deposits	Very Hard	Not Sensitive	Nutrient Poor	Basic
Drainages off Deposits	Hard	Not Sensitive	Nutrient Poor	Neutral
Tom River Area	Moderately Soft	Not Sensitive	Nutrient Poor	Basic
Tributaries of Sheardown Lake	Moderately Soft	Not Sensitive	Nutrient Poor	Basic
Tributaries of Camp Lake	Moderately Soft	Not Sensitive	Very Nutrient Poor	Basic
Background Tributary to Mary River	Soft	Not Sensitive	Nutrient Poor	Basic
Mary River Downstream of Mary Lake	Soft	Not Sensitive	Nutrient Poor	Basic
Ravn River Upstream of Angajurjualuk Lake	Very Soft	Not Sensitive	Nutrient Poor	Neutral
Cockburn Area	Very Soft	Highly Sensitive	Nutrient Poor	Neutral
Rowley River	Very Soft	Sensitive	Nutrient Poor	Basic

NOTE(S):
REFLECTS MEAN TOTAL PHOSPHOROUS CONCENTRATION DURING 2008 SAMPLING EVENTS.

Lakes

Lakes in the study area are relatively shallow (mean depths of 7.38 to 12.45 m) and experience long periods of ice cover (approximately 10 months/year). They are generally near-neutral to slightly alkaline, soft to moderately soft (hardness less than or slightly above 60 mg/L as calcium carbonate), relatively dilute (low conductivity/total dissolved solids), and relatively nutrient-poor (low phosphorus and nitrogen). Metal concentrations are relatively low in the lake waters, although some metals concentrations were greater than the CCME guidelines at some sites and times in 2007 (cadmium) and 2006 (aluminum). Details of the cadmium and aluminum exceedances are provided in Appendix 7B-1.

To assess the general characteristics of mean surface water quality and relative sensitivity in each individual lake, the descriptors included in Table 7-3.4 were applied, with the exception of the following lake-related criteria included in Table 7-3.6:

Table 7-3.6 Qualitative Characterization of Lake Systems

General Characteristic	Parameter
Acid Sensitivity[1]	**Alkalinity ($CaCO_3$ in mg/L)**
High	0 - 10
Moderate	10 - 20
Low	20 - 40
Nil	>40
Productivity Scale[2]	**Chlorophyll α (µg/L)**
Low Productivity	<2.5
Low to Moderate Productivity	2.5 - 8
Moderate Productivity	8 - 25
Moderate to High	26 - 75
High	> 75

NOTE(S):
1. DERIVED FROM SAFFRAN AND TREW (1996).
2. DERIVED FROM ENVIRONMENT CANADA (2004).

A summary of general mean surface water characteristics (based on the descriptors included in Table 7-3.4 and 7-3.6) that are important with respect to prediction of potential Project-related effects for each of the lakes are provided in Table 7-3.7.

Table 7-3.7 Characterization of Lake Systems in the Project Area

Sample Group	Hardness	Acid Sensitivity	Nutrient Level[1]	Productivity	pH
Sheardown Lake N.W.	Soft	Least	Nutrient Poor	Low Productivity	Basic
Sheardown Lake S.E.	Soft	Least	Nutrient Poor	Low Productivity	Neutral
Camp Lake	Soft	Least	Nutrient Poor	Low Productivity	Neutral
Mary Lake	Soft	Least	Nutrient Poor	Low Productivity	Basic

NOTE(S):
REFLECTS MEAN TOTAL PHOSPHOROUS CONCENTRATION DURING 2008 SAMPLING EVENTS.

3.2.4.2 Sediment Quality

The results of the baseline sediment quality study are summarized in Table 3.5 in Appendix 7B-1. Sampling locations have been grouped according to location and summary data.

Sampling locations are identified by group in Figures 7-3.6 and 7-3.7. To assist in analysis of the data, parameters that were below method detection limits (not detected) were assigned the analytical detection limit applicable for that analysis. The detection limits were not always the same, depending on the year and the laboratory that conducted the analysis. This method of data analysis is a highly conservative approach that overestimates analyte concentrations, which are either not present in the sample or are present in concentrations below the method detection limit.

River Sediment

Chromium concentrations (mean and/or maximum values) were greater than the CCME Interim Sediment Quality Guidelines (ISQG) downstream of the deposits, in the Mary River downstream of Mary Lake, and in the tributaries of Sheardown Lake and Camp Lake. Additionally, chromium concentrations were greater than the CCME Probable Effects Limit (PEL) downstream of the deposits and in the Mary River downstream of Mary Lake. All other concentrations in river sediments were within the CCME ISQG.

Cadmium and copper concentrations (maximum values) were greater than the CCME ISQG in the sediments of the tributaries of Camp Lake. All other cadmium and copper concentrations (mean and/or maximum values) in river sediments were within the CCME ISQG.

Iron concentrations (maximum values) were greater than the Ontario Sediment Quality Guidelines Lowest Effect Level (LEL) in the sediments upstream of the deposits, downstream of the deposits, and in the tributaries of Camp Lake. The greatest mean iron concentration was in Mary River downstream of the deposits, indicating that elevated iron concentrations are a naturally occurring phenomena downgradient of the Mary River ore bodies. All other iron concentrations (mean and/or maximum values) in river sediments were within the Ontario LEL.

Nickel concentrations (mean and/or maximum values) were greater than the Ontario LEL downstream of the deposits, in Mary River downstream of Mary Lake, in the tributaries of Sheardown Lake, and in the tributaries of Camp Lake. All other concentrations in river sediments were within the Ontario LEL.

None of the concentrations of analyzed parameters in either the Tom River or in the tributary to Mary River were greater than the applicable guidelines. Nitrite, mercury, silver, bismuth and thallium concentrations were not detected in samples collected from any of the sampling locations, and the concentrations of all other analyzed metals were within the applicable guidelines.

In terms of nutrients, only the Total Kjeldahl Nitrogen (TKN) concentration in the tributaries to Sheardown Lake was greater than the Ontario LEL. All other TKN and total organic carbon (TOC) concentrations in river sediments were within the applicable guidelines.

The concentrations of many parameters, including copper, iron, total phosphorous, manganese and sodium, were generally lower in river sediments than in lake sediments.

Lake Sediment

The sediments of Mary Lake, Camp Lake, Sheardown Lake NW and Sheardown Lake SE are characterized by high concentrations of iron, chromium, copper, manganese, nickel, total phosphorus, TKN and TOC; however, the concentrations generally appear to be lower in Sheardown Lake SE.

The majority of chromium concentrations (mean and/or maximum values) in all four lakes were greater than the CCME ISQG, and maximum chromium concentrations in Mary Lake and Sheardown Lake NW that were greater than the CCME PEL. All other concentrations in lake sediments were within the CCME ISQG.

Copper concentrations (mean and/or maximum values) were greater than the CCME ISQG in Mary Lake, Camp Lake and Sheardown Lake NW. All other copper concentrations in lake sediments were within the CCME ISQG.

Iron concentrations (mean and/or maximum values) in lake sediment exceeded the Ontario LEL, and maximum iron concentrations in Mary Lake, Camp Lake, and Sheardown Lake NW were greater than the Ontario Severe Effects Level (SEL).

Manganese concentrations (mean and/or maximum values) were greater than the Ontario SEL in sediment samples from Mary Lake and Sheardown Lake NW, while manganese concentrations in Camp Lake and Sheardown Lake SE were greater than the Ontario LEL.

The nickel concentrations (mean and/or maximum values) in all samples were greater than the Ontario LEL; the maximum concentration in Sheardown Lake NW was greater. Similarly, the total phosphorous concentrations in all samples were greater than the Ontario LEL, except for minimum concentrations in Mary Lake and Camp Lake, where total phosphorus was not detected.

The majority of TKN concentrations (mean and/or maximum values) in sediment samples were greater than the Ontario LEL and at least one TOC concentration in sediment samples from each lake was greater than the Ontario LEL. Nitrite, mercury, silver, cadmium, antimony and thallium concentrations were not detected in any of the lake sediment samples.

The concentrations of all other analyzed metals in lake sediments were within the applicable guidelines.

As a general observation, the concentrations of contaminants in lake sediments are higher than in river sediment, indicating that the lake sediment is acting as a sink for contaminants as they move with the water and sediment through the aquatic systems.

3.3 ISSUE SCOPING

3.3.1 Scoping Completed

Scoping activities completed by the Project team involved the following:

- Literature review (baseline conditions) - literature relating to the Regional Study Area was identified and reviewed.
- Site visits by Project personnel to collect surface water and sediment samples from established sampling locations.
- Consultation with the communities of Arctic Bay, Clyde River, Hall Beach, Igloolik and Pond Inlet (listed in alphabetical order), as described in Volume 2, Section 1.0.
- Inuit knowledge studies carried out in the same communities listed above.
- Regulatory requirements involving water and sediment quality.
- Review of previous EIS developed for comparable projects in Nunavut and the far north.
- A Mary River Project team scoping meeting held in November 2007.

These activities contributed to the identification of Valued Ecosystem Components (VECs) described below.

3.3.2 Valued Ecosystem Components

VECs are identified on the basis of either legal or formal recognition of ecological or social importance, as described in the Impact Assessment Methodology (Volume 2, Section 3.0). Legal recognition of the importance of water and concern regarding potential effects on water quality is included in Article 20 Inuit Water Rights of the Nunavut Land Claims Agreement (NLCA), under which Inuit have special water rights; if a project or activity will substantially affect the quality of water through Inuit-Owned Lands, compensation is required. Therefore, "water quality" has been identified as a VEC for this EIS. The water component of "water quality" refers to surface water (rivers, streams, lakes) and groundwater; however, groundwater quality is generally not considered to be at risk in the Project area because the extensive permafrost layer acts as an impermeable barrier eliminating/limiting potential migration of contaminants into the groundwater located below.

Sediment quality is also an essential component of the aquatic environment with the potential to affect the food chain, fish and fish habitat, and local residents. Project-related effects on sediment quality were primarily assessed qualitatively in this EIS due to limited data availability, limited information on hydrodynamics, hydraulics, transport and conversion of potential contaminants, and limitations in accurately predicting future effects on sediment quality. In most instances, effects on sediment quality were assessed using surface water quality VEC as a proxy. Residual effects on water quality were considered likely to induce a similar residual effect on sediment quality.

3.3.3 Subjects of Note

No subjects of note were identified for the water and sediment quality VEC.

3.4 WATER AND SEDIMENT QUALITY

Effects on the surface water and sediment quality VEC were assessed in accordance with the methodology outlined in Volume 2, Section 3.0. VEC-specific modifications were made to the general methodology, which are highlighted below.

3.4.1 Assessment Methods and Criteria

The following basic EA steps were undertaken during the assessment;

- Regional and local study areas were determined;
- VECs, Key Indicators and Thresholds were identified;
- Project activities that could affect surface water and sediment quality were identified;
- Project interactions with, and effects on, the surface water and sediment quality VEC were identified;
- Linkage evaluations were performed outlining potential effects related to various phases of the Project (Construction, Operation, and Closure) and Project LSAs (Milne Port, Milne Inlet Tote Road, Mine Site, Railway Alignment, and Steensby Port;
- Mitigation measures were identified to avoid or reduce the potential effects during the various phases of the Project;
- Residual effects and their relative significance were identified for the surface water and sediment quality VECs; and
- Long-term monitoring programs were identified to distinguish Project-related impacts from natural variability, in order to verify impact assessment predictions and to meet compliance/conformance criteria.

3.4.1.1 Key Indicators and Thresholds

For the assessment of potential effects on the surface water and sediment quality VEC a list of key indicators that were considered to be the most relevant and important elements of the VEC was assembled. The key indicators fall into four categories:

1) General Parameters;
2) Metals;
3) Nutrients; and
4) Petroleum Hydrocarbons.

Thresholds were identified representing a level of change where adverse effects may be expected to occur. In the case of water and sediment quality, it is important to note that the thresholds do not relate to water or sediment quality in itself, but rather to known effects on aquatic receptors that rely on water and sediment to exist.

The thresholds used in this assessment were derived from the following sources, which are relevant in the context of this environmental effects assessment:

- Schedule 4 of the Metal Mining Effluent Regulation under the Federal *Fisheries Act*;
- CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life (PAL) (2003); and
- Interim Sediment Quality Guidelines (ISQG) and Probable Effects Level (PEL) identified in the CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (2003).

The CCME PAL thresholds are typically the most stringent; hence these values were generally selected for application.

Local waters around the Project sites have not historically been used for drinking, although the Project uses and will use local waters for potable water supply, and it is conceivable that Inuit travelling over the land

could also drink any of the local water. Therefore, Health Canada's Canadian Drinking Water Guidelines (2004) have been used for comparison purposes.

To fill gaps for those key indicators that have no thresholds identified in the sources listed above, two secondary sources were adopted:

- BC Ministry of Environment (MOE) Approved and Working Water Quality Guidelines and Alert Levels; and
- Criteria Continuous Concentration (Chronic) National Recommended Water Quality Criteria, USEPA (2006).

The relationships between potential surface water and sediment quality effects, key indicators and thresholds are summarized in Table 7-3.8.

Table 7-3.8 Key Indicators and Thresholds for Water and Sediment Quality

Potential Effect	Key Indicator	Thresholds (Magnitude and Extent)			
		MMER[1]	CWQG (PAL)[2]	CDWQG[3]	NWB[4]
Water Quality from Mine Contact Water and Site Runoff	TSS (mg/L)	15	+5		35
	pH (pH unit)	6.0 - 9.5	6.5 - 9.0	6.5 - 8.5[11]	6.0 - 9.5
	Hardness $CaCO_3$ (mg/L)				
	Alkalinity $CaCO_3$ (mg/L)				
	Chloride (mg/L)		640 (Short-term) 120 (Long-term)	250[12]	
	Sulphate SO4 (mg/L)			500[12]	
	Ammonia N (total) (mg/L)		Varies[5]		
	Ammonia N (un-ionized) (mg/L)		0.019		
	Nitrate N (mg/L)		13	10	
	Nitrite N (mg/L)		0.06	3.2	
	Total P (mg/L)		see Table 7-3.4		
	Total Aluminum (mg/L)		0.005 - 0.1[6] (0.94)[7]	0.1	
	Total Antimony (mg/L)			0.006	
	Total Arsenic (mg/L)	0.5	0.005	0.01	
	Total Barium (mg/L)			1	
	Total Beryllium (mg/L)		0.0053[8]		
	Total Boron (mg/L)		29 (Short-term) 1.50 (Long-term)		
	Total Cadmium (mg/L)		0.000029[8]	0.005	
	Total Chromium (mg/L)		0.0047[7]	0.05	
	Trivalent Chromium (mg/L)		0.001		
	Hexavalent Chromium (mg/L)		0.0089		
	Total Cobalt (mg/L)				
	Total Copper (mg/L)	0.3	0.00467[7]	1.0[12]	
	Total Cyanide (mg/L)	1.0	0.005 (as free CN)	0.2	
	Total Iron (mg/L)		1.2[7]	0.3[12]	
	Total Lead (mg/L)	0.2	0.001[9]	0.01	
	Total Manganese (mg/L)			0.05[12]	

Table 7-3.8 Key Indicators and Thresholds for Water and Sediment Quality (Cont'd)

Potential Effect	Key Indicator	Thresholds (Magnitude and Extent)			
		MMER[1]	CWQG (PAL)[2]	CDWQG[3]	NWB[4]
	Total Mercury (mg/L)		0.000026	0.001	
	Total Molybdenum (mg/L)		0.073		
	Total Nickel (mg/L)	0.5	0.083[10]		
	Total Selenium (mg/L)		0.001	0.01	
	Total Silver (mg/L)		0.0001		
	Total Thallium (mg/L)		0.0008		
	Total Uranium (mg/L)		0.015	0.02	
	Total Vanadium (mg/L)		0.006[11]		
	Total Zinc (mg/L)	0.5	0.03	5.0	
	1-2 Propylene Glycol		500 (interim)		
Water Quality from Fuel Contact	Benzene (µg/L)		370		
	Toluene (µg/L)		2		
	Ethyl benzene (µg/L)		90		
	Lead (µg/L)		1		
	Oil and Grease (µg/L)		15,000		
Water Quality from Discharge of Sewage	BOD_5 (mg/L)				30
	Fecal Coliform (CFU/100mL)				1,000
Potential Effect	**Key Indicator**	**Thresholds (Magnitude and Extent)**			
		ISQG[14]	**PEL[14]**		
Sediment Quality	Arsenic (mg/kg)	5.9	17		
	Cadmium (mg/kg)	0.6	3.5		
	Chromium (mg/kg)	37.3	90		
	Copper (mg/kg)	35.7	197		
	Lead (mg/kg)	35.0	91.3		
	Mercury (mg/kg)	1.7	4.86		
	Zinc (mg/kg)	123	315		

NOTE(S):

1. MEAN MONTHLY MAXIMUM AVERAGES IN SCHEDULE 4 OF THE METAL MINING EFFLUENT REGULATION UNDER THE FEDERAL *FISHERIES ACT*.
2. CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE (PAL) (2011).
3. HEALTH CANADA GUIDELINES FOR CANADIAN DRINKING WATER QUALITY SUMMARY TABLE (2010).
4. NUNAVUT WATER BOARD WASTEWATER CRITERIA.
5. VARIES WITH TEMPERATURE AND PH.
6. VARIES WITH PH; AT PH <6.5 CRITERION IS 0.005 MG/L; AT PH >6.5 CRITERION IS 0.1 MG/L.
7. SITE SPECIFIC CRITERION DEVELOPED FOR THE MARY RIVER MINE SITE AREA (KNIGHT PIÉSOLD, 2011B)
8. VARIES WITH HARDNESS [Cd] = $10^{0.86[\log10(\text{hardness})]-3.2}$ *µg/L*. BASED ON MEAN HARDNESS IN MARY RIVER OF 84 MG/L, THE CADMIUM CRITERION WOULD BE 0.000029 MG/L.
9. VARIES WITH WITH HARDNESS. [Pb] = $e^{1.273[\ln(\text{hardness})]-4.705}$ *µg/L*. BASED ON MEAN HARDNESS IN MARY RIVER OF 84 MG/L, THE LEAD CRITERION WOULD BE 0.00255 MG/L.
10. VARIES WITH WITH HARDNESS. [Ni] = $e^{1.273[\ln(\text{hardness})]-4.705}$ *µg/L*. BASED ON MEAN HARDNESS IN MARY RIVER OF 84 MG/L, THE NICKEL CRITERION WOULD BE 0.083 MG/L.
11. BC MOE APPROVED AND WORKING WATER QUALITY GUIDELINES.
12. AESTHETIC OBJECTIVE.
13. PROPOSED GUIDELINE.
14. INTERIM SEDIMENT QUALITY GUIDELINES (ISQG) AND PROBABLE EFFECTS LEVEL (PEL) IDENTIFIED IN THE CCME CANADIAN SEDIMENT QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE (2003).

The thresholds identified in Table 7-3.8 were applied in the effects assessment in the following manner:

- MMER Schedule 4 thresholds were applied as 'end of pipe' criteria for mine contact water discharge;
- CCME PAL (or site-specific water quality objectives) were applied as receiving environment criteria for all sources; and
- NWB were applied as 'end of pipe' criteria for wastewater (sewage effluent) discharge.

A number of key parameters are naturally elevated in surface waters around the Mine Site, and as such, site specific water quality objectives (SSWQOs) were developed for the following parameters using CCME (1993) background concentration procedure (Knight Piésold, 2011b; Appendix 7B-2):

- Aluminum;
- Chromium;
- Copper; and
- Iron.

The developed SSWQOs are summarized in Table 7-3.8 (as per note 7) above. It was not appropriate to develop site specific criteria for Uranium or Selenium as explained in Appendix 7B-2.

3.4.1.2 Key Issues and Pathways

Key issues which were assessed for the surface water and sediment quality VEC included:

1. Pit water quality from the Mine Site LSA;
2. Surface runoff from Project roads in the five freshwater LSAs;
3. Discharges from Project WWTFs from the five freshwater LSAs;
4. Acid Rock Drainage (ARD) and Metal Leaching (ML) resulting from waste rock piles, ore stockpiles, open pit dewatering, construction fills, embankment of roads and railway, and open quarries in the five freshwater LSAs;
5. Nutrient input from blasting activities and chemical leaching from rail sleeper coatings in the five freshwater LSAs;
6. Suspended sediment due to construction of mine facilities, Milne Inlet Tote Road, the railway and associated water crossings;
7. Runoff at fuel storage facilities, including fuel spills and malfunctions from the five freshwater LSAs;
8. Effects from waste management activities including storage, handling and landfilling of waste, landfarming of contaminated ice/snow/soil, the management of historically contaminated material, and sewage effluent discharges in the five freshwater LSAs;
9. Effects from construction and operation of camps in the five freshwater LSAs;
10. Effects from erosion and sediment transport due to vegetation removal, cuts/fills and other disturbances in the five freshwater LSAs;
11. Effects from dust deposition in the five freshwater LSAs; and
12. Effects from drilling water withdrawals and returns in the Mine Site LSA.

The key issues identified in the EIS Guidelines were reorganized by Project component and activity to allow for consistent presentation in this Section of the EIS.

An account of key issues, indicators, and Project locations and phases that were incorporated in the effects assessment is provided in Table 7-3.9.

Table 7-3.9 Key Issues for Water and Sediment Quality

Key Issue	Indicators	Project Location (LSA)	Project Phase
Ground Preparation, Earthworks, Road and Railway construction	pH, TSS, Metals and Nutrients	All	Construction and Closure
Site Water Management	pH, TSS, Metals, Nutrients and Petroleum Hydrocarbons	Milne Inlet Tote Road LSA Mine Site LSA Rail Alignment LSA	Construction, Operation and Closure
Laydown Areas	pH, TSS, and Metals	All	Construction and Closure
Explosives	Nutrients and Petroleum Hydrocarbons	All	Construction and Operation
Quarries and Borrow Sources	pH, TSS, Metals and Nutrients	All	Construction
Tunnelling and Rock Cuts	pH, TSS, Metals, Nutrients and Petroleum Hydrocarbons	Milne Inlet Tote Road LSA Rail Alignment LSA	Construction and Operation
Camps, Waste Management and Fuel	TSS and Petroleum Hydrocarbons	All	Construction and Operation
Water Use	pH, TSS, Metals, Nutrients and Petroleum Hydrocarbons	All	Construction and Operation
Airstrips and Airstrip Use	TSS and Petroleum Hydrocarbons	All	Construction, Operation, Closure
Mine Contact Water - Exploration Drilling Effluent	pH, TSS, Metals, Nutrients and Petroleum Hydrocarbons	Mine Site LSA	Construction and Operation
Mine Contact Water - East Waste Rock Stockpile	pH, TSS, Metals and Nutrients	Mine Site LSA	Operation, Closure and Post Closure
Mine Contact Water - Open Pit and Run of Mine Stockpile	pH, TSS, Metals and Nutrients	Mine Site LSA	Operation, Closure and Post Closure
Mine Contact Water - West Waste Rock Stockpile	pH, TSS, Metals and Nutrients	Mine Site LSA	Operation, Closure and Post Closure
Mine Contact Water - Ore Stockpile	pH, TSS, Metals and Nutrients	Mine Site LSA	Operation
Treated Sewage Discharge	BOD, Oil and Grease, TSS and Nutrients	Mine Site LSA Rail Alignment LSA	Construction and Operation
Dust Deposition	TSS and Metals	All	Operation

3.4.1.3 Residual Effects Rating Criteria

Residual effects are those effects that persist after mitigation has been applied to potential effects. Each Project-related residual effect was rated using the standard criteria described in Volume 2.0 and the VEC-specific criteria identified in Table 7-3.10.

Table 7-3.10 Significance Ratings for Evaluating Residual Water and Sediment Quality Effects

Criteria	Classification	
Magnitude	Negligible	Concentrations of indicator(s) predicted to be less than threshold value(s)
	Level I	Concentrations of indicator(s) predicted to be above but within an order of magnitude of threshold value(s) (1 to 10x the threshold)
	Level II	Concentrations of Indicators predicted to be exceed threshold value(s) by an order of magnitude or greater (10 to 100x the threshold)
	Level III	Concentrations of Indicators predicted to be exceed threshold value(s) by more than two orders of magnitude (greater than 100x the threshold)
Extent The physical extent of the effect, relative to study area boundaries	Level I	Confined to the LSA
	Level II	Beyond the LSA and within the RSA
	Level III	Beyond the RSA
Duration The length of time over which a Project effect will occur	Level I	Short term (effect lasts for up to 4 years)
	Level II	Medium term (up to 25 years, for the life of the Project)
	Level III	Long term (beyond the life of the Project) or permanent
Frequency How often the effect occurs	Level I	Infrequent – rarely occurring
	Level II	Intermittent – occasionally occurring
	Level III	Continuous
Reversibility The likelihood of the VEC to recover from the effect	Level I	Fully reversible after activity is complete
	Level II	Partially reversible after activity is complete
	Level III	Non-reversible after activity is complete

Of the five rating criteria used in rating residual effects, magnitude is heavily weighted when determining the significance of the residual effect and is also the criterion that requires the most interpretation. Since the main receptor affected by changes in water quality is aquatic life, magnitude ratings were established based on aquatics-related thresholds, as summarized in Table 7-3.8.

Receiving water quality objectives (WQOs) have been established for the Protection of Freshwater Aquatic Life (CCME PAL). If receiving waters meet the selected Water Quality Objectives (CCME PAL or SSWQOs) with a discharge, this is deemed a Negligible effect to freshwater biota and hence to water and sediment quality. Level I, II and III magnitude effects are related to the relative level of exceedance of any WQOs.

The potential effects associated with discharge of mine contact water into the natural environment are well understood and have led to the enactment of the MMER under the *Fisheries Act*. The following parameters, identified in Schedule 4 of the MMER, are regulated by point-of-discharge concentrations:

- Arsenic;
- Copper;
- Cyanide;
- Lead;
- Nickel;
- Zinc;

- TSS; and
- Radium.

These parameters have been regulated due to potential deleterious effects on fish and other biota in the receiving environment. Mine contact waters may be authorized for discharge under the MMER of the *Fisheries Act*, provided the effluents at the point of discharge meet the MMER Schedule 4 criteria and pass regular testing for acute lethality and chronic toxicity.

3.4.1.4 Baseline Characterization

Using the baseline data as a frame of reference, the following methods were applied to aqueous non-point source emissions, aqueous point source emissions and airborne emissions.

3.4.1.5 Aqueous Non-Point Source Emissions

Infrastructure and activities that were widespread or had non-point source emissions, were assessed in a qualitative manner on a Project-wide basis rather than assessing residual effects for each individual water body. To identify potential sensitivity to the particular indicators and to add context to the rating, general water quality parameters determined for the Sample Group and/or the LSA were considered. The description of the general water quality characteristics for Sample Groups (rivers/streams and lakes) is provided in Tables 7-3.5 and 7-3.7.

Given the uncertainty regarding the potential contaminant source, distribution, and location that would be required to complete a quantitative assessment, a qualitative assessment was undertaken applying conservative assumptions. Examples of residual effects associated with aqueous non-point source emissions included increased TSS due to erosion and sediment transport, ARD/ML from various earth materials, nutrient additions from blasting, and petroleum hydrocarbon constituents from accidental spills.

The majority of meltwater and precipitation in the Project area occurs between June and September, the open-water period for streams and rivers. Consequently, erosion and sediment transport, nutrient and metals transport, and petroleum hydrocarbon mobilization are likely to occur in this period, when receiving waterbodies are at their maximum flows and have increased capacity to buffer these inputs.

Where residual effects were considered likely and there was a lack of reliable data available to quantify the contaminant source, a conservative approach was employed by assuming that the concentration of the key indicator(s) for that particular effect would exceed the respective threshold(s) (Table 7-3.8), resulting in a Level II magnitude effect. For these cases, it was further assumed that the magnitude could be maintained below a Level III effect (i.e., less than an order of magnitude greater than the threshold) by identifying the occurrence of the effect through environmental monitoring and responding appropriately under an adaptive management framework.

A conservative approach was also applied to assumptions regarding the effectiveness of mitigation measures, in recognition that there may be limitations associated with implementation and effectiveness, given the extreme climatic conditions in the Project area. Following that logic, where qualitative assessment was employed, a magnitude of Level I was only attributed to a residual effect when there was a high Level of Certainty that mitigation would be fully implemented and effective. All instances where the effectiveness of the mitigation was in question resulted in a magnitude rating of Level II.

3.4.1.6 Aqueous Point Source Emissions

For Project infrastructure and activities that generate point-source emissions with the potential to affect a specific receiving waterbody, the residual effects assessment focused on those particular locations, where adequate baseline data were available.

For point source mine contact water discharges, source terms of runoff water quality were obtained from geochemical testing (AMEC, 2012a and 2012b) to compare effluent water quality to MMER criteria, and to evaluate the resultant water quality in receiving waters compared to CCME PAL Guidelines. As a mitigation measure to maximize mixing, and to minimize changes in the natural flow regimes, discharges of mine contact waters will be carried out following the natural hydrograph. The Camp Lake tributary at MR-12 and the Mary River are gauged during the open water season, which will allow for real-time monitoring of flows and regulation of releases.

A mass balance approach was used, mixing annualized discharge flows with the annualized receiving flow at the nearest downstream location inhabited by fish. The mass balance model is shown below:

$$C_{Res} = \frac{(C_D \times Q_D) + (C_R \times Q_R)}{Q_{Res}}$$

Where:

C_D = indicator concentration in discharge (mg/L)
Q_D = volume of effluent discharged annually (m^3/year)
C_R = indicator concentration in receiving waterbody (mg/L)
Q_R = volume of water in the receiving waterbody annually (m^3/year)
C_{Res} = resulting (mixed) indicator concentration (mg/L)
Q_{Res} = volume of resulting (mixed) waterbody annually (m^3/year)

The model assumes near-instantaneous mixing in riverine environments due to the discharge to receiving flow ratio, and no modification of indicators due to precipitation, speciation, attenuation or degradation.

Modelling was carried out using both mean and 90th percentile baseline concentrations, and under both mean and low flow (7Q10) conditions.

Mixing Assumptions

While the water quality model used above assumes instantaneous mixing, in reality Initial Dilution Zones (IDZs) will exist at each discharge. The specifics for each discharge location are discussed below.

- West Waste Rock Stormwater Pond – Stormwater will be discharged to a natural drainage (L1) that is fishless until about 100 m before the drainage discharges into a main tributary of Camp Lake (tributary L0). The receiving water is the lower reach of L0 below the falls that provide the fish barrier. Stormwater will be mixed with the natural waters in the drainage L1, and although discharge flows are greater than natural flows, it is expected that this mixing will effectively occur over the approximate 1.5 km length to where the water flows over the falls and subsequently into tributary L0, receiving further dilution.
- East Waste Rock Stormwater Pond – Stormwater will be discharged to a natural drainage (F0) that is fishless until the F0 drainage discharges into the Mary River. Stormwater will be mixed with the natural waters in the drainage F0, and although discharge flows are similar to the natural flows, it is expected that this mixing will effectively occur over the approximate 2,500 m section to where the water flows over the falls. F0 then discharges into the Mary River at a point where the flows are highly turbulent, and therefore further mixing is expected to be nearly instantaneous.

- ROM Stockpile Stormwater Pond and Ore Stockpile Stormwater Pond –These discharges will be directly to the Mary River, but at distinct locations separated by approximately 1,500 m of river. IDZs will exist downstream of each discharge. Because of the volume and turbulent nature of flows in the Mary River, the IDZs will be confined to 20 to 30 m in length.

Source Terms – Waste Rock

Mine contact water from the Waste Rock Stockpiles at the Mine Site will be collected in stormwater ponds prior to discharge. Stormwater runoff water quality (source terms) from Waste Rock Stockpiles were derived by preparing a mass loading model using laboratory derived reaction data and the anticipated site conditions (AMEC, 2012a; see Attachment 5 in Appendix 3B). The ponds will be designed with holding capacities that act to moderate water quality. During mining, when the waste rock pile is under development, stormwater will require retention to settle out solids. The water quality modelling by AMEC (2012a) suggests that if suspended solids are properly managed, the quality of discharge will meet MMER requirements. While water treatment is not expected to be required, treatment options will be available as a contingency measure. As a conservative measure, maximum waste rock runoff quality estimates were used in the assessment.

For a number of parameters sampled in the humidity cell tests, metals were measured at or below the analytical method detection limit (MDL) for a large proportion of samples. Generally the MDLs are high relative to the selected water quality objectives (CCME PAL or SSWQOs). For these parameters, the values assigned were set at one-half the MDL (AMEC, 2012a). The 90th percentile calculated source term was influenced by predicted water quality results based largely on the non-detect results in the humidity cells for the following metals: mercury (Hg), selenium (Se), copper (Cu), arsenic (As), cadmium (Cd), chromium (Cr), silver (Ag) and thallium (Tl). Consequently, the modelled water quality for these parameters is highly conservative.

A similar issue with detection limits was identified in the baseline water quality dataset. The majority of sample results for several metals were reported as non-detect (measured below the MDL). In the baseline dataset, non-detect samples were conservatively set at the MDL. This contributed to overly conservative modelling results; i.e., when the majority of results were reported at the detection limit, the calculated values were close to or even exceeded the Water Quality Objective (WQO).

Two notable parameters, mercury and selenium, were calculated to exceed the respective WQO because of the high proportion of non-detects in both the baseline receiving waters and in the humidity cell testing.

	Mercury	**Selenium**
WQO (CCME PAL) (mg/L)	0.000026	0.001
90th Percentile Baseline Concentration (mg/L)	0.0001	0.0001
% of Detects in Baseline (Measured above MDL)	2 %	2 %
Calculated Source Term (mg/L) (west pond / east pond)	0.004 / 0.003	0.047 / 0.038
Humidity cell testing MDL (mgl/L)	0.001	0.001

As a consequence mercury and selenium are predicted to reach Level II magnitude in the assessments (see Section 3.4.2.2).

During the technical review of the DEIS, the Qikiqtani Inuit Association expressed concern over the potential for nitrates to be elevated in the waste rock stormwater runoff, due to the quantities of ammonium nitrate fuel oil (ANFO) explosives that will be used in mining.

Ammonia releases have been associated with the use of certain explosives at mining and quarrying operations. The use of ammonium nitrate and fuel oil (ANFO) explosive could cause elevated nitrates in waste rock and mine run-off. Ammonia can occur as un-ionized (NH_3) or ionized (NH^{4+}) ammonium ion species. Total ammonia is a measure of both un-ionized and ammonium ion species. The un-ionized is more toxic to aquatic life than the ionized species. Consequently, mining companies have taken a number of initiatives to address this issue. For example, Diavik Diamond Mines Inc has investigated the use, loss and mitigation measures to address nitrate losses, and as a result, has developed and implemented at its site several iterations of an Ammonia Management Plan (Diavik Diamond Mines: Ammonia Management Plan).

Annual explosive use for blasting waste rock and ore is estimated to range from 15,700 tonnes to 18,200 tonnes per annum depending on the year. Volume 3, Appendix 3B, Attachment 8, Section 2.6 states that the emulsion:AN ratio used for the Project is 70:30. The use of emulsion improves the bulk strength of the explosive and allows efficient rock breakage. The emulsion product also reduces ANFO solubility. Modeling by other companies concludes that ammonia releases can be reduced if proper controls are not implemented. The Explosives Management Plan (Volume 3, Appendix 3B, attachment 8) and Volume 10 Section 4.3.3 outline the mitigation measures that will be taken to control the nitrate concentrations entering the receiving environment.

Commercial ammonia reduction technologies, if required, include biological treatment, air stripping, ion exchange, reverse osmosis and breakpoint chlorination. Non-commercial technologies that may have future applications include aerated lagoons, constructed wetlands, land treatment and natural treatment in ponds. (Table 5, Annex C of the Diavik Diamond Mines Ammonia Management Plans), describes for each technology an ammonia reduction estimate, the environmental effect, an evaluation of technology feasibility, capital cost and operating time frames.

Source Terms –Pit Water Quality

Preliminary estimates of pit water quality were made using a similar mass loading approach to that for the waste rock drainage quality (AMEC, 2012b; see Attachment 5 of Appendix 3B). Equilibrated estimates of pit water quality are presented in Table 7-3.11. It is expected that the effluent quality during mine operations will meet MMER requirements for metals. It is possible that, during the latter portion of the mine, pH may decrease below the lower limit of the MMER (pH 6.0). The estimated water quality derived for the pit drainage includes allowance for acidic drainage from exposed potentially acid generating (PAG) rock toward the end of mine life. The quantity of this exposed rock and the data used in deriving this drainage quality is the subject of additional study at this time.

It has therefore been assumed that pH adjustment of the pit water will be required in the second half of mine life and into post-Closure. During Operations, pH adjustment will most likely be carried out inside the pit before the water is pumped to the East Waste Rock Pond. Again, humidity cell testing is expected to over-estimate the runoff quality. These modelling results are very conservative and will be reviewed once data

are available from recently initiated neutralizing potential-depleted humidity cell testing. This will improve confidence in drainage water quality and pH.

Although the pit water quality source term for the latter part of mine life is beyond the MMER range for pH and may require minor pH adjustment, the source terms (assuming no treatment) have been applied in the water quality modelling as a conservative measure.

The EEM program under MMER is specifically designed for this type of situation and is a well designed monitoring tool. It is a tiered program, meaning that the results of monitoring are used in the design of subsequent monitoring, and results also serve to identify the need for corrective action (Dumaresq *et al*. 2002).

Source Terms – Ore Runoff

Mine contact water from the ROM stockpile and the main ore stockpile at the Mine Site will be collected in stormwater ponds prior to discharge to the Mary River. Source terms were derived by calculating the 90th percentile concentrations from sampling carried out by Baffinland in 2010 from lysimeters installed in an ore stockpile generated at the site during the bulk sampling program in 2008. No runoff has been collected since then due to especially dry conditions during the 2011 field season. The runoff data, while limited, are considered conservative in that they represent runoff collected after the stockpile had been sitting dormant for two years; in reality the turnover in the ore stockpiles will be rapid and therefore the contact time between water and the ore will be limited. It has also been identified that non-representative manganese-rich ore may be a component of the lysimeter samples, since this ore was used in construction of the crusher pads where the lysimeters were located. Therefore, lysimeter results may be influenced by drainage from atypical ore.

Runoff from the ore stockpiles is not expected to require treatment beyond settlement of suspended solids in the stormwater pond. Nevertheless, treatment has been identified as a potential contingency measure that can be implemented if monitoring program results indicate that the water quality does not meet discharge criteria. More detail on contingency treatment options for mine contact water is provided in the Waste Rock Management Plan in the water licence application (Volume 3, Appendix 3B, Attachment 5).

Table 7-3.11 Predicted Pit Water Quality

Parameters	MMER Limits	Year 6	Year 10	Year 15	Year 21
pH	6 – 9.5	6.5	6.5	**5.1**	**4.2**
Sulphate (mg/L)		77	80	88	158
Arsenic (mg/L)	0.5	0.006	0.006	0.006	0.007
Copper (mg/L)	0.3	0.007	0.008	0.016	0.074
Lead (mg/L)	0.2	0.0005	0.0005	0.0007	0.0022
Nickel (mg/L)	0.5	0.004	0.005	0.018	0.11
Zinc (mg/L)	0.5	0.030	0.031	0.035	0.062
Aluminum (mg/L)		0.24	0.24	0.77	4.2
Antimony (mg/L)		0.007	0.007	0.007	0.008
Boron (mg/L)		0.060	0.062	0.067	0.11
Cadmium (mg/L)		0.00005	0.00005	0.00006	0.00016
Chromium (mg/L)		0.007	0.007	0.008	0.019
Cobalt (mg/L)		0.002	0.002	0.008	0.053

Table 7-3.11 Predicted Pit Water Quality (Cont'd)

Parameters	MMER Limits	Year 6	Year 10	Year 15	Year 21
Iron (mg/L)		<0.002	<0.002	0.031	0.22
Manganese (mg/L)		0.0001	0.0001	0.10	0.57
Mercury (mg/L)		0.0013	0.0014	0.0014	0.0016
Molybdenum (mg/L)		0.023	0.024	0.024	0.027
Selenium (mg/L)		0.015	0.016	0.016	0.022
Silver (mg/L)		0.0002	0.0002	0.0002	0.0008
Thallium (mg/L)		0.0007	0.0007	0.0007	0.0009
Vanadium (mg/L)		0.0024	0.0025	0.0025	0.0029
Barium (mg/L)		0.022	0.023	0.024	0.034
Sodium (mg/L)		1.0	1.0	1.1	1.8
Potassium (mg/L)		29.2	30.1	30.2	34.9
Calcium (mg/L)		36.0	37.2	37.4	43.4
Magnesium (mg/L)		20.2	20.8	22.9	40.0

Notes:
1. Equilibrated concentrations, which assume equilibrium with amorphous $Al(OH)_3$, ferrihydrite and manganite where estimated concentrations exceed saturation indices for those phases.

Sewage Discharges

For treated sewage discharges, a quantitative assessment was conducted relying on existing sewage quality data derived from the Baffinland compliance monitoring being conducted for the WWTF servicing the exploration camp at the Mine Site (North/South, 2009). A simple mass balance model was developed to estimate the whole-lake concentration of water quality indicators, given seasonal discharge of the entire volume of treated sewage during freshet. The mass balance method assumes that the incoming flow from the WWTF is delivered at a constant flow rate, thoroughly mixed within the lake and near-instantaneously mixed in riverine environments, with no loss or modification of constituents due to precipitation, speciation, attenuation or degradation. The mass balance equation is:

$$C_{Res} = \frac{C_D \times V_D \times 1000 + C_R \times V_R \times 1000}{(V_D + V_R) \times 1000}$$

Where:
C_{Res} = resulting (mixed) indicator concentration (mg/L)
C_D = indicator concentration in discharge (mg/L)
V_D = Volume of discharge (m^3)
C_R = indicator concentration in receiving waterbody (mg/L)
V_R = Volume of receiving waterbody (m^3)

For discharges into riverine environments, volume estimates (VD and VR) in the model were replaced by flow estimates (QD and QR). Note that the mass balance approach taken was appropriate to the assessment, and while an alternate, more confined mixing zone (VR) was considered, this review did not result in a change to the assessment methods.

A further step was taken to identify the upper limit of treated sewage effluent quality that would still meet the applicable CCME PAL guidelines at the nearest downstream location inhabited by fish. This information was included to demonstrate the range of treatment performance that could achieve conformance with the guidelines.

The results of the assessment were intended to identify potential residual effects. During their operation, treated sewage discharge quality will comply with established criteria.

3.4.1.7 Airborne Dust Emissions

For dust-related residual effects, a semi-quantitative assessment used results from quantitative modelling of dust deposition rates and patterns (Volume 5, Section 2). The predicted total suspended particulates (TSP) deposition rate (g/m^2/year) and dispersion area (m^2) associated with activities during Project Operation was identified.

Using the TSP data provided in Volume 5, Section 2, annual minimum and maximum sediment deposition (mm/year) in the receiving environment were estimated for the Mine Site using the equation:

$$T_D = (D / \rho)$$

Where:

T_D = Annual deposition thickness in mm for a given deposition rate
D = Deposition rate in g/mm^2/year
ρ = Specific density in g/mm^3

The calculation was applied to each depositional range (i.e., 7.5 - 15 g/ m^2/year) to determine the range in thickness for that given contour. With this information, the potential annual thickness of dust deposition for any given watercourse can be determined by identifying the contour range it is located in. Then, to determine total deposition thicknesses for the Operations phase, all values were multiplied by 21 (representing its 21-year duration). The annual TSP dispersion modelling for the Mine Site upon which this assessment is based is presented as Figure 5-2.7 in Volume 5.

Since most of the TSP that will be deposited at Steensby Port will fall on land that drains to the ocean, it was observed that TSP deposition will have a very minor effect on freshwater TSS concentrations and so deposition rates were not calculated, for this LSA. The annual TSP dispersion modelling for Steensby Port is presented as Figure 5-2.7 in Volume 5.

Using the assumptions that all dust generated in the Mine Site LSA ultimately enters identified watercourses (resulting in an overestimation of effect) and the entire TSP deposition rate contributes to total suspended solids (TSS) loading evenly and instantaneously on a daily basis during each of the 20 days during freshet, daily minimum and maximum TSS (mg/L) loadings were estimated using the equation:

$$TSS = \frac{(D \times A)/20}{V}$$

Where:

TSS = Daily TSS addition in mg/L
D = Deposition rate in mg/m^2/year
A = Area in m^2
20 = Number of days during freshet
V = Volume of receiving environment in L (Camp Lake, Sheardown Lake and a 6 km length of the Mary River)

A qualitative assessment of water and sediment quality effects was also made, based on the inferred chemical characterization of the dust.

3.4.1.8 Significance Determination

The potential to result in significant adverse environmental effects was determined for each residual effect, based on professional judgment of the combination of residual effect ratings for each potential effect and taking into account the environmental context and the Level of Confidence associated with each rating.

3.4.2 Residual Effects Assessment

This Section presents potential effects, mitigation measures and the residual effects assessment for three categories:

1. Aqueous Non-Point Source Emissions;
2. Aqueous Point Source Emissions; and
3. Airborne Emissions.

3.4.2.1 Aqueous Non-Point Source Emissions

Potential effects on surface water and sediment quality associated with aqueous non-point source emissions (key issues) identified in Table 7-3.9 are described below. These emissions are common where construction activities take place near water bodies and may affect watercourses throughout the Project area. Locations of infrastructure and activities are described for each LSA.

Table 7.3-12 summarizes the ratings assigned to the significance criteria of residual effects associated with each effect discussed below.

Prediction Confidence

The significance rating and confidence level assigned to the predictions of significance for aqueous non-point source discharge effects to water and sediment quality are summarized in Table 7-3.13.

Ground Preparation and Earthworks - Impact Statement SWSQ-1

Impact Statement SWSQ-1: Project-related ground preparation and earthworks may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Ground preparation and earthworks are essential prerequisites during the Construction phase in all five freshwater LSAs. The areas requiring earthworks are identified in Table 3.2.1, Major Project Components, (Volume 3), but notably include the following:

- Developing each of the key areas (Milne Port, Mine Site and Steensby Port) including the construction of buildings, laydown areas, access roads and other site infrastructure;
- Minor improvements to the roadbed of the Milne Inlet Tote Road; and
- Railway construction, including the construction access road.

Typical ground preparation activities include vegetation removal and stripping, resulting in ground surface conditions that are prone to potential erosion and liberation of potential contaminants of concern; this may have an effect on surface water quality through changes in pH or the introduction of TSS, petroleum hydrocarbons and/or nutrients. Left unmitigated, direct effects may be observed in surface water quality. By implementing standard best management practices (BMPs) (described in Volume 10) during ground preparation activities, water quality effects can be avoided or reduced to the point where only incidental

minor to moderate adverse short-term effects are anticipated. As required, the following mitigation measures will be applied:

- Minimize the footprint of disturbance;
- Schedule ground preparation to maintain adequate ground cover during periods of expected rainfall;
- Install and maintain water management features, designed to segregate and prevent co-mingling of offsite water and onsite water;
- Install and maintain adequately designed erosion control features;
- Install and maintain adequately designed sediment transport control features;
- Capture and treat potentially contaminated site run-off to applicable water quality standards prior to discharging to the receiving environment; and
- Erosion control measures.

Following the ground preparation activities, earthworks (earth moving, excavation, grading, cut/fill and backfilling) are required for development of components during Construction.

The disturbance, exposure, transportation and relocation of earth materials can potentially affect surface water quality in receiving bodies adjacent to these work areas. Left unmitigated, direct effects may be observed in surface water quality including changes in pH, introduction of TSS, petroleum hydrocarbons, and/or nutrients. By implementing standard BMPs described above, water quality impacts can be avoided or reduced to the point where only minor to moderate short-term adverse effects are anticipated.

In the event that existing contamination is suspected or encountered during earthwork activities, the Waste Management Plan (Volume 10) will be used as a guideline for containment, testing, removal, treatment and disposal of contaminated media.

Soil spoils will be re-used nearby as general fill (if suitable), stored for reclamation purposes and/or disposed of in roadside borrows. Borrows will be contoured to provide stable side slopes and restore natural drainage.

Temporary roads will be decommissioned and restored through scarification as soon as practical to reduce the risk of potential effects of erosion and sediment transport. Culverts and bridges will be removed to restore pre-disturbance drainage patterns.

The railway alignment and train-related infrastructure are described and illustrated in Volume 3. Completion of the rail line will incorporate ground preparation and earthworks, a temporary access road, rail bed construction and rail sleeper installation. The entire rail line consists of new construction through previously unaltered landscape; therefore, potential effects on water and sediment quality are anticipated.

Rail line construction activities with the potential to affect surface water and sediment quality include culvert installation, bridge construction, infilling of right-of-way through watercourses (encroachment), rail bed construction, grading, and water management.

Standard BMPs (identified in Volume 10) will be employed to address potential effects during Construction. The rail bed, rail line and associated features will be designed and installed so as to avoid contamination of surface waters. Specifically, all structures will be designed, constructed and operated in compliance with *Fisheries Act* authorizations designed to protect water quality as an integral component of fish habitat. Adherence to the conditions of the *Fisheries Act* Authorizations and standard BMPs are anticipated to result in minor adverse residual effects.

Table 7.3-12 Effects Assessment Summary - Aqueous Non-Point Source Emissions

Effect		Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
SWSQ-1 Ground preparation & earthworks	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level II:** will occur for the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-2 Site Water Management	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level I:** will occur mainly during the construction phase	**Level II:** effect is partially reversible with cost/effort	Not Significant
SWSQ-3 Laydown Areas	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level I:** will occur mainly during the construction phase	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-4 Explosives	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level II:** will occur for the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-5 Quarries and Borrow Areas	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level I:** will occur mainly during the construction phase	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-6 Tunnelling and Rock Cuts	**Negative** Water quality (pH, TSS, metals, nutrients – ammonia, brine and hydrocarbons)	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level I:** will occur mainly during the construction phase	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-7 Camps and Fuel Management	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level I:** Effect is expected to be less than threshold values	**Level I:** confined to the LSA	**Level II:** will occur intermittently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible with cost/effort	Not Significant
SWSQ-8 Water Use and Management	**Negative** Water quality (pH, TSS, metals, nutrients and hydrocarbons)	**Level I:** Effect is expected to be less than threshold values	**Level I:** confined to the LSA	**Level III:** continuous	**Level II:** will occur for the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-9 Airstrips and Airstrip Use	**Negative** TSS and Petroleum Hydrocarbons	**Level II:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** infrequent	**Level III:** will occur beyond the life of the Project	**Level I:** effect is reversible after activity is complete	Not Significant

Table 7-3.13 Significance of Residual Effects from Non-Point Source Discharges

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
SWSQ-1: Project-related ground preparation and earthworks, including road and railway construction	N	2	N/A	N/A
SWSQ-2: Project-related site water management	N	2	N/A	N/A
SWSQ-3: Project-related laydown areas	N	1	N/A	N/A
SWSQ-4: Project-related explosives manufacture, storage, and use	N	2	N/A	N/A
SWSQ-5: Quarries and borrow sources	N	2	N/A	N/A
SWSQ-6: Tunnelling and rock cuts	N	2	N/A	N/A
SWSQ-7: Camps, fuel storage and waste management	N	2	N/A	N/A
SWSQ-8: Water use and management	N	2	N/A	N/A
SWSQ-9: Airstrips and airstrip use	N	2	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

Materials from borrow sources have undergone representative geochemical testing, which has indicated that non-reactive material is available throughout the alignment for rail bed construction. The use of non-reactive rock avoids the potential for acid generation and metals leaching that could affect surface water and sediment quality. Imported materials used in rail bed construction will be screened for other obvious contaminants that could affect nearby watercourses. In the event that existing contamination is suspected or encountered during earthwork activities, the Project's Waste Management Plan will be used as a guideline for containment, testing, removal, treatment and disposal of contaminated media.

The rail sleepers will be hewn from raw wood and will not have any preservatives such as creosote or zinc chloride. One of the factors in the selection of raw wood for rail sleepers was to remove the potential for adverse water quality effects. No negative adverse effects are expected from materials leaching from the raw wood rail sleepers.

Residual Effects Rating

Magnitude

Based on a qualitative assessment, there is a potential for minor to moderate water quality effects associated with ground preparation and earthworks activities, including road and railway construction. Generally, the mitigation measures described above are expected to prevent contact of sediment-laden water with natural surface waterbodies in the LSA. Mitigation measures may, however, have limitations, especially considering the extreme climatic conditions: the effectiveness of the installation and performance

of sediment transport mitigation (e.g. silt fences) in frozen ground conditions, challenges in providing adequate ground cover, and challenges in completing earthworks in areas of permafrost.

Given the potential limitations of mitigation measures, it is anticipated that TSS loading could occasionally exceed the CCME threshold of +5 mg/L relative to baseline conditions. These effects are most likely to coincide with freshet conditions, which in themselves result in elevated TSS and have the potential to mitigate the magnitude of the potential effect through added capacity to buffer these inputs. Environmental construction monitoring is expected to be successful in identifying potential effects as they arise, and adaptive management will improve the performance of mitigation measures and thereby avoid exceedance of the CCME PAL guidelines.

In the event that existing (pre-Project) contaminated media are identified on any of the Project sites, appropriate measures will be taken to collect, treat and dispose of the material without increasing the footprint of the contamination and/or creating new pathways for contaminant transport. Currently, there are no known instances of existing contamination located in the Project area. Negligible to minor effects may be anticipated with any existing contaminated media identified during ground preparation and earthworks activities.

Based on the potential for water quality to occasionally exceed the identified thresholds, the effect was rated at Level II.

Environmental monitoring, ongoing water quality monitoring and adaptive management are expected to limit the magnitude of potential TSS related effects.

Extent

The extent of residual water and sediment quality effects associated with ground preparation and earthworks will be limited to the LSA where the infrastructure is located. Environmental construction monitoring will identify effects and where necessary, mitigation will limit the extent of the effect. The extent is rated as Level I.

Frequency

Considering the temporal relation between freshet and/or extreme weather conditions and residual water and sediment quality effects, it is anticipated that these effects will be limited to summer months when construction activities are scheduled and when freshet and the majority of rain events occur. Frequency is rated as Level I.

Duration

While ground disturbance and road and railway construction will be concentrated in the Construction phase, these facilities will require ongoing maintenance throughout the duration of the Project. The duration has been rated as Level II.

Reversibility

The potential effects are anticipated to be fully reversible, once the roads have been decommissioned and rehabilitated and natural drainage has been restored. The effect is rated as Level I.

Significance – SWSQ-1 – Project-related ground preparation and earthworks, including road and railway construction

Based on the ratings described above, ground disturbance and earthworks activities are not expected to result in significant adverse environmental effects on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence associated with the significance ranking is Medium due to the combined qualitative and semi-quantitative nature of the assessment (Table 7-3.13).

For additional details on environmental management considerations regarding ground preparation earthworks and road and railway construction, refer to the following environmental management plans included in Volume 10:

- Environmental Design Guidelines;
- Environmental Protection Plan; and
- Site Water Management Plan.

Site Water Management - Impact Statement SWSQ-2

Impact Statement SWSQ-2: Project-related site water management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Management of storm water, process water and site runoff from engineered surfaces will be required throughout the five freshwater LSAs during all Project phases. The areas requiring site water management are identified in Table 3.2.1, Major Project Components, Volume 3. A general approach to site water management is provided in the Site Water Management Plan (Appendix 10-D2), and site-specific site water management designs will be developed during the detailed design phase.

All stormwater sources have the potential to affect surface water quality through the alteration of pH and/or introduction of TSS, petroleum hydrocarbons, metals and nutrients. By implementing standard BMPs such as the Land Development Guidelines for the Protection of Aquatic Habitat (DFO, 1993), adverse effects can be avoided or reduced. The following mitigation measures will be used to manage the effects of water management on surface water quality:

- Minimize the footprint of disturbance;
- Install and maintain water management features, designed to segregate and prevent co-mingling of offsite water and onsite water.
- Install and maintain adequately designed erosion control features;
- Install and maintain adequately designed sediment transport control features;
- Where required, locate infrastructure on competent bedrock or provide ground conditions that limit permeability and transport into the active layer; and
- Capture and treat contaminated site run-off prior to discharging to the receiving environment.

For aspects of management of site water directed to specific receiving environment or having well defined discharge requirements, the assessment of residual effects is provided in Section 3.4.1.6.

Residual Effects Rating

Magnitude

Preliminary site observations coupled with experience gained from existing operations in the Project area indicate that untreated site water can typically be managed in a way that prevents contact with natural surface waterbodies and water contained in the active layer. The underlying bedrock and permafrost

conditions will act as a relatively impermeable barrier to migration of potential contaminants into groundwater.

All potentially affected stormwater sources will be collected, contained and treated to applicable water quality criteria prior to discharge. Environmental construction monitoring will focus on receiving waterbodies that have relatively soft water, i.e., sensitive to increased metal toxicity (upstream of the deposits, Mary Lake and tributaries, Camp Lake, Sheardown Lake, Ravn River and Cockburn Lake) and watercourses that are sensitive to nutrient inputs.

Based on the anticipated success of controlling stormwater and treating it to applicable discharge standards, only minor to moderate water effects are anticipated. The magnitude is rated as Level II.

Extent

Based on the scale of the surface areas where site water is being collected, the extent of residual water and sediment quality effects associated with Project-related site water management may extend beyond the LSA where the source is located, but is not anticipated to extend to the RSA scale. Environmental construction monitoring will identify residual water and sediment quality effects and where necessary, mitigation efforts will limit the extent of the effect. A Level I extent rating was assigned.

Frequency

Considering the temporal relation between freshet and/or extreme weather conditions and residual water and sediment quality effects, it is anticipated that these effects occur during summer months when construction activities are scheduled. A Level I frequency rating was assigned.

Duration

Residual water and sediment quality effects associated with site water management are expected during the Construction and Operation phases of the Project and are anticipated to coincide with the timing of freshet, when any potential effect would be expected to be diluted by high flow conditions resulting in key indicator concentrations indistinguishable from baseline. A Level I duration rating was assigned.

Reversibility

Residual surface water and sediment quality effects associated with site water management are anticipated to be partially reversible. The majority of Project areas where site water management is required will be returned to the pre-disturbed state during Closure phase. Following rehabilitation, key indicators are generally expected to return to baseline conditions through removal of the contaminant source. A Level II reversibility rating was assigned.

Significance – SWSQ-2 – Project-related Site Water Management

Based on these ratings, site water management infrastructure and site water discharge are not expected to result in significant adverse environmental effects on the water and sediment quality VEC in the five freshwater LSAs. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence associated with the significance ranking is Medium (Table 7-3.13). While the assessment is qualitative, there is a high Level of Confidence in the effectiveness of mitigation measures.

<u>Laydown Areas - Impact Statement SWSQ-3</u>

Impact Statement SWSQ-3: Project-related laydown areas may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Laydown areas are temporary sites used for the storage of equipment and construction materials during the Construction phase; proposed areas are illustrated on Figures 3.2.1, 3.2.3 and 3.2.9 in Volume 3. Requirements are dictated by equipment needs, the sequence of construction activities, and the timing of construction material delivery. These factors will be optimized to reduce the number of anticipated laydown areas, and to minimize their anticipated footprints. The two main considerations are sediment and erosion control, and introduction of hazardous substances, leading to discharge of sediment-laden or contaminated water into the receiving environment.

Left unmitigated, direct effects may be observed through the introduction of TSS and metals. By implementing standard BMPs (identified in Volume 10) during development and use, water quality effects can be avoided or minimized to the point where only minor to moderate adverse effects are anticipated. In addition to the mitigation measures described in the ground preparation section, the following mitigation measures will be employed in laydown areas, as required:

- Siting of laydown areas over competent bedrock or impermeable ground layers;
- Placement and grading of clean, free draining material to promote a workable lay down area environment;
- Installation of adequate storm water management infrastructure to restrict runoff from overland flow or seepage through the active layer into receiving waterbodies; and
- Appropriate handling and storage of hazardous materials.

Introduction of contaminants through spills, accidents and malfunctions are assessed further in Volume 9, Section 3.0.

For additional details on environmental management considerations regarding laydown areas, refer to the following environmental management plans included in Volume 10:

- Environmental Design Guidelines;
- Environmental Protection Plan; and
- Site Water Management Plan.

Residual Effects Rating

Magnitude

Based on a qualitative assessment, that minor to moderate water quality effects may be associated with Project-related laydown areas and activities. The mitigation measures described above, while they are expected to prevent contact of sediment-laden or contaminated water with natural surface waterbodies may have limitations associated with their implementation and effectiveness.

Given these limitations, TSS loading could occasionally exceed the CCME threshold of +5 mg/L relative to baseline conditions. These effects are most likely to coincide with freshet conditions, which have the potential to mitigate the magnitude of the potential effect through added capacity to buffer these inputs. Environmental construction monitoring will identify potential effects as they arise and adaptive management will reduce the risk of exceeding the CCME PAL guidelines.

Potentially hazardous materials will be stored in appropriate containment in designated locations away from water bodies, to reduce the potential for loss of hazardous materials to the aquatic environment.

Based on the potential for changes in water quality occasionally to exceed the identified thresholds, a Level II magnitude rating was assigned.

Extent

The extent of residual water and sediment quality effects associated with Project-related laydown areas will be limited to the LSA in which they are located. Environmental construction monitoring will identify effects and, where necessary, mitigation efforts preclude or limit the extent of the effect. A Level I extent rating was assigned.

Frequency

Considering the temporal relation between freshet and/or extreme weather conditions and residual water and sediment quality effects that these effects would be limited to summer months when construction activities are scheduled and when freshet and the majority of rain events in the Project area occur. A Level I frequency rating was assigned.

Duration

Residual water and sediment quality effects associated with laydown areas are only expected to occur during Construction and Closure. Potential effects are anticipated to coincide with the timing of freshet, when any potential effect would be expected to be diluted by high flow conditions resulting in key indicator concentrations indistinguishable from baseline. A Level I duration rating was assigned.

Reversibility

Residual surface water and sediment quality effects associated with Project-related laydown areas are anticipated to be fully reversible. Following the closure and rehabilitation, key indicators are generally expected to return to baseline conditions through removal of the contaminant source. A Level I reversibility rating was assigned.

Significance – SWSQ-3 – Project-related Laydown Areas

Based on these ratings, laydown areas are not expected to result in significant adverse environmental effects on the water and sediment quality VEC in the five freshwater LSAs. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence is Low due to the qualitative nature of the assessment and potential limitations related to mitigation measures (Table 7-3.13).

Explosives Manufacture, Explosives Magazine, and Explosives Use - Impact Statement SWSQ-4

Impact Statement SWSQ-4: Project-related explosives manufacture, magazine, and use may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

The proposed explosives manufacture and magazine, and blasting areas are described and illustrated in Volume 3. The quantities of explosives required are summarized in Table 3-1 of Appendix 10C-4 (Explosives Management Plan). Explosives transportation, storage and handling have the potential to affect surface water quality in receiving environments during the Construction and Operation phases.

Explosives will be used throughout the Project footprint area during Construction to operate quarries, make rock cuts and access aggregate. The effects of blasting required to carry out pre-stripping and overburden removal and extraction of ore from the open pit are assessed in Section 3.4.3.2. During early construction, packaged explosives and ANFO will be delivered from the port sites to specific areas of use. Packaged explosives will be stored in magazine areas, which will comply with the set-back requirements of NRCan.

Permanent bulk explosives factories will be established at the Mine Site and Steensby Port as early as possible to manufacture explosives from ammonium nitrate. Once the ANFO mixing plant, the ammonium

nitrate storage facility and truck wash facilities have been constructed, ANFO will be produced and distributed by truck and rail.

The truck and railcar wash facility will be constructed with water management features designed to control and collect contact water and treat potentially affected wash water to applicable standards prior to discharge.

Explosives (primarily ANFO) manufacture, transportation, storage and handling may result in the introduction of nitrogenous and petroleum hydrocarbon based components into surface water. Certain nitrogenous compounds can be toxic to aquatic life, depending on the form (e.g. nitrate, nitrite, or ammonia) and relative concentration. Elevated nitrogen concentrations can also result in the eutrophication of receiving waters where phosphorus is not limiting.

The following mitigation will be used to manage potential effects on surface water and sediment quality:

- Explosives will be stored in explosives magazines positioned in accordance with the *Nunavut Mine Health and Safety Act* and Regulations. Detonators and explosives will be stored in separate magazines, and inventory will be strictly controlled by designated supervisors.
- Prefabricated magazines will be positioned and appropriately bermed to store explosives between unloading and distribution.
- Once the bulk mixing plants have been commissioned, ammonia nitrate (AN) will be delivered in bulk and transported by truck to the permanent storage facilities.

By implementing standard BMPs identified in Volume 10 for explosives transportation, storage, and handling, water quality effects can be avoided or reduced to the point where only minor adverse effects are anticipated.

The mining pit will be mostly dry throughout the year; consequently ammonia or residual nitrogen is not expected to escape to the aquatic environment. During the freshet and summer months, any residual explosives washed away by precipitation will report to the waste rock pile; runoff will be channelled to a sedimentation pond, and discharge will be monitored for compliance with MMER water quality limits.

The interaction between explosives use and water quality can be a challenge. The primary forms of mitigation to avoid contamination by nitrogen and petroleum hydrocarbons include use of appropriate weights of explosives to achieve desired blasting results, use of blast guards to prevent 'fly-away', and adequate water management features that will prevent co-mingling of contact and noncontact water. The primary area of use of explosives during Construction are quarries and borrow sources generally sited in competent ground conditions, away from sensitive receiving waterbodies, to minimize the potential for adverse effects. As an additional measure, collection sumps can be constructed to capture and treat potentially contaminated contact water prior to discharge.

For additional details on environmental management considerations regarding the explosives magazine and explosives use, refer to the following environmental management plans included in Volume 10:

- Environmental Design Guidelines;
- Environmental Protection Plan;
- Site Water Management Plan; and
- Explosives Management Plan.

Potential for accidents and malfunctions associated with explosives manufacture, storage, and use are addressed in Volume 9, Section 3.0.

Residual Effects Rating

Magnitude

Based on a qualitative assessment, minor to moderate water quality effects may be associated with explosives manufacture, transportation, magazine and use. Due to the potentially serious nature of health and safety effects, mitigation will be tightly controlled and intently managed. The permanent bulk explosives factories, ANFO mixing plants, ammonium nitrate storage facilities, and truck wash facilities will be constructed to contain any solid explosives and contact water for appropriate treatment. It is not anticipated that nitrogenous and petroleum hydrocarbon residues originating from these sources will exceed applicable CCME thresholds. Residual effects on water quality and sediment quality are expected to be negligible to minor.

The majority of blasting during the Operation phase will be confined to the open pit where water containing elevated levels of nitrogenous and petroleum hydrocarbon residues can be collected and treated prior to discharge (described in Section 3.4.1.6).

During Construction, nitrogenous and petroleum hydrocarbon residues are likely to be released due to blasting and wastage (minimal with pre-packaged ANFO) at quarry locations and other required sites. For these other scenarios, restricting blasting to winter months, volatilization by sunlight and attenuation by vegetation and soil and containment of contact water (where possible) are expected to limit potential effects. Even with the implementation of mitigation measures, it is possible that ammonia, nitrates, nitrites and petroleum hydrocarbon residues originating from blasting activities in less confined locations may occasionally exceed their respective CCME thresholds in. These effects would likely coincide with the snow melt when accumulated nitrogen and petroleum hydrocarbon residues are released during the thaw and freshet conditions. High flow conditions will moderate the magnitude of the potential effect.

Nutrient characteristics of the receiving streams and lakes are summarized in Tables 7-3.5 and 7-3.7. The findings indicate that all of the freshwater receiving environments are relatively sensitive to nutrient inputs; therefore, environmental monitoring coupled with adaptive management will limit the magnitude of residual effects.

A Level II magnitude rating was assigned.

Extent

The extent of residual water and sediment quality effects associated with Project-related explosives manufacture, transportation, magazine and use will be limited to the LSA in which it is located. Environmental monitoring will identify residual water and sediment quality effects and where necessary, mitigation efforts will limit the extent of the effect. A Level I extent rating was assigned.

Frequency

Considering the temporal relation between freshet and/or extreme weather conditions and residual water and sediment quality effects, it is anticipated that these effects would occur during summer months when construction activities are scheduled and when freshet and the majority of rain events occur. A Level I frequency rating was assigned.

Duration

Explosives manufacture, transportation, storage and use will be required during the Construction and Operation phases. Considering that the most likely uncontrolled contribution of nitrogen to the aquatic environment would come from blasting in unconfined areas along the Milne Inlet Tote Road or Railway Alignment, it is likely the source would not persist beyond the Construction phase. Nitrogen introduced in the form of ammonium would likely be assimilated into biomass rapidly, resulting in a relatively short duration of effect. Since the nitrogen source will be removed after Construction, and given the anticipated rapid assimilation of ammonium, a Level II duration rating was assigned.

Reversibility

The potential effects are anticipated to be fully reversible once blasting activities have ceased. This assumes that residual nutrient levels will be attenuated through nitrification/denitrification and that the conclusion of blasting activities will terminate the nitrogen source. A Level I reversibility rating was assigned.

Significance – SWSQ-4 – Explosives Manufacture, Storage and Use

Based on the ratings described above, explosives manufacture, storage and use are not expected to result in significant adverse environmental effects on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence is Medium (Table 7-3.13). Despite the qualitative nature of the assessment, there is a High Level of Confidence in the effectiveness of the identified mitigation measures.

Quarries and Borrow Sources - Impact Statement SWSQ-5

Impact Statement SWSQ-5: Project-related quarries and borrow sources may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Quarries and borrow sources required for rock, fill and aggregate during construction are identified on Figures 3.2.1 through 3.2.9 in Volume 3.0. The primary concern is the potential for ARD/ML and sediment generated at these locations to affect water quality when released into the natural environment.

As a mitigation measure, materials from identified quarries and borrow sources have undergone representative geochemical testing, which has indicated that the material is non-reactive (Volume 6). Additional testing will be completed to ensure that sources used during Construction consist of non-reactive material.

Quarries and borrow sources are generally sited in competent ground conditions away from sensitive receiving waterbodies to avoid the potential for adverse effects. As an additional measure, collection sumps will capture and treat affected contact water to applicable water quality standards prior to discharge. As stated in the Borrow Pit and Quarry Management Plan (Volume 3, Appendix 3B, Attachment 6) Baffinland will strive to avoid quarry site that have the potential for ARD/ML. A detailed ARD/ML testing protocol for potential quarry sites is presented in the Borrow Pit and Quarry Management Plan. Based on the results of the representative geochemical testing, it is not anticipated that treatment will be required to address ARD/ML issues.

For additional details on environmental management considerations regarding quarries and borrow sources, refer to the following environmental management plans included in Volume 10:

- Environmental Design Guidelines;
- Environmental Protection Plan;
- Site Water Management Plan; and
- Explosives Management Plan.

Residual Effects Rating

Magnitude

A semi-quantitative assessment of magnitude was based on representative geochemical testing of materials from quarries and borrows sources, which indicated that the sampled materials are non-reactive (Volume 6). The use of non-reactive materials makes it likely that run-off from quarries and borrow sources will meet the CCME thresholds for pH and metals (ARD/ML). Tables 7-3.5 and 7-3.7, which summarize acid sensitivity of the receiving streams and lakes, indicate that none of the streams or lakes is particularly sensitive to acidic inputs.

Nitrogenous and petroleum hydrocarbon residues originating from blasting activities, as well as sediment-laden water, will be confined to the water management infrastructure within each quarry and borrow site. While mitigation measures will prevent contact of storm water with natural surface waterbodies, they may have limitations associated with their implementation and effectiveness. Given these limitations, it is anticipated that uncontrolled discharges of water from quarries and borrow sources may occasionally exceed applicable CCME thresholds. These exceedances would likely coincide with freshet conditions during snow melt; this will mitigate the potential effect through dilution.

Environmental construction monitoring will be comprehensive, with an emphasis on those receiving bodies that have relatively soft water quality, a condition that can result in increased susceptibility to metals uptake.

A Level II magnitude rating was assigned.

Extent

The extent of residual water and sediment quality effects associated with quarry or borrow sources will be limited to the LSA in which they are located. The relative insensitivity of watercourses to acidic inputs suggests a relatively high potential to buffer through elevated levels of calcium carbonates that are present. Environmental monitoring will identify effects and, where necessary, mitigation efforts will limit their extent. A Level I extent rating was assigned.

Frequency

Considering the temporal relation between freshet and/or extreme weather conditions and residual water and sediment quality effects, these effects will be limited to summer months when construction activities are scheduled and when freshet and the majority of rain events occur. A Level I frequency rating was assigned.

Duration

Quarries and borrow sources will be required during the Construction phase. Potential effects are anticipated to coincide with the timing of freshet, when any potential effect will be diluted by high flow conditions, resulting in key indicator concentrations indistinguishable from baseline. A Level I duration rating was assigned.

Reversibility

The potential effects associated with quarry or borrow sources are anticipated to be fully reversible once blasting is completed and these locations have been closed and rehabilitated. A Level I reversibility rating was assigned.

Significance – SWSQ-5 – Quarries and Borrow Sources

Based on the ratings described above, the residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence associated with the significance ranking is Medium due to the semi-quantitative nature of the assessment (Table 7-3.13).

Tunnelling and Rock Cuts - Impact Statement SWSQ-6

Impact Statement SWSQ-8: Project-related tunnelling and rock cuts may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Tunnelling and rock cut locations are described and illustrated in Volume 3. Activities consist of repetitive cycles of drill, blast, muck and consolidate. Brine water, explosives residues and waste rock are the main products that, if left unmitigated, might affect surface water quality. By implementing standard BMPs described below (see also the explosives magazine and explosives uses Section above), water quality effects will be avoided or reduced to the point where only minor to moderate adverse effects are anticipated.

Due to the permafrost conditions, it is anticipated that brine (solution containing sodium chloride) will be used as the principal fluid to lubricate drill heads and prevent drill rods from freezing in the rock. The face and muck pile may also require washing down. There will be a net loss in the muck and hence salt and water replenishment will be required. The brine will be re-circulated by sump stations in the tunnel that will pump the water back to the brine plant, losing as little water as possible. Total sodium chloride requirement is estimated at 1,400 t. Runoff from tunnel construction activities may contain some brine, cementitious residues and fugitive petroleum products. Provisions for water treatment will be identified during final project design. Sediment basins will be used to retain suspended solids and will be periodically cleaned out, with the dredged sludges appropriately disposed. At the portals, surface water runoff will be directed away from the tunnel to a sump located at a low point, where it will pass through sedimentation tanks and undergo analysis prior to discharge.

The majority of the cuts will be into rock, most of which will be used as fill in the railway embankment. Approximately 1 M m^3 of rock generated at the tunnels will not be used as fill and will be disposed of within the railway right-of-way south of the tunnels alongside Cockburn Lake. Any rock identified as reactive will be transported to the mine site and placed in the Waste Rock Stockpiles to ensure that ARD/ML water is treated prior to discharge.

One of the fundamental criteria for the railway design was to avoid cuts in ice-rich soils where thermal changes could compromise geotechnical stability; those considered unavoidable are mostly at the approaches to crossings and are necessary to avoid excessive pier height for the bridges or excess fill over culverts. Cuts that are not near crossings are predominantly in rock.

Ice-rich soils that thaw become wet and prone to slumping, and considerable quantities of sediment-laden water may be released. To reduce the potential for sediment runoff and to ensure long-term stability the following disposal criteria will be applied:

- As a preferred option, soil spoils will be disposed of in low-lying areas or below-grade excavations within exhausted quarries. Once deactivated, quarries are a disturbed footprint with no future use and therefore make ideal disposal sites.
- In all instances, disposed overburden materials will be placed >33 m from any surface water body, as a standard condition of land use approvals in Nunavut;
- Disposal locations will be approved by the appropriate construction personnel (i.e., engineer, construction superintendent or foreman) who have been given such authority, to avoid unauthorized and indiscriminate disposal;
- Disposal locations will be located at distance from the railway embankment itself so as to avoid any alteration to runoff or thermal regime (damming effect);
- Local depressions or low relief areas will be selected, not slopes where the material will run-off easily;
- The stockpile will be designed with a minimal slope that is physically stable;
- Sediment and erosion control measures will be designed and installed to prevent runoff of sediment; and
- Overburden soils will be transported directly to the disposal site without short-term storage and re-handling.

Residual Effects Rating

Magnitude

A combined quantitative and qualitative assessment of magnitude was based on representative geochemical testing of materials that will be removed during tunnelling and rock cut activities, and potential effects associated with the discharge of tunnelling fluid. The representative geochemical indicated that the materials are non-reactive (Volume 6). The removal of non-reactive materials makes it unlikely that contact water will exceed the CCME thresholds for pH and metals, but, in the event that reactive material *is* encountered, additional mitigation outlined in the waste rock management plan will be implemented to limit potential effects. In addition, as noted in Tables 7-3.5 and 7-3.7, none of the freshwater receiving environment in the Project area is particularly sensitive to acidic inputs.

Minor to moderate residual water and sediment quality effects resulting from brine- and explosive residue-laden discharges may be associated with tunnelling and rock cut activities. The confined nature of these work areas makes water collection and treatment reliable. Engineered drainage and sumps will be used to collect and treat potentially contaminated water prior to discharge. The treated contact water is expected to meet applicable CCME thresholds.

Generally, these mitigation measures will prevent contact of brine and explosive residue-laden water with natural surface waterbodies; however, as described previously in this section, mitigation measures may have limitations associated with their implementation and effectiveness.

Given these limitations, it is possible that discharges may occasionally exceed applicable CCME thresholds. These effects are most likely to coincide with freshet conditions, which have the potential to mitigate the

magnitude their effects through added capacity to buffer these inputs. Environmental construction monitoring will identify potential effects as they arise and adaptive management will reduce the risk of exceeding the CCME PAL guidelines and improve the performance of mitigation measures.

Based on the potential for occasional exceedances of applicable CCME thresholds, a Level II magnitude rating was assigned.

Extent

The extent of residual water and sediment quality effects will be limited to the LSA in which the construction is located. Environmental construction monitoring will identify effects and, where necessary, mitigation efforts will limit their extent. A Level I extent rating was.

Frequency

Considering the temporal relationship between freshet and/or extreme weather conditions and residual water and sediment quality effects, these effects will be limited to summer months when construction activities are scheduled and when freshet and the majority of rain events occur. A Level I frequency rating was assigned.

Duration

Tunnelling and rock cuts will be completed during Construction. Effects are anticipated to coincide with the timing of freshet, when any potential effect would be expected to be diluted by high flow conditions, resulting in key indicator concentrations indistinguishable from baseline. A Level I duration rating was assigned.

Reversibility

The potential effects associated with tunnelling and rock cuts are anticipated to be fully reversible, once Construction is completed and the sources of potential contaminants are removed from the area. A Level I reversibility rating was assigned.

Significance – SWSQ-6 – Tunnelling and Rock Cuts

Based on these ratings, tunnelling and rock cut activities are not expected to result in a significant adverse environmental effect on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). Based on the combined qualitative and semi-quantitative nature of the assessment, the Level of Confidence associated with the significance ranking is Medium (Table 7-3.13).

Camps, Fuel Storage and Waste Management - Impact Statement SWSQ-7

Impact Statement SWSQ-7: Project-related camps, fuel storage and waste management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Temporary and permanent camps will be located throughout the Project area as described and illustrated in Volume 3. The potential effects include changes in water and sediment quality due to withdrawal (described in Section 1), waste management, fuel storage, and discharge of sewage (addressed later in this section).

Waste management facilities, to be installed early in the Construction phase, will receive materials from sources throughout the Project area. In order to protect water quality, the following management actions have been adopted at waste management facilities:

- Incineration of non-hazardous combustible wastes;
- Landfilling of inert non-combustible wastes;

- Temporary storage and off-site shipping of hazardous and recyclable waste materials; and
- On-site treatment for hydrocarbon-impacted materials (soil, water, ice, and snow).

Diesel, gasoline and aviation fuel will be delivered to temporary camp locations via tanker trucks and will be stored in double-walled fuel tanks located on foundations equipped with impermeable bermed liners and bedding materials. The storage site will be far enough removed from receiving watercourses to reduce the potential for water quality effects. An effects assessment of leaks and spills and the potential for petroleum hydrocarbon contamination is provided in Volume 9, Section 3.0.

Fuel will be delivered to the camps at Milne Port (Construction phase only), the Mine Site and Steensby Port via marine vessels and tanker trucks and will be stored in large volume double-walled tanks located on foundations equipped with impermeable bermed liners and bedding materials. These tanks will undergo hydrostatic leak testing, which will involve a one-time water withdrawal from various sources to fill the fuel tanks and test their integrity. The water will be collected, analyzed and treated to applicable water quality guidelines prior to discharge.

Within the bermed fuel storage areas, any fuel-contact water will be collected in engineered drainage and sumps, treated to applicable water quality standards, and then discharged if it does not exceed the CCME thresholds for TSS, oil and grease, or petroleum hydrocarbons.

Once permanent fuel storage has been constructed, the existing bladder fuel farms will be decommissioned following applicable standards to prevent potential contamination of water sources located downgradient. .

All fuel transfers will be carried out in bermed areas so that spills can be readily contained and managed. An effects assessment relating to leaks and spills is provided in Volume 9, Section 3.0.

Residual Effects Rating

Magnitude

Effects associated with fuel storage and use and waste management were all assessed qualitatively. Mitigation measures described above will prevent the discharge of fuel contact water that exceeds CCME thresholds for TSS, oil and grease, or petroleum hydrocarbons.

Waste management mitigation as described above will limit any potentially adverse effects to a negligible to minor magnitude.

A Level I magnitude rating was assigned.

Extent

The extent of the potential effect is likely to be limited to watercourses located in the LSA in which a camp is situated. A Level I extent rating was assigned.

Frequency

The frequency of potential effects will be periodic and limited to summer months when the majority of precipitation falls in the Project Area. A Level II frequency rating was assigned.

Duration

Camps, fuel storage and waste management will be required during Construction and Operation; therefore, a Level II duration rating was assigned.

Reversibility

The potential effects are anticipated to be partially reversible once this infrastructure is decommissioned and rehabilitated. A Level II reversibility rating was assigned.

Significance – SWSQ-7 – Camps, Fuel Storage and Waste Management

Based on these ratings, construction and operation of camps, fuel storage and waste management are not expected to result in significant adverse environmental effects on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence is Medium (Table 7-3.14). While the assessment is qualitative in nature, there is a High Level of Confidence in the effectiveness of mitigation measures.

Water Use and Management - Impact Statement SWSQ-8

Impact Statement SWSQ-8: Project-related water use and management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

Water withdrawal will support a number of Project-related activities (see Tables 7-2.5, 7-2.6, 7-2.9 and 7-2.10). Withdrawal from these sources has the potential for indirect effects on surface water quality by reducing the total volume of water in the system at that location. Mitigation associated with water abstraction is described in Section 2.3.2.

Various Project-related water uses have the potential to affect water and sediment quality when process water is released back into the freshwater environment, including:

- Aggregate washing;
- Concrete manufacture;
- Concrete curing;
- Truck wash; and
- Equipment/floor wash-down.

Water for aggregate washing will be pumped from the potable water source and stored in a designated washing area. The main consideration with aggregate wash water is the potential for it to contain a high TSS concentration. Wash water will be reused and recycled to the extent possible, and solids will be settled out prior to discharge.

Water used for concrete manufacture and curing will be pumped from the potable water source and stored at the batch plant. Volumetric trucks will be used for remote concrete pours, and standard BMPs (described in Volume 10) will be put in place to ensure that untreated contact water is not discharged. The main consideration with concrete contact water is the potential to contain elevated TSS and pH, which may affect water quality in the environment. Concrete contact water will be treated through settlement and with pH adjustment (e.g. carbon dioxide sparging) prior to discharge.

Truck wash facilities will be constructed with water management features designed to segregate and prevent co-mingling of offsite and onsite water. A drain system and sump will capture and treat potentially contaminated water to applicable quality standards prior to discharge.

Snow, ice, soil or water that has been contaminated by petroleum hydrocarbons has the potential to impair water quality. Any such materials will be transported to the Mine Site or Steensby Port for collection in lined, bermed treatment landfarm facilities, and materials that have been in contact with oil will be transported to the same locations for treatment in oil/water treatment facilities in the maintenance shops. Contaminated snow will be placed into cells in the landfarms; after thawing it will be treated and discharged. Discharges will not be directed into the freshwater environment; therefore, only minor adverse effects are anticipated from incidental occurrences.

Residual Effects Rating

Magnitude

Negligible to minor magnitude residual water quality effects may be associated with water abstraction (see Tables 7-2.5, 7-2.6, 7-2.9 and 7-2.10). The greatest volume of water will be required during the Construction phase. Based on the effects assessment conducted for the water quantity VEC in Section 2, withdrawals will conform to DFO's water withdrawal threshold for ice covered lakes, which are intended to protect fish and fish habitat (i.e., water quality).

Water used for other activities (e.g., aggregate washing, concrete manufacture, concrete curing, and dust suppression for the quarry crusher) will be managed to ensure the discharges meet applicable CCME water quality guidelines. Negligible to minor water and sediment quality effects are anticipated.

Potential effects of contaminated by petroleum hydrocarbons were assessed qualitatively. Based on the mitigation described above, it is anticipated that treated contact water discharges will meet applicable CCME water quality guidelines and only negligible to minor adverse effects are expected.

A Level I magnitude rating was assigned.

Extent

The extent of the potential effect is likely to be limited to watercourses from which the abstraction or water use is occurring. A Level I extent rating was assigned.

Frequency

The frequency of the potential effect will be year round, while seasonal discharge of treated contact water will occur during freshet. A Level III frequency rating was assigned.

Duration

Effects are anticipated to last through the Construction and Operation phases; therefore, a Level II duration rating was assigned.

Reversibility

The potential effects are anticipated to be fully reversible, once water withdrawal and treated contact water discharge are discontinued. A Level I reversibility rating was assigned.

Significance – SWSQ-8 – Water Use and Management

Based on these ratings, water use and management are not expected to result in significant adverse environmental effects on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence is Medium (Table 7-3.13). While aspects of the assessment are qualitative, there is a High Level of Confidence in the effectiveness of mitigation measures.

Airstrips and Airstrip Use - Impact Statement SWSQ-9

Impact Statement SWSQ-9: Project-related airstrips and airstrip use may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs.

The airstrip and related infrastructure are described in Volume 3. Its construction and operation have the potential to affect surface water quality in adjacent water bodies. The primary concern during Construction stems from erosion and sediment transport during ground preparation and earthworks. Mitigation measures are summarized in the Sections above.

During the Operation phase, the primary concern stems from the possibility of contaminating nearby water bodies with runoff from the surface of the airstrip, including de-icing agents such as propylene glycol. De-icing by a portable discharge unit will be carried out in a defined area to the side of the runway using propylene glycol. A synthetic organic polymer (EK 35) will be used as a dust suppressant on the airstrips as needed.

Water management features will be installed and maintained to prevent co-mingling of offsite water with potentially affected onsite water. Any potentially contaminated water will be treated to applicable quality standards prior their discharge.

For additional details on environmental management considerations regarding airstrips and airstrip use, refer to the following environmental management plans included in Volume 10:

- Environmental Design Guidelines;
- Environmental Protection Plan;
- Wastewater Management Plan; and
- Surface Water Management Plan.

Residual Effects Rating

Magnitude

As a result of the crowned configuration of the airstrip, surface run-off will be directed to drainage collection structures around the perimeter. Mitigation measures will prevent contact of sediment-laden water with natural surface waterbodies; however, mitigation measures may have limitations associated with their implementation and effectiveness. Given these limitations, it is anticipated that TSS loading could occasionally exceed the CCME threshold of +5 mg/L relative to baseline conditions. These exceedances would likely coincide with freshet conditions during snow melt, which is likely to dilute and mitigate any potential effects.

Use of propylene glycol is anticipated to result in negligible to minor water quality effects as collection and treatment will to ensure that the CCME interim guideline is not exceeded.

The synthetic organic polymer EK 35 is not an identified substance under CCME PAL; therefore, it is recommended that potential effects be assessed through routine water quality monitoring.

Based on the potential for infrequent exceedances of applicable CCME thresholds, a Level II magnitude rating was assigned.

Extent

The extent of the potential effect is likely to be limited to waterbodies adjacent to the airstrips. A Level I extent rating was assigned.

Frequency

The frequency of potential effects will be limited to summer months, when the majority of precipitation falls in the Project Area. A Level I frequency rating was assigned.

Duration

Airstrips and airstrip use will be required during Construction, Operations and Closure. Potential effects are anticipated to coincide with the timing of freshet, when high flows will act to reduce concentrations and render them indistinguishable from baseline. A Level III duration rating was assigned.

Reversibility

The potential effects are anticipated to be fully reversible once the infrastructure is decommissioned and rehabilitated. A Level I reversibility rating was assigned.

Significance – SWSQ-9 – Airstrips and Airstrip Use

Based on these ratings, airstrips and airstrip use are not expected to result in significant adverse environmental effects on the water and sediment quality VEC. The residual effect is ranked as *Not Significant* (Table 7-3.12). The Level of Confidence is Medium (Table 7-3.13). While the assessment is qualitative, there is a high Level of Confidence in the effectiveness of the identified mitigation measures.

3.4.2.2 Aqueous Point Source Emissions

Potential effects on surface water and sediment quality associated with aqueous point source emissions (key issues) identified in Table 7-3.9 are described below. These emissions are from a single, identifiable, localized source and affect a specific receiving waterbody. Locations of infrastructure and activities involving each aqueous point source emission are presented by LSA.

Table 7.3-14 summarizes the ratings assigned to the significance criteria of residual effects associated with each effect discussed below.

Prediction Confidence

The confidence level assigned to the predictions of significance for aquaeous non-point source discharge effects to water and sediment quality are summarized in Table 7-3.15.

Milne Port LSA

All aqueous point source emissions from the Milne Port LSA are directed into Milne Inlet (marine environment) via surface release through a combination of constructed/natural drainage to areas that have no identified sensitive receptors (i.e., fish and/or fish habitat). Due to the absence of sensitive secondary receptors, an assessment of freshwater effects was not completed. The assessment of residual effects associated with emissions into the marine environment, where secondary receptors are located, is addressed in Volume 8.

Milne Inlet Tote Road LSA

No aqueous point source emissions into the freshwater receiving environment are located in the Milne Inlet Tote Road LSA.

Table 7.3-14 Effects Assessment Summary - Aqueous Point-Source Discharges

Effect		Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
SWSQ-10 West Waste Rock Stormwater Discharge to Camp Lake and Tributaries	**Negative** Water quality (pH, TSS, metals, ammonia, nitrite)	**Level II**: Concentrations of indicator(s) predicted to exceed threshold value(s) by an order of magnitude or greater	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level III:** long-term/permanent	**Level II:** effect is partially reversible (water treatment, if required)	Not Significant
SWSQ-11 Waste Rock and Ore Stormwater Discharge to Mary River	**Negative** Water quality (pH, TSS, metals, ammonia, nitrite)	**Level I**: concentrations of indicator(s) predicted to be above but within an order of magnitude of threshold value(s)	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the Operation phase (life of the Project)	**Level II:** effect is partially reversible (water treatment, if required)	Not Significant
SWSQ-12 Exploration Drilling Runoff to Mary River	**Negative** Water quality (pH, TSS, chlorides)	**Level I**: concentrations of indicator(s) predicted to be above but within an order of magnitude of threshold value(s)	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the Operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-13 Pit Lake and Waste Rock Discharges to Mary River in Post-closure	**Negative** Water quality (pH, TSS, metals)	**Level I**: concentrations of indicator(s) predicted to be above but within an order of magnitude of threshold value(s)	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level III:** long-term/permanent	**Level II:** effect is partially reversible (water treatment, if required)	Not Significant
SWSQ-14 Exploration Camp WWTF Effluent Discharge to Sheardown Lake	**Negative** Water quality (pH, TSS, BOD, nutrients, ammonia)	**Level I:** Effect is expected to be less than threshold values	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the Operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-15 Mine Site WWTF Effluent Discharge to Mary River	**Negative** Water quality (pH, TSS, BOD, nutrients, ammonia)	**Level I:** Effect is expected to be less than threshold values	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the Operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant

Table 7-3.15 Significance of Residual Effects from Point Source Discharges

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
SWSQ-10 West Waste Rock Stormwater Discharge to Camp Lake and Tributaries	N	3	N/A	N/A
SWSQ-11 Waste Rock and Ore Stormwater Discharge to Mary River	N	3	N/A	N/A
SWSQ-12 Exploration Drilling Runoff to Mary River	N	2	N/A	N/A
SWSQ-13 Pit Lake and Waste Rock Discharges to Mary River in Post-closure	N	2	N/A	N/A
SWSQ-14 Exploration Camp WWTF Effluent Discharge to Sheardown Lake	N	2	N/A	N/A
SWSQ-15 Mine Site Camp WWTF Effluent Discharge to Mary River	N	2	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

Mine Site LSA

Impact Statements SWSQ-10 to SWSQ-13: Project-related discharges of mine contact water may result in impaired surface water and sediment quality in the Mine Site LSA.

Management of storm water and process water that has been in contact with the iron ore (mine contact water) is required at the Mine Site; specific areas are identified in Volume 3, Table 3.1.1. Plans and drawings illustrating proposed site water management infrastructure for mine contact water are provided in the Site Water Management Plan (Appendix 10-D2).

The following sources (see Figure 3-2.3) have been identified for inclusion in the aqueous point source emissions assessment because they involve mine contact water that will be discharged into the freshwater environment:

- West Waste Rock Stockpile runoff to Camp Lake and Tributaries (SWSQ-10);
- Waste rock and ore stockpile runoff to Mary River (SWSQ-11);
- Exploration drilling runoff (SWSQ-12); and
- Pit lake water and waste rock discharges to Mary River in post-closure (SWSQ-13).

The development of source terms (runoff water quality estimates) for waste rock, ore and pit water is described in Section 3.4.1.6.

Given the variability in runoff flows, the ponds were sized to accommodate the two-year extreme event. Discharge is anticipated to be distributed evenly with the natural flows from approximately mid-June until September.

Details regarding theoretical treatment options are provided in the Waste Rock Management Plan (Volume 3, Appendix 3B, Attachment 5). The main findings suggest that, with sufficient storage and upstream control, any water quality issues that arise can be managed. If the only challenge with the water quality is TSS concentration, this will often be solved using retention time alone. With a buffer pond that has a sufficiently large retention time it is possible to allow particles to settle while discharging - either by gravity or pumping - in a continuous system.

All mine contact water (including that from the ore stockpiles) in the Milne Port and Steensby Port LSAs is discharged to the ocean; their potential effects are assessed in Volume 8.

Residual effects ratings for the various mine contact water discharges are provided below.

West Waste Rock Stormwater Discharge to Camp Lake and Tributaries - Impact Statement SWSQ-10

Runoff discharged from the West Waste Rock Stockpile (via Pond 1) has the potential to adversely affect water quality in the tributary of Camp Lake to which stormwater will be discharged, and downstream into Camp Lake.

Contact water (runoff) from the West Waste Rock Stockpile will be settled in the west pond (Pond 1) prior to discharge to tributary L1, which in turn reports to tributary L0 and subsequently to Camp Lake. The arrangement of the stockpile, the SWM pond and the receiving environment are illustrated in Figure 3-2.3 in Volume 3.0. It is predicted, based on waste rock seepage modelling, that runoff from the stockpile will meet MMER requirements (Volume 3, Appendix 3B, Attachment 5, Waste Rock Management Plan).

Background water quality was measured in the open-water seasons (June to September) of 2006, 2007, 2008 and 2011. Open-water season means were calculated for key water quality parameters at sampling locations L0-01, L1-02 and L1-08. Water quality sampling included analysis of routine water quality parameters identified in the Baseline Water and Sediment Quality Report in Appendix 7B-1. Background mean and 90th percentile baseline concentrations were applied to the modelling.

Mean and low flow rates (or annual volumes) were obtained from hydrological surveys conducted over five years (2006, 2007, 2008, 2010 and 2011).

A mass balance approach was applied using the methodology described in Section 3.4.1.6 to estimate water quality in the receiving waters under mean flow conditions and by discharging runoff following the natural hydrograph. Resultant water quality in Camp Lake tributary L1 (at the location of falls which prevent the upstream passage of fish), downstream where L1 reports to tributary L0 and then at Camp Lake is presented in Table 7-3.16. The same analysis during the 10-year dry year is presented in Table 7-2.17.

Residual Effects Rating

Magnitude

The mass balance modelling indicates that several parameters will have Level II magnitude effects to water quality under both mean and low flow conditions at the nearest downstream location inhabited by fish at L0, and in Camp Lake (Hazard Quotient - HQ of >1 and <10). An HQ >10 and <100 was applied for mercury using 90th percentile baseline concentrations. All other parameters are at Level I or lower.

As mentioned in Section 3.4.1.6, each of the metals showing an HQ >1 (a Level I effect) or HQ >10 (a Level II effect) is identified in the humidity cell testing as having >50 % non-detects, and half the detection limits were assumed for non-detect results. Consequently, the derived source terms for these metals are substantially based on the MDLs. Most of these same parameters (including arsenic, cadmium, chromium, mercury, selenium and silver, as well as other metals that do not trigger a Level I effect) have measured baseline concentrations that are mostly non-detect, and therefore the calculated mean or 90th percentile concentrations are substantially based on MDLs. On this basis, the assignment of a Level II magnitude rating for water and sediment quality effects arising from discharge of stormwater from the waste rock pond to the Camp Lake tributaries and Camp Lake is considered to be highly conservative. Baffinland is exploring options for re-testing or additional testing to obtain a dataset of more precise measurements for these parameters.

Aquatic Effects Monitoring, Environmental Effects Monitoring and routine water quality monitoring are expected to identify potential effects as they arise, and adaptive management will reduce the risk of exceeding the predicted effects level.

Duration

Discharge of mine contact water from the West Waste Rock Stockpile into the lower reach of Camp Lake tributary L1 will be required during the Operation, Closure and post-closure phases of the Project; a Level III duration rating was assigned.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September. A Level II frequency rating was assigned.

Extent

The extent of the potential effect is expected to be limited to the Mine Site freshwater LSA and to reach negligible levels where Camp Lake discharges into Mary Lake. A Level I extent rating was assigned.

Reversibility

The potential effects are anticipated to be partially reversible. A Level II reversibility rating was assigned.

Significance – SWSQ-10 – West Waste Rock Stormwater Discharge to Camp Lake and Tributaries

Based on these ratings, discharge of mine contact water from the West Waste Rock Stockpile into the tributary of Camp Lake is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence (Table 7-3.15) is High due to the quantitative nature and conservative assumptions of the assessment. Additionally the EEM requirements of MMER provide assurance that effects will be detected and necessary corrective actions implemented.

Table 7-3.16 Predicted Water Quality in Camp Lake Tributaries and Camp Lake Under Mean Flow Conditions (West Pond Discharge)

									WATER QUALITY IN THE RECEIVING WATERS									
Parameter	Units	Baseline Water Quality (L0-01, L1-02, L1-08)			Baseline Water Quality Camp Lake	Receiving Water Quality Objectives (See Note 5)	Discharge Scenario		CAMP LAKE TRIB L1 BEFORE DISCHARGE TO TRIB L0				MOUTH OF TRIB L0 AT OUTLET TO CAMP LAKE				CAMP LAKE	
							Flows Used		Discharge Equalized to Mean Summer Flow Discharge Volume = 843,000 m^3/yr Mean Baseline Flows in L1 = 790,807 m^3/yr				Discharge Equalized to Summer Flow - Additional Dilution in L0 Discharge Flows = 1,633,807 m^3/yr Mean Baseline Flows in L0 (MR-10) at outlet to lake = 976,453 m^3/yr				Assume Instantaneous Mixing within lake = 27,511,100 m^3 Discharge Flows into Camp Lake (MR-10 Outlet Flows + Discharge Volume) = 2,610,260 m^3/yr	
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration		Baseline Concentrations		Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ	Mean (Lake) 90th Percentile (Streams)	HQ
							MMER	West Waste Rock Pile Source Terms										
pH		7.84	8.38		7.61	6.5 - 9.0	-	6.9	7.35	-	7.62	-	7.54	-	7.90	-	7.64	-
Hardness	mg/L $CaCO_3$	74.11	121.00		57.69	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	mg/L	0.0190	0.0390	82%	0.0095	0.94	-	0.12	0.071	0.1	0.081	0.1	0.052	0.05	0.065	0.07	0.0143	0.02
Antimony	mg/L	-	0.0004	0%	0.00010	-	-	0.0031	-	-	0.0018	-	-	-	0.0013	-	0.00020	-
Arsenic	mg/L	-	0.0050	6%	0.00018	0.005	0.50	0.0025	-	-	0.0037	0.7	-	-	0.0042	0.8	0.00053	0.1
Barium	mg/L	0.0093	0.0119	59%	0.00565	-	-	0.064	0.038	-	0.039	-	0.027	-	0.029	-	0.0076	-
Beryllium	mg/L	-	0.0050	0%	0.00050	0.0053	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	-	0.0320	10%	0.01000	1.5	-	0.025	-	-	0.028	0.02	-	-	0.030	0.02	0.012	0.01
Cadmium	mg/L	-	0.00010	10%	0.000023	0.000029	-	0.000020	-	-	0.00006	2.0	-	-	0.00007	2.6	0.00003	0.9
Chromium	mg/L	-	0.0010	10%	0.00055	0.0047	-	0.0029	-	-	0.0020	0.4	-	-	0.0016	0.3	0.00064	0.1
Cobalt	mg/L	-	0.0003	4%	0.00011	-	-	0.00079	-	-	0.00055	-	-	-	0.00046	-	0.00014	-
Copper	mg/L	0.0015	0.0020	94%	0.00207	0.0047	0.30	0.0031	0.0023	0.5	0.0026	0.5	0.0020	0.4	0.0024	0.5	0.0021	0.4
Iron	mg/L	0.0471	0.0610	67%	0.03152	1.2	-	<0.002	0.023	0.02	0.030	0.03	0.032	0.03	0.042	0.03	0.032	0.03
Lead	mg/L	0.0002	0.0007	18%	0.000171	0.001	0.20	0.00020	0.0002	0.2	0.00044	0.4	0.0002	0.2	0.001	0.5	0.0002	0.2
Manganese	mg/L	0.0063	0.0100	51%	0.002289	-	-	0.00004	0.0031	-	0.0049	-	0.004	-	0.0068	-	0.002678	-
Mercury	mg/L	-	0.00010	2%	0.000040	0.000026	-	0.00057	-	-	0.00034	13	-	-	0.00025	9.7	0.000058	2.2
Molybdenum	mg/L	0.0027	0.0050	46%	0.000620	0.073	-	0.010	0.0065	0.1	0.0076	0.1	0.0051	0.07	0.0066	0.09	0.0011	0.02
Nickel	mg/L	0.0030	0.0050	32%	0.00109	0.083	0.50	0.0019	0.0024	0.03	0.0034	0.04	0.0026	0.03	0.0040	0.05	0.0013	0.02
Selenium	mg/L	-	0.0050	2%	0.00100	0.001	-	0.0077	-	-	0.0064	6	-	-	0.0059	5.87	0.0014	1.4
Silver	mg/L	-	0.0001	4%	0.000017	0.0001	-	0.000064	-	-	0.00008	0.8	-	-	0.00009	0.9	0.000023	0.2
Thallium	mg/L	-	0.0002	0%	0.00010	0.0008	-	0.00029	-	-	0.00025	0.3	-	-	0.00023	0.3	0.00011	0.1
Uranium	mg/L	0.0016	0.0027	100%	0.000402	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	-	0.0010	2%	0.00100	0.006	-	0.0010	-	-	0.0010	0.2	-	-	0.0010	0.2	0.0010	0.2
Zinc	mg/L	0.0020	0.0030	25%	0.00247	0.03	0.50	0.013	0.008	0.3	0.008	0.3	0.006	0.2	0.006	0.2	0.00280	0.1

NOTES:
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE.
6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT.

Table 7-3.17 Predicted Water Quality in Camp Lake Tributaries and Camp Lake in a Dry Year (West Pond Discharge)

Parameter	Units	Baseline Water Quality (L0-01, L1-02, L1-08)			Baseline Water Quality Camp Lake	Receiving Water Quality Objectives (See Note 5)	Discharge Scenario		WATER QUALITY IN THE RECEIVING WATERS									
							Flows Used		CAMP LAKE TRIB L1 BEFORE DISCHARGE TO TRIB L0				MOUTH OF TRIB L0 AT OUTLET TO CAMP LAKE				CAMP LAKE	
									Discharge Equalized to 10-Year Low Flow Discharge Volume = 354,060 m^3/yr 10-Year Low Baseline Flows in L1 = 332,139 m^3/yr				Discharge Equalized to 10-Year Low Flow - Additional Dilution in L0 Discharge Flows = 686,199 m^3/yr 10-Year Low Baseline Flows in L0 (MR-10) at outlet to lake = 410,110 m^3/yr				Assume Instantaneous Mixing within lake = 27,511,100 m^3 Discharge Flows into Camp Lake (MR-10 Outlet Flows + Discharge Volume) = 1,096,309 m^3/yr	
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration		Baseline Concentrations		Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ	Mean (Lake) 90th Percentile (Streams)	HQ
							MMER	West Waste Rock Pile Source Terms										
pH		7.84	8.38		7.61	6.5 - 9.0	-	6.9	7.35	-	7.62	-	7.54	-	7.90	-	7.62	-
Hardness	mg/L $CaCO_3$	74.11	121.00		57.69	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	mg/L	0.0190	0.0390	82%	0.0095	0.94	-	0.286	0.157	0.2	0.166	0.2	0.105	0.11	0.119	0.13	0.0137	0.01
Antimony	mg/L	-	0.0004	0%	0.00010	-	-	0.007	-	-	0.004	-	-	-	0.003	-	0.0002	-
Arsenic	mg/L	-	0.0050	6%	0.00018	0.005	0.50	0.006	-	-	0.0055	1.1	-	-	0.0053	1.06	0.00038	0.08
Barium	mg/L	0.0093	0.0119	59%	0.00565	-	-	0.152	0.083	-	0.084	-	0.056	-	0.057	-	0.0076	-
Beryllium	mg/L	-	0.0050	0%	0.00050	0.0053	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	-	0.0320	10%	0.01000	1.5	-	0.060	-	-	0.046	0.03	-	-	0.041	0.03	0.0112	0.01
Cadmium	mg/L	-	0.00010	10%	0.000023	0.000029	-	0.00005	-	-	0.00007	2.5	-	-	0.00008	2.9	0.00003	0.87
Chromium	mg/L	-	0.0010	10%	0.00055	0.0047	-	0.007	-	-	0.0040	0.9	-	-	0.0029	0.62	0.00064	0.14
Cobalt	mg/L	-	0.0003	4%	0.00011	-	-	0.0019	-	-	0.0011	-	-	-	0.0008	-	0.00014	-
Copper	mg/L	0.0015	0.0020	94%	0.00207	0.0047	0.30	0.007	0.0045	1.0	0.0048	1.0	0.0034	0.7	0.0037	0.8	0.00213	0.5
Iron	mg/L	0.0471	0.0610	67%	0.03152	1.2	-	0.002	0.024	0.02	0.031	0.03	0.033	0.03	0.042	0.0351	0.032	0.03
Lead	mg/L	0.0002	0.0007	18%	0.000171	0.001	0.20	0.0005	0.0003	0.3	0.0006	0.6	0.0003	0.3	0.0006	0.6	0.00019	0.2
Manganese	mg/L	0.0063	0.0100	51%	0.002289	-	-	0.00010	0.0031	-	0.0049	-	0.0043	-	0.0068	-	0.0025	-
Mercury	mg/L	-	0.00010	2%	0.000040	0.000026	-	0.001	-	-	0.00075	29	-	-	0.00051	19.46	0.000058	2.23
Molybdenum	mg/L	0.0027	0.0050	46%	0.000620	0.073	-	0.024	0.014	0.2	0.015	0.2	0.010	0.13	0.011	0.15	0.0010	0.01
Nickel	mg/L	0.0030	0.0050	32%	0.00109	0.083	0.50	0.005	0.004	0.05	0.005	0.06	0.003	0.04	0.005	0.06	0.00123	0.01
Selenium	mg/L	-	0.0050	2%	0.00100	0.001	-	0.018	-	-	0.0119	12	-	-	0.0093	9.31	0.0013	1.32
Silver	mg/L	-	0.0001	4%	0.000017	0.0001	-	0.0002	-	-	0.00013	1.3	-	-	0.00012	1.2	0.00002	0.21
Thallium	mg/L	-	0.0002	0%	0.00010	0.0008	-	0.001	-	-	0.00045	0.6	-	-	0.00036	0.448	0.00011	0.14
Uranium	mg/L	0.0016	0.0027	100%	0.000402	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	-	0.0010	2%	0.00100	0.006	-	0.002	-	-	0.0017	0.3	-	-	0.0014	0.24	0.0010	0.17
Zinc	mg/L	0.0020	0.0030	25%	0.00247	0.03	0.50	0.031	0.017	0.6	0.017	0.6	0.011	0.4	0.012	0.4	0.0028	0.1

NOTES:
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT.
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE.
6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT.

Waste Rock and Ore Stormwater Discharge to the Mary River - Impact Statement SWSQ-11

Runoff discharged from the East Pond (Pond 2) during operations, containing both East Waste Rock Stockpile runoff and pit water, has the potential to adversely affect water quality in the Mary River.

A mass balance approach similar to that used for the West Waste Rock Stormwater (SWSQ-10) was applied using the methodology described in Section 3.4.1.6 to estimate water quality in the receiving waters under mean flow conditions and by discharging effluent following the natural hydrograph. Resultant water quality in the Mary River following discharge of the East Pond is presented in Table 7-3.18, and the same analysis during the 10-year dry year is presented in Table 7-3.19.

Residual Effects Rating

Magnitude

The mass balance modelling indicates that Level I magnitude effects to water quality will occur under both mean and low flow conditions (all indicator parameters <10x the applicable WQO) in the Mary River at each of the locations modelled:

- In the Mary River at MR-12 where tributary F0 containing the east pond effluent reports to the Mary River, under mean flow conditions (Table 7-3.18) and the 10-year dry condition (Table 7-3.19); and
- At the point of mixing of the discharge of stormwater from the main ore stockpiles, including the ROM stormwater discharge, under mean flow conditions (Table 7-3.20) and the 10-year dry condition (Table 7-3.21); and

Fish habitat is present at the outlet of MR-12 (tributary F0), for which the resultant water quality in Mary River is shown on the far right of Tables 7-3.18 and 7-3.19. At this location, Level I water quality effects may be experienced based on an HQ >1 for mercury, selenium and silver (under mean flow conditions). Copper and chromium are added under the dry year condition. As discussed in the assessment of discharges from the West Waste Rock Pond, the calculated baseline concentrations and source terms used in the modelling are from datasets where these parameters were predominantly non-detect. As such, a Level I magnitude rating is highly conservative.

Farther downstream, the ROM and main ore stockpiles will discharge into the Mary River. The resultant water quality in the Mary River considering these discharges as well as the east waste rock stormwater discharge discussed above is presented in Tables 7-3.20 and 7-3.21. Mercury, selenium and silver (under mean flow and low flow conditions), have a calculated HQ >1, suggesting a Level I magnitude effect with the same qualifiers as described above.

The resultant water quality downstream in Mary Lake was approximated considering discharges from the west stormwater pond via Camp Lake and the multiple discharges to Mary River, which also report to Mary Lake. Based on the average lake volume of 169,000,000 m^3, HQs of 4, 1 and 1 were calculated for mercury, selenium and silver, respectively. Given that the modelling inputs (both baseline and source terms) for each of these parameters are based on MDLs, it is anticipated that the HQ values will be below 1, achieving a negligible effect on water quality in Mary Lake.

Duration

While the temporary ore stockpiles will to discharge stormwater during the Operations phase only, a Level II duration rating is assigned to this effect. The east waste rock pond and pit will continue to discharge runoff in the long term; however the post-closure effects of this is assessed separately in SWSQ-13.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when discharge is proposed. A Level II frequency rating was assigned.

Extent

The extent of the potential effect is expected to reach negligible levels where the Mary River discharges into Mary Lake, so, given that the effect is expected to be limited to the Mine Site freshwater LSA, a Level I extent rating was assigned.

Reversibility

The potential effects associated with the discharge of mine contact water from the East Waste Rock Stockpile into the Mary River system are anticipated to be partially reversible. A Level II reversibility rating was assigned.

Significance – SWSQ-11 – Waste Rock and Ore Stormwater Discharge to the Mary River

Based on these ratings, discharge of mine contact water from the East Waste Rock Stockpile, ROM stockpile and Main Ore Stockpile into the Mary River is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence is High due to the quantitative and conservative nature of the assessment.

Exploration Drilling Runoff - Impact Statement SWSQ-12

Exploration drilling has been undertaken by Baffinland since 2004, at Deposits No. 1, 2 and 3 at the Mine Site. Calcium chloride brine is required to lower the freezing point of water in the drillhole and prevent drill rods from freezing. The exploration drilling area and the surrounding environment are illustrated in Figure 3-2.3 in Volume 3.0.

Drilling fluids help to remove cuttings from the hole, clean and cool the drill bit, reduce friction between the drill string and the sides of the borehole, and seal the borehole. Common drilling fluids include water and water with additives (sodium chloride and bentonite) that control the drilling fluid weight. Bentonite drilling additives may contain petroleum or other organic compounds. Baffinland will construct sumps to contain these wastes, and will recycle drill water to the extent possible.

Baseline water quality sampling since 2005 has periodically measured elevated conductivity and chlorides in the Mary River, to which runoff from drilling ultimately reports. On occasion chloride has been measured at concentrations greater than the CCME PAL criteria of 120 mg/L (long-term exposure) and 640 mg/L (long-term exposure). Over the years, Baffinland has made improvements to its management of drilling brine, including:

- Automating calcium chloride mixing operations to consistently meet target brine concentrations – this has prevented both spillage and over-use of calcium chloride powder, consequently reducing potential loadings of calcium chloride in drilling runoff to the Mary River;
- Constructing sumps to contain the drilling brine; and
- Recycling water from the sumps.

Each of these measures has reduced the amount of drilling brine that discharged from drilling operations.

Table 7-3.18 Predicted Water Quality in the Mary River under Mean Flow Conditions (East Pond Discharge)

Parameter	Units	Baseline Water Quality in Trib F0 (F0-01, F0-05)			Baseline Water Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	Discharge Scenario			COMBINED EFFLUENT DISCHARGE FROM THE EAST WASTE ROCK POND	WATER QUALITY IN THE RECEIVING WATERS							
									Flows Used			Mean Volume of Effluent from East Pond = 370,138 m^3/yr Mean Volume of Effluent from Open Pit = 224,978 m^3/yr	WATER QUALITY IN TRIB F0 - CATCHMENT MR-12 (U/S OF FISH HABITAT)				WATER QUALITY IN MARY RIVER AT MR-12 OUTLET (FISH HABITAT)			
													Mean Volume of Effluent Discharged from East Pond and Open Pit = 595,116 m^3/yr Mean Volume to mix at MR-12 = 4,152,146 m^3/yr					Mean Volume of Effluent Discharged from Tributary, East Pond and Open Pit = 4,747,262 m^3/yr Mean Volume to mix in Mary River = 78,185,678 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration	90th Percentile Concentration	% Detects		Baseline Concentrations			Mean	Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ
									MMER	Pit Water Source Terms (Year 21)	East Waste Rock Source Terms									
pH		8.01	8.31		7.83	8.20		6.5 - 9.0	-	4.20	6.9	5.88	7.74	-	8.01	-	7.83	-	8.19	-
Hardness	mg/L $CaCO_3$	84	133		58	105		-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	mg/L	0.020	0.042	81%	0.191	0.394	100%	0.94	-	4.2	0.095	1.65	0.22	0.2	0.24	0.3	0.19	0.2	0.39	0.4
Antimony	mg/L	-	0.0004	0%	-	0.0001	2%	-	-	0.008	0.0025	0.0046	-	-	0.001	-	-	-	0.00015	-
Arsenic	mg/L	-	0.0010	4%	-	0.0010	8%	0.005	0.50	0.007	0.0020	0.0039	-	-	0.001	0.3	-	-	0.00102	0.2
Barium	mg/L	0.00945	0.01068	47%	0.01011	0.01319	57%	-	-	0.0340	0.051	0.045	0.014	-	0.015	-	0.010	-	0.013	-
Beryllium	mg/L	-	0.0050	0%	-	0.0005	0%	0.0053	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	-	0.010	2%	-	0.010	6%	1.5	-	0.11	0.020	0.054	-	-	0.016	0.01	-	-	0.010	0.01
Cadmium	mg/L	-	0.0000200	0%	-	0.00002	8%	0.000029	-	0.00016	0.000016	0.00007	-	-	0.000026	0.9	-	-	0.000020	0.7
Chromium	mg/L	0.0010	0.0010	8%	0.0018	0.0020	27%	0.0047	-	0.019	0.0023	0.0086	0.0020	0.4	0.0020	0.4	0.0018	0.4	0.0020	0.4
Cobalt	mg/L	0.0002	0.0003	4%	0.0002	0.0002	20%	-	-	0.053	0.00063	0.020	0.0027	-	0.0028	-	0.00035	-	0.00035	-
Copper	mg/L	-	0.0009	38%	0.0012	0.0018	64%	0.0047	0.30	0.074	0.0025	0.030	-	-	0.0045	1.0	-	-	0.0020	0.4
Iron	mg/L	0.04	0.05	19%	0.18	0.36	86%	1.2	-	0.22	<0.002	0.084	0.045	0.04	0.054	0.05	0.17	0.1	0.34	0.3
Lead	mg/L	0.00016	0.00020	13%	0.00029	0.00087	35%	0.001	0.20	0.0022	0.00016	0.0009	0.00026	0.3	0.00029	0.3	0.00029	0.3	0.00084	0.8
Manganese	mg/L	0.00260	0.01000	32%	0.00386	0.01000	48%	-	-	0.57	0.00004	0.22	0.029	-	0.036	-	0.0053	-	0.011	-
Mercury	mg/L	-	0.00010	0%	-	0.00010	2%	0.000026	-	0.0016	0.00045	0.0009	-	-	0.00020	8	-	-	0.00011	4.1
Molybdenum	mg/L	0.00306	0.00500	38%	0.00288	0.00500	46%	0.073	-	0.027	0.0078	0.015	0.0046	0.06	0.0063	0.09	0.0030	0.04	0.0051	0.07
Nickel	mg/L	0.0032	0.0050	10%	0.0031	0.0050	92%	0.083	0.50	0.11	0.0015	0.043	0.0081	0.1	0.010	0.1	0.0034	0.04	0.0053	0.06
Selenium	mg/L	-	0.001	0%	-	0.001	0%	0.001	-	0.022	0.0051	0.011	-	-	0.0023	2.3	-	-	0.0011	1.1
Silver	mg/L	-	0.00010	4%	-	0.00010	10%	0.0001	-	0.0008	0.000051	0.00033	-	-	0.00013	1.3	-	-	0.00010	1.0
Thallium	mg/L	-	0.0001	0%	-	0.0001	0%	0.0008	-	0.0009	0.00023	0.00048	-	-	0.00015	0.185	-	-	0.00010	0.1
Uranium	mg/L	0.00213	0.00299	100%	0.00252	0.00468	98%	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	-	0.001	0%	0.001	0.001	11%	0.006	-	0.0029	0.00083	0.0016	-	-	0.0011	0.179	-	-	0.0010	0.2
Zinc	mg/L	-	0.009	8%	0.003	0.006	25%	0.03	0.50	0.062	0.010	0.030	-	-	0.012	0.386	-	-	0.0063	0.2

NOTES:
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT.
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE.
6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT.

Table 7-3.19 Predicted Water Quality in the Mary River under 10-Year Dry Conditions (East Pond Discharge)

Parameter	Units	Baseline Quality in Trib F0 (F0-01, F0-05)			Baseline Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	MMER (Mean Monthly)	Discharge Scenario	COMBINED EFFLUENT DISCHARGE FROM THE EAST WASTE ROCK POND	WATER QUALITY IN RECEIVING WATERS							
										Flows Used	10-Year Low Flow Volume of Effluent from East Pond = 244,291 m^3/yr -10-Year Low Flow Volume of Effluent from Open Pit = 148,485 m^3/yr	WATER QUALITY IN TRIB F0 - CATCHMENT MR-12 (U/S OF FISH HABITAT)				WATER QUALITY IN MARY RIVER AT MR-12 OUTLET (FISH HABITAT)			
												10-Year Low Flow Volume of Effluent Discharged from East Pond and Open Pit = 392,777 m^3/yr 10-Year Low Flow Volume to mix at MR-12 = 2,740,417 m^3/yr				10-Year Low Flow Volume of Effluent Discharged from Tributary, East Pond and Open Pit = 3,133,194 m^3/yr 10-Year Low Flow Volume to mix in Mary River = 53,166,261 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration	90th Percentile Concentration	% Detects			Baseline Concentrations			Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ
										Pit Water Source Terms (Year 21)	East Waste Rock Source Terms									
pH	0	8.01	8.31		7.83	8.20		6.5 - 9.0	-	4.20	6.9	5.88	7.74	-	8.01	-	7.83	-	8.19	-
Hardness	mg/L $CaCO_3$	84	133		58	105		-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	mg/L	0.020	0.042	81%	0.191	0.394	100%	0.94	-	6.4	0.144	2.50	0.33	0.4	0.35	0.4	0.20	0.2	0.39	0.4
Antimony	mg/L	-	0.0004	0%	-	0.0001	2%	-	-	0.012	0.004	0.01	-	-	0.0012	-	-	-	0.00016	-
Arsenic	mg/L	-	0.0010	4%	-	0.0010	8%	0.005	0.50	0.011	0.003	0.006	-	-	0.002	0.3	-	-	0.001	0.2
Barium	mg/L	0.00945	0.01068	47%	0.01011	0.01319	57%	-	-	0.0515	0.077	0.07	0.01673	-	0.018	-	0.010	-	0.013	-
Beryllium	mg/L	-	0.0050	0%	-	0.0005	0%	0.0053	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	-	0.010	2%	-	0.010	6%	1.5	-	0.17	0.030	0.082	-	-	0.019	0.01	-	-	0.011	0.01
Cadmium	mg/L	-	0.0000200	0%	-	0.00002	8%	0.000029	-	0.00024	0.00002	0.0001	-	-	0.00003	1.1	-	-	0.00002	0.7
Chromium	mg/L	0.0010	0.0010	8%	0.0018	0.0020	27%	0.0047	-	0.029	0.003	0.013	0.003	0.5	0.003	0.5	0.0018	0.4	0.0020	0.4
Cobalt	mg/L	0.0002	0.0003	4%	0.0002	0.0002	20%	-	-	0.080	0.0010	0.031	0.004	-	0.004	-	0.0004	-	0.0004	-
Copper	mg/L	-	0.0009	38%	0.0012	0.0018	64%	0.0047	0.30	0.112	0.004	0.045	-	-	0.006	1.4	-	-	0.0021	0.4
Iron	mg/L	0.04	0.05	19%	0.18	0.36	86%	1.2	-	0.33	0.002	0.13	0.051	0.04	0.060	0.05	0.17	0.1	0.34	0.3
Lead	mg/L	0.00016	0.00020	13%	0.00029	0.00087	35%	0.001	0.20	0.0033	0.0002	0.001	0.0003	0.3	0.0004	0.4	0.00029	0.3	0.00084	0.8
Manganese	mg/L	0.00260	0.01000	32%	0.00386	0.01000	48%	-	-	0.86	0.00006	0.33	0.043	-	0.050	-	0.006	-	0.01221	-
Mercury	mg/L	-	0.00010	0%	-	0.00010	2%	0.000026	-	0.0024	0.001	0.001	-	-	0.0003	9.8	-	-	0.00011	4.2
Molybdenum	mg/L	0.00306	0.00500	38%	0.00288	0.00500	46%	0.073	-	0.041	0.012	0.023	0.006	0.08	0.007	0.1	0.0030	0.04	0.0051	0.07
Nickel	mg/L	0.0032	0.0050	10%	0.0031	0.0050	92%	0.083	0.50	0.17	0.002	0.064	0.011	0.1	0.012	0.1	0.004	0.04	0.0054	0.07
Selenium	mg/L	-	0.001	0%	-	0.001	0%	0.001	-	0.033	0.008	0.02	-	-	0.003	3.1	-	-	0.0011	1.1
Silver	mg/L	-	0.00010	4%	-	0.00010	10%	0.0001	-	0.0012	0.0001	0.001	-	-	0.0002	1.5	-	-	0.00010	1.0
Thallium	mg/L	-	0.0001	0%	-	0.0001	0%	0.0008	-	0.0014	0.0003	0.001	-	-	0.0002	0.2	-	-	0.00010	0.1
Uranium	mg/L	0.00213	0.00299	100%	0.00252	0.00468	98%	0.015	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	-	0.001	0%	0.001	0.001	11%	0.006	-	0.0044	0.001	0.002	-	-	0.001	0.2	-	-	0.0010	0.2
Zinc	mg/L	-	0.009	8%	0.003	0.006	25%	0.03	0.50	0.094	0.015	0.045	-	-	0.014	0.5	-	-	0.0064	0.2

NOTES

1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT.
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE.
6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT

Table 7-3.20 Predicted Water Quality in the Mary River under Mean Flow Conditions (All Discharges)

Parameter	Units	Baseline Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	MMER	Discharge Scenario						WATER QUALITY IN MARY RIVER AFTER EAST POND DISCHARGE (FROM TABLE 7-3.18)		WATER QUALITY IN MARY RIVER AFTER ROM AND MAIN STOCKPILE DISCHARGE			
							Flows Used						Mean Volume of Effluent Discharged from Tributary, East Pond and Open Pit = 4,747,262 m3/yr Mean Volume to mix in Mary River = 78,185,678 m3/yr		Mean Volume after Discharge of Tributary, East Pond, Open Pit and Mary River Upstream of MR-12 = 82,932,940 m^3/yr Mean Volume of ROM Pond = 18,203 m^3/yr Mean Volume of Effluent from Main Ore Stockpiles = 143,489 m^3/yr Total Ore Effluent = 161,692 m^3/yr Additional Dilution in Mary River = 5,333,330 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects			Ore Runoff (Based on Lysimeter Monitoring Results of Bulk Sample Ore Stockpile)						Mean Baseline	90th Percentile Baseline	Mean Baseline	HQ	90th Percentile Baseline	HQ
							Lump Ore Total Metals (2010-09-07)	Lump Ore Total Metals (2010-09-19)	Fine Ore Total Metals (2010-09-07)	Fine Ore Total Metals (2010-09-19)	Mean Ore Stockpile Source Terms	95th Percentile Ore Stockpile Source Terms						
pH	0	7.83	8.20		6.5 - 9.0	-	5.76	5.93	6.68	6.48	6.21	6.65	7.8	8.2	7.8	-	8.2	-
Hardness	mg/L $CaCO_3$	58	105		-	-												
Aluminum	mg/L	0.191	0.394	81%	0.94	-	0.127	<0.015	<0.02	<0.06	0.044	0.112	0.19	0.39	0.19	0.2	0.39	0.4
Antimony	mg/L	-	0.0001	0%	-	-	<0.0005	<0.0005	<0.002	<0.002	0.001	0.001	-	0.00015	-	-	0.00015	-
Arsenic	mg/L	-	0.0010	4%	0.005	0.50	<0.0005	<0.0005	<0.002	<0.002	0.001	0.001	-	0.0010	-	-	0.0010	0.2
Barium	mg/L	0.01011	0.01319	47%	-	-	0.0236	0.0251	0.0213	0.0115	0.020	0.025	0.010	0.013	0.010	-	0.013	-
Beryllium	mg/L	-	0.0005	0%	0.0053	-	<0.0025	<0.0025	<0.01	<0.01	0.003	0.005	-	-	-	-	-	-
Boron	mg/L	-	0.010	2%	1.5	-	0.16	0.16	0.21	0.31	0.210	0.295	-	0.010	-	-	0.011	0.007
Cadmium	mg/L	0.00003	0.00010	0%	0.000029	-	0.000203	0.000198	<0.0002	0.00057	0.00027	0.00051	-	0.00002	-	-	0.00003	0.9
Chromium	mg/L	0.0018	0.0020	8%	0.0047	-	<0.0025	<0.0025	<0.01	<0.01	0.003	0.0050	0.0018	0.0020	0.0018	0.4	0.0020	0.4
Cobalt	mg/L	0.0002	0.0002	4%	-	-	0.09740	0.1080	0.0462	0.1400	0.098	0.1352	0.0003	0.0004	0.00058	-	0.00059	-
Copper	mg/L	0.0012	0.0018	38%	0.0047	0.30	0.00183	<0.0025	<0.002	<0.01	0.002	0.0045	-	0.0020	-	-	0.0019	0.4
Iron	mg/L	0.18	0.36	19%	1.2	-	0.825	0.031	0.041	0.082	0.24	0.714	0.17	0.34	0.17	0.1	0.34	0.3
Lead	mg/L	0.00029	0.00087	13%	0.001	0.20	<0.0003	0.001	<0.001	<0.001	0.0005	0.0009	0.00029	0.00084	0.00029	0.3	0.00084	0.8
Manganese	mg/L	0.00386	0.01000	32%	-	-	18.4	21.5	65.5	112	54.4	105.0	0.005	0.01147	0.197	-	0.203	-
Mercury	mg/L	-	0.00010	0%	0.000026	-	<0.00001	0.00004	<0.00001	<0.00001	0.00001	0.00003	-	0.00011	-	-	0.00011	4.0
Molybdenum	mg/L	0.00288	0.00500	38%	0.073	-	<0.00025	<0.00025	<0.001	0.0012	0.0005	0.001	0.0030	0.0051	0.0030	0.04	0.0051	0.1
Nickel	mg/L	0.0031	0.0050	10%	0.083	0.50	0.0977	0.107	0.035	0.113	0.088	0.112	0.0034	0.0053	0.0036	0.04	0.005	0.1
Selenium	mg/L	**-**	**0.001**	0%	0.001	-	<0.005	0.0051	<0.02	<0.02	0.007	0.010	**-**	0.0011	-	**-**	0.0011	1.1
Silver	mg/L	-	0.00010	4%	0.0001	-	<0.00005	<0.00005	<0.0002	<0.0002	0.00006	0.00010	-	0.00010	-	-	0.00010	1.0
Thallium	mg/L	-	0.0001	0%	0.0008	-	<0.0005	<0.0005	<0.002	<0.002	0.001	0.001	-	0.00010	-	-	0.00010	0.1
Uranium	mg/L	0.00252	0.00468	100%	0.015	-	0.00010	<0.00005	<0.0002	<0.0002	0.00008	0.00010	-	-	-	-	-	-
Vanadium	mg/L	0.001	0.001	0%	0.006	-	<0.005	<0.005	<0.02	<0.02	0.006	0.010	-	0.0010	-	-	0.0010	0.2
Zinc	mg/L	0.003	0.006	8%	0.03	0.50	<0.005	<0.015	<0.02	<0.06	0.013	0.027	-	0.0063	-	-	0.0063	0.2

NOTES
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON
6. DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT

Table 7-3.21 Predicted Water Quality in the Mary River under 10-Year Dry Conditions (All Discharges)

Parameter	Units	Baseline Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	MMER	Discharge Scenario						WATER QUALITY IN MARY RIVER AFTER EAST POND DISCHARGE (TABLE 7-3.19)		WATER QUALITY IN MARY RIVER AFTER ROM AND MAIN STOCKPILE DISCHARGE			
							Flows Used						10-Year Low Flow Volume of Effluent Discharged from Tributary, East Pond and Open Pit = 3,133,194 m3/yr 10-Year Low Flow Volume to mix in Mary River = 53,166,261 m3/yr		10-Year Low Flow Volume after Discharge of Tributary, East Pond, Open Pit and Mary River Upstream of MR-12 = 56,299,454 m^3/yr 10-Year Low Flow Volume of ROM Pond = 12,378 m^3/yr 10-Year Low Flow Volume of Effluent from Main Ore Stockpiles = 97,573 m^3/yr Total Ore Effluent = 109,951 m^3/yr Additional Dilution in Mary River = 3,626,664 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects			Ore Runoff (Based on Lysimeter Monitoring Results of Bulk Sample Ore Stockpile)						Mean Baseline	90th Percentile Baseline	Mean Baseline	HQ	90th Percentile Baseline	HQ
							Lump Ore Total Metals (2010-09-07)	Lump Ore Total Metals (2010-09-19)	Fine Ore Total Metals (2010-09-07)	Fine Ore Total Metals (2010-09-19)	95th Percentile Ore Stockpile For Mean Flows Source Terms	Ore Stockpile Source Terms (Dry Year)						
pH	0	7.83	8.20		6.5 - 9.0	-	5.76	5.93	6.68	6.48	6.65	6.65	7.83	8.01	7.82	-	8.0	-
Hardness	mg/L $CaCO_3$	58	105		-	-												
Aluminum	mg/L	0.191	0.394	81%	0.94	-	0.127	<0.015	<0.02	<0.06	0.112	0.170	0.20	0.39	0.20	0.2	0.39	0.4
Antimony	mg/L	-	0.0001	0%	-	-	<0.0005	<0.0005	<0.002	<0.002	0.001	0.002	-	0.000162	-	-	0.00016	-
Arsenic	mg/L	-	0.0010	4%	0.005	0.50	<0.0005	<0.0005	<0.002	<0.002	0.001	0.002	-	0.00103	-	-	0.00103	0.2
Barium	mg/L	0.01011	0.01319	47%	-	-	0.0236	0.0251	0.0213	0.0115	0.025	0.038	0.010	0.013	0.011	-	0.013	-
Beryllium	mg/L	-	0.0005	0%	0.0053	-	<0.0025	<0.0025	<0.01	<0.01	0.005	0.008	-	-	-	-	-	-
Boron	mg/L	-	0.010	2%	1.5	-	0.16	0.16	0.21	0.31	0.295	0.447	-	0.011	-	-	0.011	0.008
Cadmium	mg/L	0.00003	0.00010	0%	0.000029	-	0.000203	0.000198	<0.0002	0.00057	0.00051	0.00078	-	0.000021	-	-	0.000027	0.9
Chromium	mg/L	0.0018	0.0020	8%	0.0047	-	<0.0025	<0.0025	<0.01	<0.01	0.0050	0.008	0.0018	0.0020	0.0018	0.4	0.0020	0.4
Cobalt	mg/L	0.0002	0.0002	4%	-	-	0.09740	0.1080	0.0462	0.1400	0.1352	0.205	0.0004	0.0004	0.0008	-	0.0008	-
Copper	mg/L	0.0012	0.0018	38%	0.0047	0.30	0.00183	<0.0025	<0.002	<0.01	0.0045	0.007	-	0.0021	-	-	0.0020	0.4
Iron	mg/L	0.18	0.36	19%	1.2	-	0.825	0.031	0.041	0.082	0.714	1.08	0.17	0.34	0.17	0.1	0.35	0.3
Lead	mg/L	0.00029	0.00087	13%	0.001	0.20	<0.0003	0.001	<0.001	<0.001	0.0009	0.001	0.00029	0.00084	0.0003	0.3	0.00084	0.8
Manganese	mg/L	0.00386	0.01000	32%	-	-	18.4	21.5	65.5	112	105.0	159.1	0.006	0.012	0.30	-	0.30	-
Mercury	mg/L	-	0.00010	0%	0.000026	-	<0.00001	0.00004	<0.00001	<0.00001	0.00003	0.00005	-	0.00011	-	-	0.00011	4.2
Molybdenum	mg/L	0.00288	0.00500	38%	0.073	-	<0.00025	<0.00025	<0.001	0.0012	0.001	0.0017	0.0030	0.0051	0.0030	0.04	0.0051	0.1
Nickel	mg/L	0.0031	0.0050	10%	0.083	0.50	0.0977	0.107	0.035	0.113	0.112	0.170	0.004	0.0054	0.0038	0.05	0.0057	0.1
Selenium	mg/L	**-**	**0.001**	0%	0.001	-	<0.005	0.0051	<0.02	<0.02	0.010	0.015	**-**	0.0011	-	**-**	0.0011	1.1
Silver	mg/L	-	0.00010	4%	0.0001	-	<0.00005	<0.00005	<0.0002	<0.0002	0.0001	0.0002	-	0.00010	-	-	0.00010	1.0
Thallium	mg/L	-	0.0001	0%	0.0008	-	<0.0005	<0.0005	<0.002	<0.002	0.001	0.002	-	0.00010	-	-	0.00011	0.1
Uranium	mg/L	0.00252	0.00468	100%	0.015	-	0.00010	<0.00005	<0.0002	<0.0002	0.0001	0.0002	-	-	-	-	-	-
Vanadium	mg/L	0.001	0.001	0%	0.006	-	<0.005	<0.005	<0.02	<0.02	0.010	0.015	-	0.0010	-	-	0.0010	0.2
Zinc	mg/L	0.003	0.006	8%	0.03	0.50	<0.005	<0.015	<0.02	<0.06	0.027	0.041	-	0.0064	-	-	0.0065	0.2

NOTES:
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT.
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
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6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.

Residual Effects Rating

Magnitude

Based on historic water quality monitoring results (chloride results with a mean of 117 mg/L and 90th percentile concentration of 159 mg/L downstream of the deposits), choride results range from below the threshold (CCME PAL criterion for chloride) to occasionally above but within the same order of magnitude of the threshold, representing a Level I magnitude.

Duration

Discharge of exploration drilling runoff into Mary River will be required during the Construction and Operation phases of the Project. A Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when exploration drilling is scheduled. A Level II frequency rating was assigned.

Extent

The extent of the potential effect is likely to be limited to the area of mixing in Mary River. A Level I extent rating was assigned.

Reversibility

The potential effects associated with the discharge of exploration drilling runoff into Mary River are anticipated to be partially reversible. A Level II reversibility rating was assigned.

Significance – SWSQ-12 – Exploration Drilling Runoff

Based on these ratings, discharge of exploration drilling runoff into Mary River is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence is Moderate due to the semi-quantitative nature of the assessment.

Pit Lake Water and Waste Rock Discharges to Mary River in Post-Closure – Impact Statement SWSQ-13

At the end of mining, the open pit will gradually fill with water from precipitation; time is estimated at 85 to 147 years, depending on annual precipitation, evaporation and other factors (Knight Piésold, 2008).

During the years that the pit is filling, runoff will continue to discharge to tributary F0 and the Mary River from the East Waste Rock Stockpile.

AMEC (2012b) developed water quality estimates for pit water for the final year of mining (Year 21), which were applied in a water quality model under the assumption that, once the pit has filled, in each subsequent (post-Closure) year all precipitation into the open pit will accumulate and spill over the southwest edge facing the Mary River, behaving like a spillway, and that water will be released during the open water period according to the natural hydrograph.

Based on pit water quality for Year 21 of mining, it is possible the water will have a pH of around 4.2, which is outside of the pH range of the MMER (6.0 to 9.0). Adjustment of pH will be carried out periodically through post-closure using either batch lime treatment or in-line treatment, drawing down the pit lake periodically. As mentioned in Section 3.4.1.6, the mass loading modelling carried out is based on

conservative assumptions and Baffinland is continuing to study the geochemistry of waste rock and ore to further refine predictions and management plans.

Residual Effects Ratings

Magnitude

The estimated water quality in the Mary River from pit water and east waste rock stormwater discharges, assuming no treatment to adjust pH of pit water, is presented in Table 7-3.22. The mass balance modelling indicates that Level I magnitude effects to water quality will occur under low flow conditions, with a calculated HQ between 1 and 10 for mercury, selenium and silver. It is noted that an HQ >10 was calculated for mercury within the F0 tributary, upstream of fish; however, since the assessment of water and sediment quality is based on fish as the receptor, the effects assessment considers the resultant water quality at fish habitat within the Mary River, where all parameters have an HQ value less than 10.

Duration

The effects associated with the discharge of pit water and waste rock runoff into the Mary River are permanent; Level III duration. The waste rock seepage will run off into the Mary River starting in the first year post-closure, whereas the pit water is not expected to discharge to the Mary River until the pit fills, after 80 years or more.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when exploration drilling is scheduled. A Level II frequency rating was assigned.

Extent

The extent of the potential effect is likely to be limited to the Mine Site freshwater LSA; a Level I extent rating was assigned.

Reversibility

The effects associated with the discharge of pit water and waste rock runoff into the Mary River is partially reversible. A Level II reversibility rating was assigned.

Significance – SWSQ-13 – Pit Lake Water and Waste Rock Discharges to Mary River in Post-Closure

Based on these ratings, discharge of pit water and stormwater from the East Waste Rock Stockpile into the Mary River is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence (Table 7-3.15) is Medium, due to the assumptions made in the mass loading models and the consequently highly conservative nature of the effect prediction.

Table 7-3.22 Predicted Water Quality in the Mary River During Post-closure Due to Discharges of Pit Water and Waste Rock Stormwater under 10-Year Low Flow Conditions

Parameter	Units	Baseline Quality in Trib F0 (F0-01, F0-05)			Baseline Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	MMER (Mean Monthly)	Discharge Scenario			COMBINED EFFLUENT DISCHARGE FROM THE EAST WASTE ROCK POND	WATER QUALITY IN RECEIVING WATERS							
										Flows Used			10-Year Low Flow Volume of Effluent from East Pond = 244,291 m^3/yr 10-Year Low Flow Volume of Effluent from Open Pit = 296,971 m^3/yr	WATER QUALITY IN TRIB MR-12 (U/S OF FISH HABITAT) 10-Year Low Flow Volume of Effluent Discharged from East Pond and Open Pit = 541,262 m^3/yr 10-Year Low Flow Volume to mix at MR-12 = 2,740,417 m^3/yr				WATER QUALITY IN MARY RIVER AT MR-12 (FISH HABITAT) 10-Year Low Flow Volume of Effluent Discharged from Tributary, East Pond & Open Pit = 3,281,679 m^3/yr 10-Year Low Flow Volume to mix in Mary River = 53,166,261 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration	90th Percentile Concentration	% Detects			Baseline Concentrations			Mean	Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ
										Pit Water Source Terms (Year 21)	East Waste Rock Source Term (Mean Flows)	East Waste Rock Source Terms (Dry Year)									
pH	0	8.01	8.31		7.83	8.20		6.5 - 9.0	-	4.20	6.9	6.9	5.42	7.58	-	7.83	-	7.82	-	8.18	-
Hardness	mg/L $CaCO_3$	84	133		58	105		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	5.7	18.6		8.3	17.0		120	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Suspended Solids	mg/L	-	2		3	6		15	15.00	-	-	-	-	-	-	-	-	-	-	-	-
Total Alkalinity	mg/L $CaCO_3$	74	108		47	81		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia	mg/L	0.06	0.11		0.05	0.07		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	0.1	0.1		-	0.1		13	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite	mg/L	0.011	0.017		0.010	0.014		0.06	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphate	mg/L	2	4		3	5		-	-	239	26	39	149	26	-	28	-	4	-	6	-
Total Phosphorous	mg/L	0.013	0.030		0.013	0.026		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	mg/L	0.020	0.042	81%	0.191	0.394	100%	0.94	-	6.4	0.095	0.144	3.56	0.60	0.6	0.62	0.7	0.21	0.229	0.41	0.4
Antimony	mg/L	-	0.0004	0%	-	0.0001	2%	-	-	0.012	0.003	0.004	0.01	-	-	0.0017	-	-	-	0.00019	-
Arsenic	mg/L	-	0.0010	4%	-	0.0010	8%	0.005	0.50	0.011	0.002	0.003	0.007	-	-	0.0020	0.4	-	-	0.00106	0.2
Barium	mg/L	0.00945	0.01068	47%	0.01011	0.01319	57%	-	-	0.0515	0.051	0.077	0.06	0.01831	-	0.019	-	0.011	-	0.014	-
Beryllium	mg/L	-	0.0050	0%	-	0.0005	0%	0.0053	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	-	0.010	2%	-	0.010	6%	1.5	-	0.17	0.020	0.030	0.105	-	-	0.026	0.02	-	-	0.011	0.01
Cadmium	mg/L	-	0.0000200	0%	-	0.00002	8%	0.000029	-	0.00024	0.00002	0.00002	0.0001	-	-	0.000040	1.4	-	-	0.000021	0.7
Chromium	mg/L	0.0010	0.0010	8%	0.0018	0.0020	27%	0.0047	-	0.029	0.002	0.003	0.017	0.004	0.8	0.0037	0.8	0.0019	0.406	0.0021	0.4
Cobalt	mg/L	0.0002	0.0003	4%	0.0002	0.0002	20%	-	-	0.080	0.0006	0.0010	0.044	0.008	-	0.0076	-	0.0006	-	0.00063	-
Copper	mg/L	-	0.0009	38%	0.0012	0.0018	64%	0.0047	0.30	0.112	0.003	0.004	0.063	-	-	0.011	2.4	-	-	0.0023	0.5
Iron	mg/L	0.04	0.05	19%	0.18	0.36	86%	1.2	-	0.33	0.001	0.002	0.18	0.064	0.1	0.072	0.06	0.17	0.144	0.34	0.3
Lead	mg/L	0.00016	0.00020	13%	0.00029	0.00087	35%	0.001	0.20	0.0033	0.0002	0.0002	0.002	0.0005	0.5	0.00049	0.5	0.00030	0.299	0.00085	0.8
Manganese	mg/L	0.00260	0.01000	32%	0.00386	0.01000	48%	-	-	0.86	0.00004	0.00006	0.47	0.080	-	0.087	-	0.008	-	0.01445	-
Mercury	mg/L	-	0.00010	0%	-	0.00010	2%	0.000026	-	0.0024	0.00045	0.00068	0.002	-	-	0.00035	13.6	-	-	0.00011	4.4
Molybdenum	mg/L	0.00306	0.00500	38%	0.00288	0.00500	46%	0.073	-	0.041	0.008	0.012	0.028	0.007	0.1	0.0088	0.12	0.0031	0.043	0.0052	0.07
Nickel	mg/L	0.0032	0.0050	10%	0.0031	0.0050	92%	0.083	0.50	0.17	0.002	0.002	0.092	0.018	0.2	0.019	0.2	0.004	0.048	0.0058	0.07
Selenium	mg/L	-	0.001	0%	-	0.001	0%	0.001	-	0.033	0.005	0.008	0.02	-	-	0.0044	4.4	-	-	0.0012	1.2

Table 7-3.22 Predicted Water Quality in the Mary River During Post-closure Due to Discharges of Pit Water and Waste Rock Stormwater under 10-Year Low Flow Conditions (Cont'd)

Parameter	Units	Baseline Quality in Trib F0 (F0-01, F0-05)			Baseline Quality in Mary River (E0-01, E0-03, E0-10)			Receiving Water Quality Objectives (See Note 5)	MMER (Mean Monthly)	Discharge Scenario			COMBINED EFFLUENT DISCHARGE FROM THE EAST WASTE ROCK POND	WATER QUALITY IN RECEIVING WATERS							
										Flows Used			10-Year Low Flow Volume of Effluent from East Pond = 244,291 m^3/yr 10-Year Low Flow Volume of Effluent from Open Pit = 296,971 m^3/yr	WATER QUALITY IN TRIB MR-12 (U/S OF FISH HABITAT) 10-Year Low Flow Volume of Effluent Discharged from East Pond and Open Pit = 541,262 m^3/yr 10-Year Low Flow Volume to mix at MR-12 = 2,740,417 m^3/yr				WATER QUALITY IN MARY RIVER AT MR-12 (FISH HABITAT) 10-Year Low Flow Volume of Effluent Discharged from Tributary, East Pond & Open Pit = 3,281,679 m^3/yr 10-Year Low Flow Volume to mix in Mary River = 53,166,261 m^3/yr			
		Mean Concentration	90th Percentile Concentration	% Detects	Mean Concentration	90th Percentile Concentration	% Detects			Baseline Concentrations			Mean	Mean	HQ	90th Percentile	HQ	Mean	HQ	90th Percentile	HQ
										Pit Water Source Terms (Year 21)	East Waste Rock Source Term (Mean Flows)	East Waste Rock Source Terms (Dry Year)									
Silver	mg/L	-	0.00010	4%	-	0.00010	10%	0.0001	-	0.0012	0.0001	0.0001	0.001	-	-	0.00020	2.0	-	-	0.00011	1.1
Thallium	mg/L	-	0.0001	0%	-	0.0001	0%	0.0008	-	0.0014	0.0002	0.0003	0.001	-	-	0.00023	0.3	-	-	0.00011	0.1
Uranium	mg/L	0.00213	0.00299	100%	0.00252	0.00468	98%	0.015	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	-	0.001	0%	0.001	0.001	11%	0.006	-	0.0044	0.001	0.001	0.003	-	-	0.0013	0.2	-	-	0.0010	0.2
Zinc	mg/L	-	0.009	8%	0.003	0.006	25%	0.03	0.50	0.094	0.010	0.015	0.058	-	-	0.017	0.6	-	-	0.0066	0.2

NOTES:
1. MODEL ASSUMES COMPLETE NEAR INSTANTANEOUS MIXING OF EFFLUENT AND RECEIVING WATER.
2. NO MEAN CONCENTRATION CALCULATED WHERE THE MAJORITY OF SAMPLING RESULTS WERE BELOW THE METHOD DETECTION LIMIT.
3. EFFLUENT SOURCE TERMS PROVIDED BY AMEC (JANUARY, 2012).
4. EFFLUENT SOURCE TERM OF 0.001 USED IN CALCULATIONS FOR IRON.
5. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROECTION OF AQUATIC LIFE (PAL) (2003), CONTINUOUS CONCENTRATION (CHRONIC) NATIONAL RECOMMENDED WATER QUALITY CRITERIA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (2006)), BRITISH COLUMBIA MINISTRY OF ENVIRONMENT APPROVED AND WORKING WATER QUALITY GUIDELINES OR SUTER THRESHOLDS, AS APPLICABLE.
6. IN ORDER TO ESTIMATE EFFLUENT SOURCE TERMS, HALF THE METHOD DETECTION LIMIT OF A PARAMETER WAS ADOPTED WHERE MORE THAN HALF OF THE RESULTS FOR THAT PARAMETER WERE NON-DETECT (I.E. LESS THAN THE MDL). THESE EFFLUENT SOURCE TERMS ARE HIGHLIGHTED IN BLUE.
7. RESULTS WITH AN HQ GREATER THAN 1 ARE HIGHLIGHTED IN ORANGE, TO FOCUS DISCUSSION IN THE EFFECTS ASSESSMENT.

Exploration Camp WWTF Effluent Discharge to Sheardown Lake - Impact Statement SWSQ-14

Project-related discharges of treated sewage effluent may result in changes to surface water and sediment quality in the Mine Site LSA. Sewage from the existing exploration camp will be treated in the existing packaged WWTF, discharged to polishing ponds, and then discharged via an outfall to Sheardown Lake. It is expected that this camp and associated WWTF will continue to operate through the Operation phase.

Potential effects on water and sediment quality associated with the discharge of sewage include:

- Increases in BOD and reduction in dissolved oxygen;
- Increases in nutrients such as nitrogen and phosphorus;
- Increases in metal concentrations in water and sediment;
- Increases in faecal coliforms,
- Changes in temperature profiles; and
- Increases in other substances such as petroleum hydrocarbon constituents.

To mitigate potential effects, WWTFs will be operated at permanent camp locations at the Mine Site, Milne Port (Construction phase only), and Steensby Port, with the two latter WWTFs discharging to the marine environment. During the Operation phase, sewage waste will be collected and incinerated, so no sewage effluent discharge will occur at Milne Port.

In the Mine Site LSA, two independently operated WWTFs will be operated to serve the two camps during the Construction, Operation and Decommissioning phases. The WWTFs will consist of modular rotating biological contactors (RBC) designed to meet current water licence requirements. Treated effluent from the existing exploration camp WWTF will continue to be discharged into the northern section of Sheardown Lake (to the west of the main tributary) through an insulated heat-traced pipeline (Volume 3, Figure 3-2.3). Treated discharge from the new WWTF will be directed to the Mary River during periods of freshet flow (approximately mid-June through mid-September). The new WWTF will operate with the same treatment objectives outlined in the current water licence, described in Volume 3.0.

In the Railway Alignment LSA, sewage from the construction camps will be collected in holding tanks and trucked to the WWTFs at either the Mine Site or Steensby Port WWTF.

Discharge of treated effluent from the exploration camp WWTF to Sheardown Lake (SWSQ-14) is assessed below, followed by an assessment of the Mine Site WWTF to Mary River (SWSQ-15).

Residual Effects Rating

Magnitude

Baseline lake water quality was measured in Sheardown Lake during the open-water seasons of 2006, 2007 and 2008, and during the ice-cover seasons of 2007 and 2009. Open-water mean baseline concentrations were calculated for key water quality parameters for Sheardown Lake NW using the data collected in 2007 and 2008; data collected in 2006 were excluded due to limited quantity and quality.

Actual sewage effluent quality and discharge rates to Sheardown Lake NW in August 2009 were used to predict sewage effluent quality.

Considering the WWTF is currently operating at this location and operating parameters are well defined, modelling focused on determining the magnitude of effects at a range of extents (whole lake, 0.01 km^2 and 0.1 km^2) and did not contemplate the determination of maximum effluent quality that would meet CCME PAL guidelines in the receiving environment. Potential effects of the discharge of treated sewage effluents from the 150 person exploration camp on water quality in Sheardown Lake were assessed using a mass balance

modelling approach. Lake volume was obtained from the bathymetric survey conducted in August 2007. The mass-balance modeling approach assumed a "closed" system (i.e., no inflow or outflow), open water conditions, no settling or degradation of effluent parameters (which is a conservative approach with respect to assessing effects in Sheardown Lake), and cumulative loading associated with effluent releases. To maintain a conservative approach, the loadings associated with these cumulative releases were calculated and assumed to be instantaneously released to the lake. Results of the modelling are shown in Table 7-3.23.

Table 7-3.23 Resulting Water Quality in Sheardown Lake from Sewage Effluent Discharge

Key Indicator	Sheardown Lake Baseline	Sewage Effluent Quality	Sheardown Lake Resulting		
			Whole Lake	0.01 km^2 Area	0.1 km^2 Area
pH (pH unit)	8.00	7.65	8.00	7.95	8.00
TSS (mg/L)	2	11.8	2	3	2
TKN (mg/L)	0.12	2.3	0.12	0.24	0.13
Ammonia N (mg/L)	<0.02	0.083	0.01	0.01	0.01
Total P (mg/L)	0.003	0.21	0.003	**0.014**[1]	0.004
BOD (mg/L)	<1	6.3	0.5	0.8	0.5
Faecal Coliforms (CFU/100 ml)	<1	<10	0.5	1.0	0.6

NOTE(S):
1. BOLDED VALUES EXCEED CCME GUIDELINE.

The mass balance modelling indicates that the change in total phosphorous may have a localized effect (0.01 km^2) that exceeds the applicable CCME PAL guideline; however, this effect is not anticipated to occur at the scale of 0.1 km^2 (which was arbitrarily selected to illustrate the relative extent of the effect) or throughout the whole lake. The predicted BOD concentrations do not raise concerns that dissolved oxygen concentrations will be discernibly altered from baseline conditions. Essentially, the ratio of discharge volume to lake volume is so small that little effect is expected. Negligible to minor magnitude residual water quality effects may be associated with discharge of sewage effluent from the 150-person exploration camp into Sheardown Lake; therefore a Level I magnitude rating was assigned.

Water Licence compliance monitoring and routine water quality monitoring are expected to be successful in identifying potential effects before they arise, and adaptive management will be employed to reduce the risk of exceeding the CCME PAL guidelines.

Duration

The discharge of treated sewage effluents from the exploration camp will be required during all phases of the Project. A Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be continuous as discharge of sewage effluent will occur annually throughout the open water season, estimated to be 80 days. A Level III frequency rating was assigned.

Extent

The extent of the potential effect is limited to a small area (<100 m^2) surrounding the discharge location. A Level I extent rating was assigned.

Reversibility

The potential effects associated with discharge of sewage effluent from the 150 person exploration camp into Sheardown Lake are anticipated to be fully reversible, once the camp site is decommissioned. A Level I reversibility rating was assigned.

Significance – SWSQ-14 – Exploration Camp WWTF Effluent Discharge to Sheardown Lake

Based on the ratings criteria described above, discharge of sewage effluent from the exploration camp into Sheardown Lake is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence is Moderate due to the semi-quantitative nature of the assessment.

Mine Site WWTF Effluent Discharge to Mary River - Impact Statement SWSQ-15

Treated discharge from the new WWTF for the main Mine Site accommodation complex will accumulate in a large polishing pond for storage, and will be directed to the Mary River during freshet. The new WWTF will have the same treatment objectives outlined in the current water licence, described in Volume 3.0. During the Construction phase, the main WWTF will treat sewage from a larger camp than will be required during Operations, and will also receive sewage trucked from the two northerly railway construction camps. The average daily influent volume is estimated at 560 m^3/day (Volume 3, Table 3-1.1). During the Operation phase, once construction camps have been decommissioned, the daily influent volume will be reduced to approximately 170 m^3/day. Treated sewage will be stored in the polishing pond over the winter and will be decanted to the Mary River during periods of open water flow. The estimated 120,000 m^3 of sewage will be generated annually will discharged over a period of up to 90 days.

Magnitude

Background water quality was measured in the open-water season (June to September) of 2006, 2007 and 2008. Open-water season means were calculated for key water quality parameters at sampling locations E0-10. Water quality sampling included analysis of routine water quality parameters. Background flow rates were obtained from the hydrological survey conducted by KPL in 2007 and 2008.

Actual sewage effluent quality and rates discharged to Sheardown Lake NW in August 2009 were used in the model to reflect typical sewage effluent quality.

Since the WWTF is not currently operating at this location and operating parameters are yet to be defined, modelling focused on determining the magnitude of effects associated with a discharge quality identical to that observed from the exploration camp, as well as a maximum effluent quality that would meet CCME PAL guidelines in the receiving environment.

Potential effects of the discharge of treated sewage effluents at the Mine Site WTTF were assessed using a mass balance model. The modelled conditions for peak use during Construction assumed that sewage effluent would be discharged over 80 days between June and August. The model also assumed near instantaneous mixing and no degradation of effluent parameters (a conservative approach). Results of the modelling are shown in Table 7-3.24.

The results indicate that no key indicators are expected to exceed the applicable CCME PAL guidelines. This prediction assumes discharge quality will be similar to that observed at the existing exploration camp. The predicted BOD concentrations do not raise concerns that dissolved oxygen concentrations will be discernibly altered from baseline conditions, given the expected aeration rate in the Mary River during freshet flows. The ratio of sewage effluent discharge volume to receiving environment volume is so small that little effect is expected to be observed. Negligible to minor magnitude residual water quality effects may result from the discharge of sewage effluent from the Mine Site WWTF into the Mary River; therefore, a Level I magnitude rating was assigned.

Water Licence compliance monitoring and routine water quality monitoring are expected to be successful in identifying potential compliance issues as they arise, and adaptive management will be employed to reduce the risk of exceeding the CCME PAL guidelines.

Table 7-3.24 Resulting Water Quality in Mary River from Sewage Effluent Discharge

Key Indicator	Mary River Baseline	Sewage Effluent Quality	Mary River Resulting	Maximum Sewage Effluent Quality	Maximum Mary River Resulting
pH (pH unit)	7.90	7.65	7.90	*9.5*[2]	7.90
TSS (mg/L)	2.64	11.8	2.65	*35*[2]	2.65
TKN (mg/L)	0.13	2.3	0.13	100	0.16
Ammonia N (mg/L)	0.03	0.083	0.0276	650	0.25[3]
Total P (mg/L)	0.011	0.21	0.0108	25	0.019[4]
BOD (mg/L)	0.001[1]	6.3	0.003	*30*[2]	0.01
Faecal Coliforms (CFU/100 ml)	0.001[1]	<10	0.004	*1000*[2]	0.34

NOTE(S):

1. SHADED PARAMETERS WERE NOT MEASURED DURING BASELINE SAMPLING SO AN ARBITRARY LOW VALUE OF 0.001 WAS SELECTED TO ILLUSTRATE THAT THE RESULTING CONCENTRATION WILL NOT VARY CONSIDERABLY FROM THE BASELINE CONCENTRATION AND RESULT IN A CONCENTRATION OF CONCERN.
2. ITALICIZED PARAMETERS ARE MAXIMUM DISCHARGE CRITERIA SET BY THE NUNAVUT WATER BOARD.
3. CCME PAL FOR TOTAL AMMONIUM BASED ON pH 9.0 and T=0^{o}C. THIS VALUE WAS SELECTED AS A CONSERVATIVE CRITERION AS ALLOWABLE TOTAL AMMONIUM CONCENTRATION INCREASES FOR ALL pH < 9.0.
4. TOTAL P WITHIN SAME CCME TROPHIC LEVEL.

Duration

The discharge of treated sewage effluents from the Mine Site WWTF will be required during all phases of the Project. A Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be continuous as discharge of sewage effluent will occur annually throughout the open water season, estimated to be 80 days. A Level II frequency rating was assigned.

Extent

The extent of the potential effect is limited to the mixing area downstream of the confluence of the discharge point and Mary River; hence a Level I extent rating was assigned.

Reversibility

The potential effects are anticipated to be fully reversible once the camp site is decommissioned and rehabilitated. A Level I reversibility rating was assigned.

Significance – SWSQ-15 – Mine Site WWTF Effluent Discharge to the Mary River

Based on the ratings criteria described above, discharge of sewage effluent from the Mine Site WWTF into the Mary River is not expected to result in an adverse environmental effect on water and sediment quality in the Mine Site LSA. The residual effect is ranked as *Not Significant* (Table 7-3.14). The Level of Confidence is Medium due to the semi-quantitative nature of the assessment (Table 7-3.15).

3.4.2.3 Airborne Emissions

Potential effects on surface water and sediment quality associated with airborne emissions (key issues) identified in Section 3.5.2 are described below. Airborne emissions will include fugitive dust from construction and road use, as well as ore dust from open pit mining and material handling. These airborne emissions may affect watercourses throughout the Project area.

The potential effects and mitigation measures associated with each Project component and/or activity discussed below are summarized in Table 7-3.25. The prediction confidence associated with each residual effects prediction is summarized in Table 7-3.26.

Construction-Related Dust Emissions – Impact Statement SWSQ-16

Dust emissions will occur during the Construction phase within all five freshwater LSAs due to ground disturbance, vehicle traffic and quarrying. Similar dust emissions will be created during the Closure phase. These emissions will be mitigated by applying standard dust suppression techniques. By virtue of the fact that Construction and Closure phase airborne emissions are of short (Level I) duration, the residual effect after mitigation has been applied is *Not Significant*.

During the Operation phase, the mining, crushing, stockpiling and handling of ore will generate dust.

Operational Dust Deposition - Milne Port LSA

During the Operation phase, Milne Port will be used only intermittently every few years. No major dust deposition will occur as a result of this intermittent use, so the effect of dust deposition is expected to be negligible.

Operational Dust Deposition - Milne Inlet Tote Road LSA

During the Operation phase, the Tote Road will be used only intermittently every few years. No major dust deposition will occur as a result of this intermittent use, so the effect of dust deposition is expected to be negligible.

Operational Dust Deposition - Mine Site LSA

Magnitude

Predicted dust generation and dispersion associated with the various sources at the Mine Site during the Operation phase was calculated in Volume 5, and the modelled annual deposition of total suspended particulate (TSP) at the Mine Site during operations in shown on Figure 7-3.8.

Table 7-3.25 Effects Assessment Summary - Airborne Emissions

Effect		Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
SWSQ-16: Construction phase fugitive dust	**Negative** Water quality (TSS) All LSAs	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level I:** will occur for the construction phase	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-17: Increased TSS from Dust Deposition in Local Watercourses around the Mine Site	**Negative** Water quality (TSS) in Mine Site LSA	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant
	Negative Water quality (metals) in Mine Site LSA	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant
	Negative Sediment quality (metals) in Mine Site LSA	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level II:** beyond the LSA and within the RSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant
SWSQ-18: Operations dust – Railway LSA (rail traffic)	**Negative** Water quality (TSS and metals) in Railway LSA	**Level I:** Effect may results in a change less than threshold values	**Level I:** confined to the LSA	**Level I:** will rarely occur	**Level II:** will occur for the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
	Negative Sediment quality (TSS and metals) in Railway LSA	**Level I:** Effect may results in a change less than threshold values	**Level I:** confined to the LSA	**Level I:** will rarely occur	**Level II:** will occur for the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant
SWSQ-19: Operations dust dispersion – Steensby Port LSA (ore handling)	**Negative** Water quality (TSS) in Steensby Port LSA	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant
	Negative Water quality (metals) in Steensby Port LSA	**Level I:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant
	Negative Sediment quality (metals) in Steensby Port LSA	**Level II:** Effect may result in a change above but within one order of magnitude of threshold	**Level I:** confined to the LSA	**Level II:** will occur frequently	**Level II:** will occur for the operation phase (life of the Project)	**Level II:** effect is partially reversible after activity is complete	Not Significant

Table 7-3.26 Significance of Residual Effects from Dust Deposition

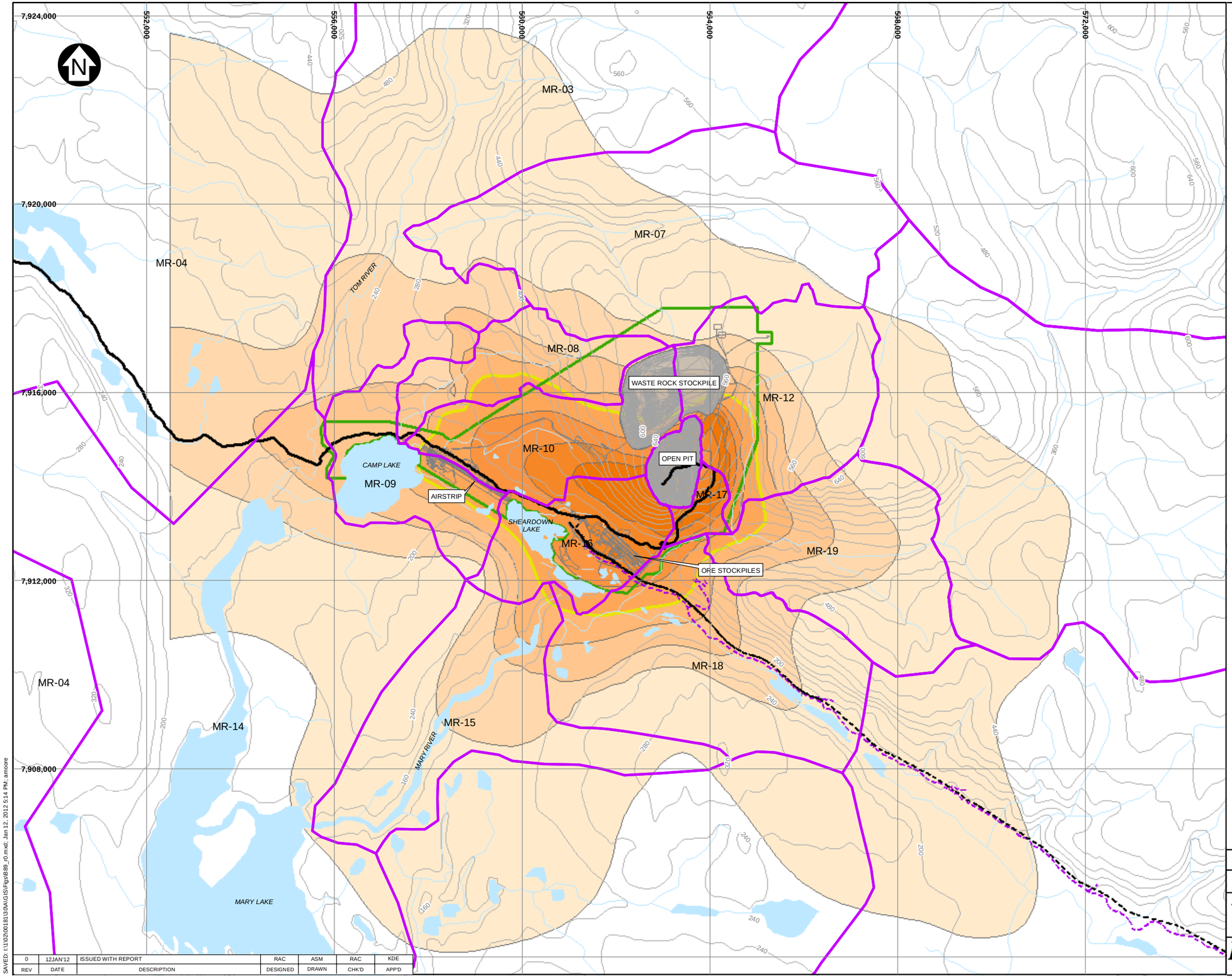
Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
SWSQ-16: Construction phase fugitive dust (all freshwater LSAs)	N	2	N/A	N/A
SWSQ-17-1: Deposition of airborne dust (TSS in water) at Mine Site during operations	N	2	N/A	N/A
SWSQ-17-2: Deposition of airborne dust (metals in water) at Mine Site during operations	N	2	N/A	N/A
SWSQ-17-3: Deposition of airborne dust (metals in sediment) at Mine Site during operations	N	2	N/A	N/A
SWSQ-18: Deposition of airborne dust (TSS, metals; water, sediment) along Railway during operations	N	2	N/A	N/A
SWSQ-19: Deposition of airborne dust (TSS, metals; water, sediment) at Steensby Port during operations	N	2	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

A portion of dust emissions falling on land will be transported by surface runoff into nearby waters, thereby potentially increasing TSS and metals concentrations in water and sediment. Resultant changes in water and sediment quality are a potential concern to freshwater biota through increased TSS, sedimentation of fish habitat, and sedimentation of incubating fish eggs.

The annual TSP contours presented in Figure 7-3.8 were interpreted to calculate TSS scenarios and deposition thickness. Table 7-3.27 presents the calculated thickness of dust deposition for each TSP deposition range.

TSP deposition was also established by watershed, so that the TSP loading could be related to total flows within each catchment to approximate potential TSS concentrations in each catchment. Table 7-3.28 presents the calculated dust loading within each of the key catchment areas at the Mine Site, and Table 7-3.30 summarizes the calculated TSS concentrations in key mine site catchments. The calculated TSS concentrations assume that 75 % of the dust accumulated over the 9-month winter period runs off into nearby watercourses over a 21-day period during freshet in June (assuming 25 % of winter dustfall is lost through dispersion of wind-blown snow).



LEGEND:

- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- CONTOUR
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- CATCHMENT

Annual TSP Dep. ($g/m^2/yr$)

- 2 - 7.5
- 7.5 - 15
- 15 - 30
- 30 - 55
- 55 - 120
- 120 - 240
- 240 - 480
- > 480

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOUR INTERVAL IS 40 METRES.
4. PROPOSED INFRASTRUCTURE PROVIDED BY HATCH, 2011.
5. ANNUAL TOTAL SUSPENDED PARTICULATE CONTOURS PROVIDED BY RWDI AIR INC.

SCALE 1 0.5 0 1 2 3 4 km

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12JAN'12	ISSUED WITH REPORT	RAC	ASM	RAC	KDE

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

TSP DEPOSITION AND CATCHMENT BOUNDARIES MINE SITE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	3

FIGURE 7-3.8 REV 0

Table 7-3.27 Thickness of TSP Deposition by TSP Depositional Range at the Mine Site

Zone	TSP Deposition Range (g/m2/year)		Area (m^2)	Thickness of Depositional Layer (mm)			
				Minimum		Maximum	
	Min	Max		Per Year	Project Life	Per Year	Project Life
1	2	7.5	128,919,493	0.0005	0.010	0.002	0.036
2	7.5	15	21,888,131	0.0017	0.036	0.003	0.072
3	15	30	11,019,892	0.0034	0.072	0.007	0.144
4	30	55	1,056,610	0.0069	0.144	0.013	0.265
5	55	120	2,533,020	0.0126	0.265	0.028	0.578
6	120	240	2,133,793	0.0275	0.578	0.055	1.156
7	240	480	1,466,385	0.0550	1.156	0.110	2.312
8	480	960	3,399,763	0.1101	2.312	0.220	4.624

Direct Deposition of TSP and TSS Runoff from Airborne Dust into Camp and Sheardown Lakes

One potential concern to freshwater biota (Section 4) is the deposition of dust in waterbodies. Sheardown and Camp Lakes are located closest to the mining and ore handling operations at the Mine Site and will receive direct deposition of dust as well as runoff of airborne dust on land.

Camp Lake is fed by catchments MR-08, MR-09 and MR-10, which would receive an annual cumulative deposition within the three catchments of 2,246,972,601 g of dust (total suspended particulate) (Table 7-3.28). Applying the highly conservative assumption that all sediment deposited within the three catchments reported to Camp Lake as bottom sediment as a worst case, 0.24 mm of dust would accumulate on the lake bottom each year.

By the same logic, Sheardown Lake is fed by catchment MR-16 only, and would receive deposition of 2,163,650,390 g of dust (total suspended particulate) on an annual basis (Table 7-3.28). Applying the same assumption that all sediment deposited within the catchment reported to Sheardown Lake as bottom sediment as a worst case, 0.54 mm of dust would accumulate on the lake bottom each year.

The deposition of dust into lakes is of concern to freshwater biota, and therefore the above estimates are carried forward to the freshwater biota effects assessment in Section 4.

SWSQ-17: Increased TSS from Dust Deposition in Local Watercourses around the Mine Site

Dust emissions from mining and ore handling will be deposited on the surrounding land, and will have the opportunity to runoff into local watercourses, increasing TSS and resulting in elevated metals concentrations in water and sediment. Each of these effects is assessed below.

Table 7-3.28 Total TSP Depositional Loadings for Key Mine Site Catchments

Annual TSP Deposition ($g/m^2/yr$)			MR-08	MR-09	MR-10	MR-12	MR-15	MR-16	MR-17	MR-18	MR-19
Min	Max	Med	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)
2	7.5	4.75				6,611,190	11,366,000	95,115		10,097,000	7,639,370
7.5	15	11.25	2,093,490	1,887,650	334,480	3,086,160	4,728,930	250,914		4,838,410	4,252,630
15	30	22.5	2,913,100	5,075,940	821,239	1,607,400	868,667	472,065		3,081,260	1,914,970
30	55	42.5	1,204,260	1,124,730	899,770	1,008,070	831,534	635,577		1,913,740	855,631
55	120	87.5	795,998	1,089,310	2,844,620	1,016,150	88,490	1,633,110	23,103	1,494,080	535,961
120	240	180		12,826	3,226,280	615,526		1,831,280	214,572	567,636	560,986
240	480	360			1,434,720	465,969		1,901,190	477,561	45,511	
480	960	720			484,055	389,767		1,341,370	583,350		
Totals (g/yr)			209,927,388	281,910,761	1,755,134,453	793,220,795	169,817,023	2,163,650,390	632,578,398	502,345,711	311,454,305

SWSQ-17-1: Increased TSS

Magnitude

How much dust will be available to runoff, and the distribution of that runoff over the year, is difficult to predict or model. Much of the year, dust will fall on snow, which will experience considerable blowing before spring freshet arrives in mid-June. When freshet arrives, runoff is rapid since much of the ground remains frozen early in freshet. It was assumed in the calculations presented in Table 7-3.30 that 9 months of accumulation of dust landing on snow would be released over a 21-day freshet period starting in mid- to late June. It was assumed that 25 % of the 9-month accumulation is dissipated over the winter with blowing snow.

The TSS threshold established for the assessment is based on the CCME PAL of +5 mg/L, with the values shown in Table 7-3.29 assigned for magnitude.

Table 7-3.29 Magnitude Thresholds for TSS in Surface Water

Effects Level	TSS Range (mg/L)	Colour
Negligible	>5	
Level I	5 to 50	
Level II	51 to 500	
Level III	>500	

By comparison, the MMER Schedule 4 has a TSS threshold of 15 mg/L and the NWB wastewater guideline has a TSS criterion of 35 mg/L. Calculated TSS concentrations under the various scenarios exceeding the CCME PAL thresholds (Table 7-3.29) are highlighted in Table 7-3.30. The effects magnitudes presented in Tabled 7-3.30 below are effects before mitigation is applied, and are shown for illustrative purposes.

Table 7-3.30 Calculated TSS Concentrations in Key Mine Site Catchments Due to Annual Dust Deposition (Without Mitigation)

Catchment	MR-08	MR-09	MR-10	MR-12	MR-15	MR-16	MR-17	MR-18	MR-19
Mean Flow (m3/s)	0.38	0.92	0.46	1	16	0.5	13.5	15	13.5
TSS (mg/L)	171	95	627	286	3	2,549	15	10	7

For catchments within the Mary River (MR-15, MR-17, MR-18 and MR-19), the added TSS increases due to dust deposition without mitigation are negligible to Level I magnitude. The calculated TSS additions are generally within an order of magnitude of the +5 mg/L threshold (and within the MMER threshold of TSS for 15 mg/L). However, the headwater catchments (MR-08, MR-09, MR-10, MR-12, and MR-16) are smaller with lower unit runoffs. Runoff water quality in MR-10 benefits from 40 % of catchment flows being collected in the west waste rock pond, which will provide for settlement of solids and will subsequently discharge at a maximum TSS concentration of 15 mg/L as required by the MMER.

The above estimates of TSS without mitigation underscore the importance of developing and implementing a stormwater management plan to capture runoff and settle solids before runoff reaches nearby watercourses. Stormwater facilities will target the most affected catchments to reduce TSS runoff into local watercourses, and it is expected that TSS can be reduced to the 5 to 50 mg/L range (a Level I magnitude effect). A target TSS concentration in adjacent watercourses of 15 mg/L has been identified. Iron and other metals will remain within levels that achieve a Level II magnitude for TSS metals effects in water, as

discussed below in SWSQ-19-2. This is the same TSS concentration which effluent discharges will meet to maintain compliance with MMER.

Duration

Ore dust (TSP) will be generated at the Mine Site during the Operation phase only. At Closure, with dust emissions ceasing, it is expected that TSS concentrations will reduce and stormwater management facilities can be decommissioned. A Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when freshet and the majority of rain falls in the Project area. A Level I frequency rating was assigned.

Extent

The extent of the potential effect is expected to be limited to the LSA; therefore, a Level I extent rating was assigned.

Reversibility

The potential effects associated with dust generated in the Mine Site LSA are anticipated to be partially reversible after the Operations phase is complete. A Level II reversibility rating was assigned.

Significance (SWSQ-17-1: Increased TSS)

Based on the ratings described above, dust generated by the Mine Site during Operation is predicted to result in a *Not Significant* adverse environmental effect on water and sediment quality in the Mine Site LSA. The Level of Confidence is Moderate due to the semi-quantitative nature of the assessment.

SWSQ-17-2: Metals in Ore Dust Runoff Affecting Water Quality

Related to the TSS issue described above, ore dust deposited on water or running off land into water has the potential to affect water quality by elevating metals concentrations in relation to the CCME PAL criteria. The relationship between TSS and metals concentrations in the ore dust was evaluated in order to assess the potential effects of elevated metals in water.

Magnitude

Over 8,000 assay results for ore were totaled to obtain 75th percentile concentrations of the ore, and thus understand the likely chemical concentration of TSS in runoff. The same logic has been applied to metals concentrations as TSS regarding magnitude of effects (Table 7-3.31).

Table 7-3.31 Magnitude Thresholds for Metals in Dust Affecting Water Quality

Effects Level	Concentration Range (mg/L)	Colour
Negligible	>WQO	
Level I	1 to 10x WQO	
Level II	10 to 100x WQO	
Level III	>100x WQO	

Table 7-3.32 presents the correlation between metals and TSS over a range of TSS concentrations.

Table 7-3.32 Estimated Metals Concentrations in Ore Dust Runoff

Parameter	75th Percent Concentration in Ore (ppm)	Water Quality Objective	Ore Dust Runoff - TSS Concentrations (mg/L)						
			1.0	5.0	10.0	25.0	50.0	100.0	500.0
Al	0.9 %	0.94	0.009	0.045	0.09	0.225	0.45	0.9	**4.5**
As	40	0.005	0.00004	0.0002	0.0004	0.001	0.002	0.004	**0.02**
Be	No Data	0.0053	-	-	-	-	-	-	-
B	No Data	1.5	-	-	-	-	-	-	-
Cd	10	0.000029	0.00001	**0.00005**	**0.0001**	**0.00025**	**0.0005**	**0.001**	**0.005**
Cr	28	0.0047	0.000028	0.00014	0.00028	0.0007	0.0014	0.0028	**0.014**
Cu	19	0.00467	0.000019	0.000095	0.00019	0.000475	0.00095	0.0019	**0.0095**
Fe	69 %	1.2	0.6914	**3.457**	**6.914**	**17.285**	**34.57**	**69.14**	**345.7**
Pb	33	0.001	0.000033	0.000165	0.00033	0.000825	**0.00165**	**0.0033**	**0.0165**
Hg	No Data	0.000026	-	-	-	-	-	-	-
Mo	10	0.073	0.00001	0.00005	0.0001	0.00025	0.0005	0.001	0.005
Ni	51	0.083	0.000051	0.000255	0.00051	0.001275	0.00255	0.0051	0.0255
Se	No Data	0.001	-	-	-	-	-	-	-
Ag	No Data	0.0001	-	-	-	-	-	-	-
Tl	30	0.0008	0.00003	0.00015	0.0003	0.00075	**0.0015**	**0.003**	**0.015**
U	No Data	0.015	-	-	-	-	-	-	-
V	0.006 %	0.006	0.000056	0.000280	0.000560	0.001401	0.002802	0.005604	**0.028022**
Zn	50	0.03	0.00005	0.00025	0.0005	0.00125	0.0025	0.005	0.025

NOTES:
1. 75TH PERCINTILE DATA IS BASED ON ORE ASSAY DATA PROVIDED BY BAFFINLAND
2. WATER QUALITY OBJECTIVES (WQO) - BASED ON CCME PAL, AND SSWQO'S FOR Al, Cr, Cu AND Fe.
3. Al CONCENTRATION CALCULATED FROM Al_2O_3 REPORTED IN THE ESSAYS.
4. V CONCENTRATION CALCULATED FROM V_2O_5 REPORTED IN THE ESSAYS.

The screening of metals concentrations relative to TSS concentrations (Table 7-3.32) shows that an increase in TSS due to runoff of dust will result in a corresponding increase in chromium and iron concentrations, and other metals at high TSS concentrations. Management of elevated metals, therefore, is about managing and mitigating TSS concentrations from ore dust runoff, as described in SWSQ-19-1.

Based on the assessment in SWSQ-19-1, TSS concentrations in surface waters are targeted to meet a threshold established for Project site runoff of 15 mg/L TSS post-mitigation, resulting in a corresponding Level I magnitude water quality effect due to metals in TSS.

Duration

Ore dust will be generated at the Mine Site during the Operation phase only. At Closure, with dust emissions ceasing, it is expected that metals concentrations in water will reduce along with TSS concentrations, and stormwater management facilities can be decommissioned. A Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when freshet and the majority of rain falls in the Project area. A Level I frequency rating was assigned.

Extent

The extent of the potential effect is expected to be limited to the LSA; therefore, a Level I extent rating was assigned.

Reversibility

The potential effects associated with dust generated in the Mine Site LSA are anticipated to be partially reversible after the Operations phase is complete. A Level II reversibility rating was assigned.

Significance - SWSQ-17-2: Metals Water Quality Estimates in Ore Dust Runoff

Based on the ratings described above, elevated metals arising from runoff of ore dust deposition at the Mine Site during Operation phase is expected to result in a *Not Significant* adverse environmental effect on water and sediment quality in the Mine Site LSA. The Level of Confidence is Medium due to the semi-quantitative nature of the assessment.

SWSQ-17-3: Dust Effects to Sediment Quality at the Mine Site

Ore dust that is directly deposited from the air or runs off into watercourses will affect sediment quality in streams and lakes. Even with implementation of effective mitigation, ore dust will accumulate in the sediment of streams and lakes within the Mine Site LSA.

Residual Effects Rating

Magnitude

To establish the sediment quality of a substrate consisting largely of ore dust, the 75th percentile metals concentrations in the ore (Table 7-3.32) were compared against the Probable Effects Level (PEL) criteria and Interim Sediment Quality Guidelines (ISQG) identified in the CCME (2003) Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, as a worst case indicator of potential effects (Table 7-3.34). This assessment is conservative in that it assumes that sediment was comprised of ore dust only without natural contributions to sediment. The magnitude ratings described above for water quality have been adopted as shown in Table 7-3.33, relative to the PEL criteria.

Table 7-3.33 Magnitude Thresholds for Sediment Quality

Effects Level	Concentration Range (mg/L)	Colour
Negligible	<SQG (or LEL)	
Level I	>SQG (or LEL) and <PEL	
Level II	1 to 10x PEL	
Level III	10 to 100x PEL	

Arsenic and cadmium in the ore exceed the PEL criteria by an order of magnitude (Level II rating), and iron exceeds the PEL by a factor of 17 (a Level III magnitude rating), while all other key indicator metals are below the PEL. However, given the conservative nature of this assessment (i.e., the assumption that ore dust comprises the entire sediment load deposited in streams and lakes), it is expected that in reality even iron will not exceed the PEL by more than 10x, and is likely to be a Level II magnitude effect or lower.

Duration

Ore dust will be generated at the Mine Site during the Operation phase only. At Closure, with dust emissions ceasing, it is expected that metals concentrations in water will reduce along with TSS concentrations, and stormwater management facilities can be decommissioned. A Level II duration rating was assigned.

Frequency

The frequency will be annual, limited to the period between June and September when freshet and the majority of rain falls in the Project area. A Level I frequency rating was assigned.

Extent

The extent of the potential effect is expected to be limited to the LSA; therefore, a Level I extent rating was assigned.

Reversibility

The potential effects associated with dust generated in the Mine Site LSA are anticipated to be partially reversible after the Operations phase is complete. A Level II reversibility rating was assigned.

Significance - SWSQ-17-3: Dust Effects to Sediment Quality at the Mine Site

Based on the ratings described above, ore dust deposition into sediment of streams and lakes in the Mine Site LSA are expected to result in a *Not Significant* adverse environmental effect on sediment quality in the Mine Site LSA (Table 7-3.25). The Level of Confidence is Medium due to the semi-quantitative nature of the assessment (Table 7-3.26).

Impact Statement SWSQ-18: Operational Dust Deposition - Railway Alignment LSA

Magnitude

The potential for the Railway to generate ore dust during transportation was considered in the air quality effects assessment (Volume 5, Section 2.6.3.2), which concluded that, based on the particle size of the ore being transported (lack of fines), dust generation will be minimal. Accordingly, potential effects of dusting from the rail cars on water and sediment quality along the Railway are expected to be negligible (Level I).

Duration

The residual effects associated with dust generated in the Railway Alignment LSA were considered for only the Operation phase of the Project; a Level II duration rating was assigned.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when freshet and the majority of rain falls in the Project area. A Level I frequency rating was assigned.

Extent

The extent of the potential effect is likely limited to the LSA, and is rated as Level I.

Table 7-3.34 Comparison of Ore Dust with Sediment Quality Guidelines

Key Indicator	Baseline Sediment Quality				CCME Thresholds		ON[1]/BC[2] Thresholds		Metals in Ore	Magnitude Rating
	Camp Lake	Sheardown Lake N.W.	Background Tributary to Mary River	Downstream of Deposit	ISQG	PEL	LEL	SEL		
Arsenic (mg/kg)	0.0027	0.00289	0.0009	0.001	5.9	17			40	Level II
Cadmium (mg/kg)	0.0005	0.0005	0.00035	0.0005	0.6	3.5			10	Level II
Chromium (mg/kg)	0.06083	0.06013	0.02427	0.02598	37.3	90			28	Negligible
Copper (mg/kg)	0.0315	0.0355	0.00343	0.00459	35.7	197			19	Negligible
Iron (%; mg/kg)	29.7	32.8	11.3	13.7			20,000[1]	40,000[1]	69 % 690,000	Level III
Lead (mg/kg)	0.01583	0.01481	0.0018	0.00244	35.0	91.3			33	Negligible
Mercury (mg/kg)	0.0001	0.0001	0.0001	0.00016	1.7	4.86			No data	Not determined
Nickel	0.05	0.053	0.013	0.013			16[1]	75[1]	51	Level I
Selenium	0.001	0.001	0.0008	0.00097			2[2]		No data	Not determined
Zinc (mg/kg)	0.0485	0.0573	0.0074	0.0089	123	315			50	Negligible

NOTES:
1. Ontario Sediment Quality Guidelines: Lower Effect Level (LEL) and Severe Effect Level (SEL)
2. British Columbia Sediment Quality Guidelines

Reversibility

The potential effects associated with dust generated in the Railway Alignment LSA are anticipated to be fully reversible after the Operations phase is complete. Reversibility is rated as Level I.

Significance – SWSQ-18 – Operations Dust Along the Railway

Based on the ratings described above, dust generated along the Railway Alignment during Operation phase is not expected to result in an adverse environmental effect on water and sediment quality in the Railway LSA. The residual effect is ranked as *Not Significant* (Table 7-3.25). The Level of Confidence is Medium due to the semi-quantitative nature of the assessment (Table 7-3.26).

Operational Dust Deposition (TSS and Metals in Water; Metals in Sediment) - Steensby Port LSA - Impact Statement SWSQ-19

Magnitude

Predicted dust generation and dispersion associated with the various sources at the Steensby Port during the Operation phase are provided in Volume 5. The extent and pattern of dust fall dispersion throughout the Steensby Port LSA, illustrated in Appendix 5C-5, shows that most of the annual TSP deposition will occur on Steensby Island, where the ore stockpiles and ore dock are located, and over the marine waters/ice. A length of mainland coastline with freshwater streams will receive a maximum of 5 g/m^2/year. Dust is expected to have a minor influence on freshwater and sediment quality at a section of the coastline at Steensby Port. This effect was considered qualitatively and a Level I magnitude rating was assigned.

Duration

The residual effects associated with dust generated in the Steensby Port LSA were considered for only the Operation phase of the Project and were thus rated as Level II.

Frequency

The frequency of the potential effect will be annual, limited to the period between June and September when freshet and the majority of rain falls in the Project area. A Level I frequency rating was assigned.

Extent

The extent of the potential effect is limited to the RSA ;much of the TSS/sediment will be transported into Steensby Inlet on an annual basis during the freshet. A Level II extent rating was assigned.

Reversibility

The potential effects associated with dust generated in the LSA are anticipated to be fully reversible after the Operations phase is complete. A Level I reversibility rating was assigned.

Significance – SWSQ-19 – Operations Dust at Steensby Port

Based on the ratings described above, dust generated from Steensby Port during the operation phase is not expected to result in an adverse environmental effect on the water and sediment quality VEC in the LSA. The residual effect is ranked as *Not Significant* (Table 7-3.25). The Level of Confidence is Medium due to the semi-quantitative nature of the assessment (Table 7-3.26).

3.4.3 Information Gaps

The following data and analyses would be beneficial in adding to the Level of Confidence in the residual effects predictions provided in this section. These results could serve to confirm assumptions used in modelling:

- Measurement of air quality during the Construction phase, including dust fall on water and accumulation in sediment;
- Measurement of water quality changes associated with water diversions.

3.4.4 Follow Up

3.4.4.1 Management and Monitoring Plans

Table 7-3.35 provides a summary of the management plans that have been prepared related to water management and the protection of water and sediment quality.

Table 7-3.35 Management and Monitoring Plans Applicable to Water and Sediment Quality

Management Plan	Location
Air Quality and Noise Abatement Management Plan	Appendix10D-1
Emergency and Spill Response Plan	Appendix 3B, Attachment 5
Surface water, Aquatic Ecosystems, Fish and Fish Habitat Management Plan	Appendix 3B, Attachment 5
Wastewater Management Plan	Appendix 3B, Attachment 5
Waste Management Plan	Appendix 3B, Attachment 5
Landfill Operating Manual (Annex 4 of the Waste Management Plan)	Appendix 3B, Attachment 5
Landfarm Design and Operating Plan (Annex 5 of the Waste Management Plan)	Appendix 3B, Attachment 5
Borrow Pits and Quarry Management Plan	Appendix 3B, Attachment 6
Waste Rock Management Plan (includes contingency water treatment options for mine contact water)	Appendix 3B, Attachment 5
Hazardous Materials Management Plan	Appendix 3B, Attachment 5
Environmental Protection Plan	Appendix 3B, Attachment 5
Fish Habitat Compensation Plan	Appendix 10D-7
Road Management Plan	Appendix 10D-8
Railway Management Plan	Appendix 10D-9.1 and 10D-9.2

Detailed stormwater management plans, water balances and sediment and erosion control plans prepared during the detailed design phase as part of a future update to the Surface Water, Aquatic Ecosystems, Fish and Fish Habitat Management Plan will be important for the management of ore dust runoff at the Mine Site.

3.4.4.2 Environmental Effects Monitoring Framework

An Environmental Effects Monitoring Framework (Appendix 10D-13) is a component of Baffinland's EHS Management System. Within the framework are a series of Environmental Effects Monitoring (EEM) Plans focused on valued ecosystem components.

The following EEM studies will be developed for water and sediment quality as follows:

- Monitoring of sewage effluents as a condition of water licence;
- Monitoring of water quality in local drainages to confirm predictions of metals concentrations and compliance with TSS targets and metals; and
- Monitoring of sediment quality in streams and lakes, the latter in accordance with guidance from Environment Canada for sampling of arctic lakes with low deposition rates.

3.4.4.3 Environmental Effects Monitoring (MMER)

The MMER under the *Fisheries Act* stipulates a number of conditions under which a mine may release effluent into the environment – for example meeting the discharge limits in Schedule 4 of the MMER and discharge of an effluent that is not toxic to aquatic life. Under the MMER, an Environmental Effects Monitoring Program is to be designed, approved by Environment Canada and implemented to measure Project-related effects on fish populations, fish tissue and benthic invertebrates thereby assessing the mitigation that was employed. Characterization of effluent quality, effluent toxicity, and receiving water quality will also be required components.

A MMER Environmental Effects Monitoring Study Design Framework (Appendix 10D-14) has been prepared as a proactive initiative for the future development of an Environmental Effects Monitoring (EEM) Study Design. A discussion on water quality was held with Environment Canada on December 9, 2011, and an early draft of the Study Design Framework subsequently provided to Environment Canada was discussed on December 21, 2011. Baffinland looks forward to ongoing dialogue with Environment Canada to advance the development of the EEM Study Design in accordance with the regulatory timelines to achieve compliance.

3.4.4.4 Environmental Construction Monitoring

Environmental construction monitoring will be relied on during construction activities that have the potential to affect water and sediment quality. These construction activities tend to occur when work is located in or around water or when surface materials are exposed. This form of monitoring aids in ensuring effectiveness of mitigation measures and compliance with applicable water quality criteria.

3.4.4.5 Dustfall Monitoring

An air quality monitoring program is proposed at each of the key Project sites (Mine Site and Steensby Port), and at a representative location along the Railway. TSP will be measured using hi-vol samplers over a period of several months at the start of Operations, and again in Year 1 or 2 of operations, to validate assessment predictions on ambient air quality and potential effects to other VECs. TSP samples will be tested to confirm metals concentrations. This monitoring is described in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1).

3.5 IMPACT STATEMENT

Impact Statement SWSQ-1: Ground preparation and earthworks may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, adverse Project-related ground preparation and earthworks are not anticipated to result in significant residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-2: Site water management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and

adaptive management, Project-related site water management are not anticipated to result in significant residual adverse effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-3: Laydown areas may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related laydown areas are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-4: Explosives manufacture, magazine, and use may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related explosives manufacture, magazine, and use are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-5: Quarries and borrow sources may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related quarries and borrow sources are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-6: Tunnelling and rock cuts may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related tunnelling and rock cuts are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-7: Camps, fuel storage and waste management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related camps, fuel storage and waste management are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-8: Water use and management may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related water use and management are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-9: Airstrips and airstrip use may result in changes to surface water and sediment quality in the five freshwater aquatic LSAs. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related airstrips and airstrip use are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-10: Mine contact water discharges will result in changes to surface water and sediment quality in Camp Lake and its tributaries, within the Mine Site LSA. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related discharges of mine contact water are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-11: Mine contact water discharges from pit water as well as stockpiles of ore and waste rock will result in changes to surface water and sediment quality in the Mary River, within the Mine Site LSA. With appropriate use of mitigation measures, monitoring and adaptive management, Project-

related discharges of mine contact water are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-12: Runoff from ongoing drilling operations will result in changes to surface water and sediment quality in the Mary River, within the Mine Site LSA. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related discharges of drilling runoff are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-13: Mine contact water discharges from the pit water and east waste rock pile during post-closure will result in changes to surface water and sediment quality in the Mary River, within the Mine Site LSA. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related discharges of mine contact water are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statements SWSQ-14 and SWSQ-15: Treated sewage effluent discharges to Sheardown Lake and the Mary River may result in changes to surface water and sediment quality in the Mine Site LSA. With appropriate use of mitigation measures, monitoring and adaptive management, Project-related discharges of treated sewage effluent are not anticipated to result in significant adverse residual effects on water (freshwater) or sediment quality.

Impact Statement SWSQ-16: - Construction fugitive dust emissions – fugitive dust emissions will be generated across the five freshwater LSAs, mainly during the Construction phase. With the appropriate use of dust suppression techniques the residual effects of fugitive construction dust on water and sediment quality are predicted to be *Not Significant*.

Impact Statement SWSQ-17: Increased TSS from Dust Deposition in Local Watercourses at the Mine Site – Deposition of ore dust will occur across the Mine Site freshwater LSA during the operation phase. With the effective implementation of stormwater management and sediment control techniques, it is predicted that the residual effects ore dust deposition on water and sediment quality will be *Not Significant*.

Impact Statement SWSQ-18: Operations Dust – Railway LSA – Airborne ore dust generated from ore cars along the Railway during operations is predicted to be minimal (Volume 5) and consequently the residual effects of airborne ore dust and water and sediment quality is predicted to be *Not Significant*.

Impact Statement SWSQ-19: Operations dust dispersion – Steensby Port LSA - The extent and pattern of dust fall dispersion throughout the Steensby Port LSA on freshwater bodies is expected to be minor, and consequently the residual effects on water (freshwater) and sediment quality is predicted to be *Not Significant*.

Summary of Significance

Overall, the Project is not expected to result in any significant adverse effects on Water and Sediment Quality.

Potential for Cumulative Effects

The only identified interactions with other water users or Projects involve the potential future development of Deposits 2 through 7 and the transmission line associated with the Separation Lake Hydroelectric Project. Assuming the Proponent adopts a similar strategy for environmental management and protection of the aquatic environment during these projects, no cumulative effects on fresh water or sediment quality are expected. Cumulative effects are considered and assessed in detail in Volume 9, Section 1.

3.6 AUTHORS

This impact statement was prepared by Richard Cook, B.Sc. (Senior Scientist) and Deena Duff (Senior Engineer) of Knight Piésold, with support by Megan Cooley, (Senior Aquatic Biologist/Toxicologist, North/South Consultants).

SECTION 4.0 - FRESHWATER AQUATIC BIOTA AND HABITAT

4.1 INTRODUCTION

The following provides a description of:

- The freshwater biota and habitat in local study areas (LSAs) and the regional study area (RSA) potentially affected by Project activities. This description provides the baseline for assessing potential impacts of the Project;
- The approach and methods for the assessment of potential Project-related impacts to freshwater biota and habitat;
- The results of the impact assessment, including a description of proposed mitigation;
- A summary of residual effects; and
- An outline of an environmental effects monitoring program.

In general, the assessment is aimed at determining the nature and magnitude of potential impacts to freshwater biota and habitat and ultimately, identifying the significance of anticipated impacts to these resources. The assessment incorporates results of the impact assessments for environmental components that affect freshwater biota and habitat, including the water quantity and water and sediment quality assessments presented in Sections 2.0 and 3.0, respectively.

4.2 BASELINE SUMMARY

Information sources for describing the existing freshwater biota and habitat in the LSAs and RSA included baseline studies conducted in support of the Project, information collected under the Inuit Qaujimajatuqangit (IQ) study, and literature review. Freshwater biota and habitat field studies were initiated in 2005 and continued through 2011. Results of sampling of lower trophic level biota completed in 2011 are pending. Additional field surveys of selected railway stream crossing sites were also completed in 2011 and are described in Appendix 7C.

The following provides an overview of the methods and results of freshwater aquatic biota and habitat studies conducted during the baseline studies for the Project, as well as information collected from the IQ studies and scientific literature. The methods and years of study differed by study area and are presented according to the following LSAs:

- Milne Port;
- Milne Inlet Tote Road;
- Mine Site;
- Railway; and
- Steensby Port.

4.2.1 Background

Freshwater aquatic baseline studies were conducted initially by Knight Piésold Ltd. (Knight Piésold) and then by North/South Consultants Inc. (NSC) over the period of 2005-2011. Baseline study programs for describing freshwater aquatic biota and habitat included collection of information on:

- Aquatic habitat (streams and lakes);
- Primary producers (phytoplankton, periphyton, and aquatic plants);

- Secondary producers (zooplankton, invertebrate drift, and benthic invertebrates);
- Fish communities and populations;
- Fish condition;
- Fish movements; and
- Metals in Arctic Char (*Salvelinus alpinus*) tissues.

A review of Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011) and *Species at Risk Act* (SARA 2011) species lists was conducted to determine if any rare, threatened, at risk, or endangered freshwater aquatic species are present in the LSAs. No species identified in COSEWIC or SARA lists were found in the Project LSAs.

4.2.2 Methods

Appendix 7C provides a detailed description of sampling and analysis methods employed during the conduct of the baseline studies for the Project. The following provides a general overview of the field program sampling methods employed over the course of the studies.

Aquatic habitat was assessed in streams and lakes in the LSAs through aerial surveys and ground based sampling techniques. Assessment protocols used for streams were adapted from the Department of Fisheries and Oceans (DFO) and British Columbia Ministry of the Environment (1989) and NSC (2006). Surveyed habitat was classified by quality (Important, Marginal, Not Fish-bearing) based on observed characteristics and fish presence/absence (Present, Probable, Not Present). Selected lakes were surveyed for bathymetry and substrate using side-scanning sonar or more detailed Geographic Information System (GIS)-based techniques. Mapping of the euphotic zone and distribution of macrophytes were also used to characterize available lacustrine habitat.

Primary producers were sampled in streams (periphyton and phytoplankton chlorophyll *a*) and lakes (phytoplankton chlorophyll *a* and community composition). Periphyton was sampled from representative cobble at selected sites and analysed for ash free dry weight (AFDW) and chlorophyll *a*. Phytoplankton chlorophyll *a* in streams was measured in surface grab samples collected in conjunction with the water quality sampling program, as described in Section 3.2.3. Phytoplankton species composition and biomass in lakes were examined in samples collected across the euphotic zone in conjunction with the water quality sampling program. Lake chlorophyll *a* samples were analysed from samples of water collected 1 m from the surface and 1 m from the bottom.

Studies of secondary producers included invertebrate drift in selected streams, zooplankton in lakes, and benthic macroinvertebrates in lakes and streams. Invertebrate drift was sampled seasonally and at regular daily intervals with drift traps set at the outlets of selected streams. Wisconsin nets lifted vertically through the water column collected seasonal samples of lacustrine zooplankton. Benthic macroinvertebrates in lakes and streams were sampled with dredges and Surber samplers, respectively. All invertebrate samples were identified to the lowest taxonomic level possible by qualified taxonomists.

Fish population studies varied across the five LSAs, being most extensive and intensive in the Mine LSA. Studies in the other four LSAs focussed primarily on fish habitat and fish presence/absence. Studies in the Mine LSA included determination of fish presence/absence, juvenile and adult fish distribution (spatial and temporal), fish movements, fish population characteristics, fish condition, and anadromy. Fish capture techniques in all LSAs used of a variety of sampling gear, including hoop nets, gill nets, backpack electrofishing, minnow traps and angling. Fish movements within and between waterbodies were monitored primarily in the Mine LSA and employed mark-recapture techniques (Floy® and acoustic tagging) and

analysis of strontium concentrations in otoliths. Identification and description of barriers were also used to determine potential fish movements across the five LSAs. Arctic Char were captured from the Mine LSA and liver and muscle samples were analysed for metals.

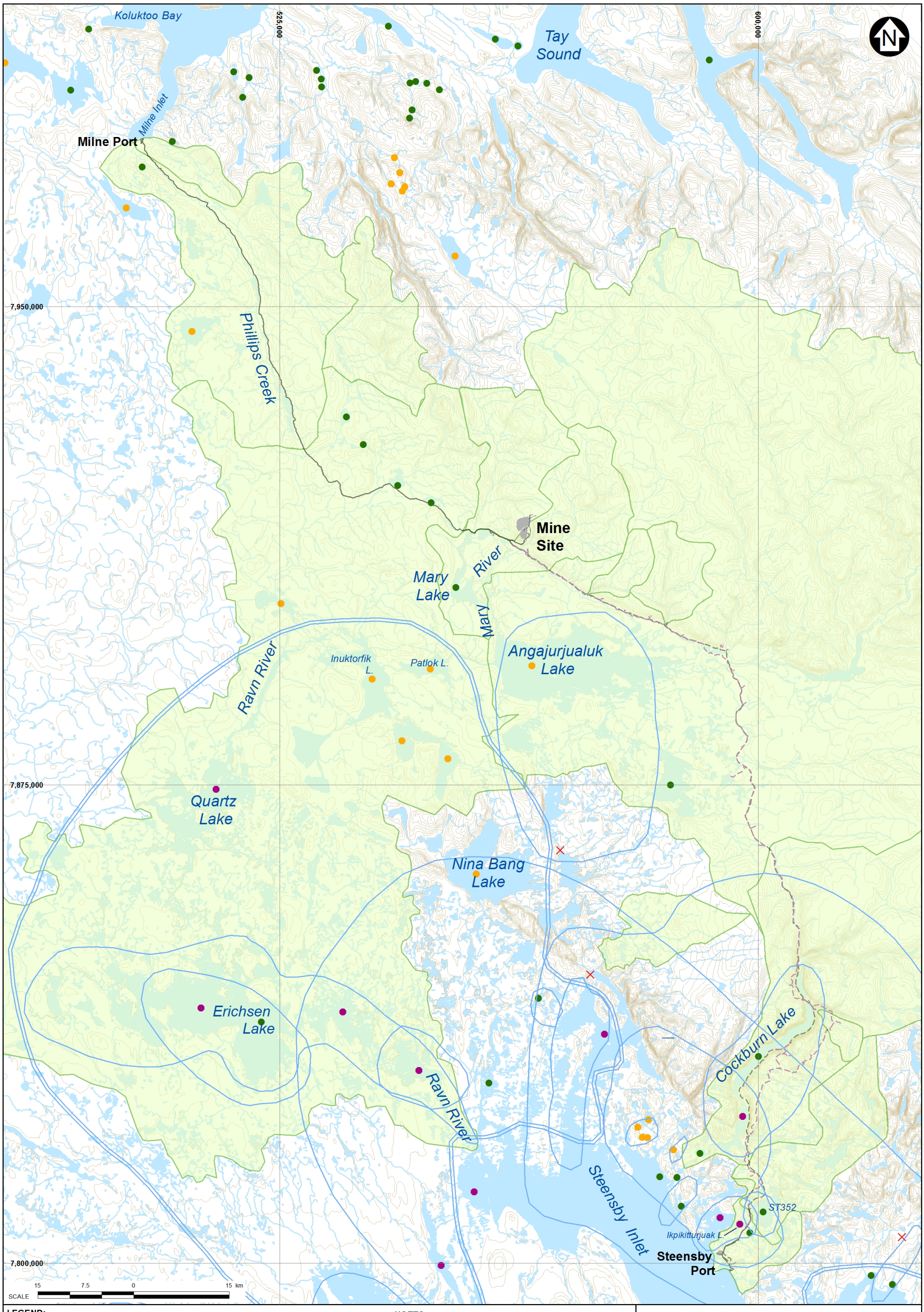
All programs were subject to rigorous quality assurance/quality control (QA/QC) procedures including adherence to sampling protocols, use of Canadian Association for Laboratory Accreditation Inc. (CALA) analytical laboratories, standard measures to prevent sample contamination (where applicable), and taxonomic verifications (where applicable).

4.2.3 Milne Port LSA

The Milne Port LSA includes a major coastal watershed (Phillips Creek), several small, coastal streams that drain directly into Milne Inlet, small, shallow headwater ponds near the coast, and deeper headwater lakes in the highlands to the southeast (Figure 7-1.2). Coastal areas within the footprint of existing and proposed port infrastructure are of relatively low relief with most streams having direct connections to Milne Inlet. Baseline studies focused primarily on aquatic habitat and fish presence/absence in streams and lakes in the area in 2009 and 2010.

IQ information indicates that there is little harvesting occurring with regard to the freshwater environment in the immediate vicinity of the Milne Port site. The presence of Arctic Char was noted for some inland lakes, some of which were indicated to be land-locked (Figure 7-4.1).

In 2009-2010 a total of 18 lake and 33 stream sites within the Milne Port Area were surveyed for fish habitat and fish presence/absence (Figure 7-4.2). Phillips Creek (M03-1) and streams M11-1, M13-1, M18-1, and M02-1 are the largest of the LSA streams flowing into Milne Inlet. All five have sufficient depths and flows to maintain open water connections to Milne Inlet with habitat consisting primarily of riffle/pool over cobble/gravel substrata. All remaining watercourses in the coastal area are small, ephemeral spring runoff streams that drain snowmelt from the highlands to the south, providing no fish habitat. Coastal lacustrine (e.g. ML-01 to ML-13) habitat consists entirely of small, shallow ponds with no overwintering potential and intermittent connections to nearby streams, providing no fish habitat. Surveyed headwater lakes (ML-015, ML-016, ML-018, ML-019, ML-020) are located at relatively high elevation to the south of the Port Site (Figure 7-4.2). The nearshore areas of most of these lakes are largely comprised of fines with overlying cobble and gravel and maximum lake depths are likely suitable for overwintering. However, waterfall barriers exist between the coastal reaches of all Milne Port Area streams (including Phillips Creek) and any potential upstream overwintering habitat. The presence of these barriers prevents movement of fish between Milne Inlet and the headwater lakes and restricts fish use of the lower reaches to summer foraging by anadromous Arctic Char.



LEGEND:

PRESENCE OF ARCTIC CHAR

- GENERAL LOCATION
- LAND-LOCKED
- ANADROMOUS (SEA-RUN)
- FISHING BARRIERS (SUCH AS FALLS)
- WATERBODIES OF IMPORTANCE
- RAILWAY ALIGNMENT (PROPOSED)
- CONSTRUCTION ACCESS ROAD (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- CONTOUR
- REGIONAL CATCHMENTS
- INFRASTRUCTURE

NOTES:

1. BASE MAP: (1:250 000) © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. CONTOUR INTERVAL IS 20 AND IS IN METRES.
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.
4. PROPOSED RAILWAY CONSTRUCTION ACCESS ROAD ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC. DRAWING NO.: RAILWAY ALIGNMENT AND CONST ACCESS RD - MARY RIVER STEENSBY 2010 -12AUG2010.dwg
5. IQ STUDY INFORMATION FROM MARY RIVER INUIT KNOWLEDGE STUDY PROVIDED BY KNIGHT PIESOLD (IN-PROGRESS)

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

IQ STUDY RESULTS - ARCTIC CHAR

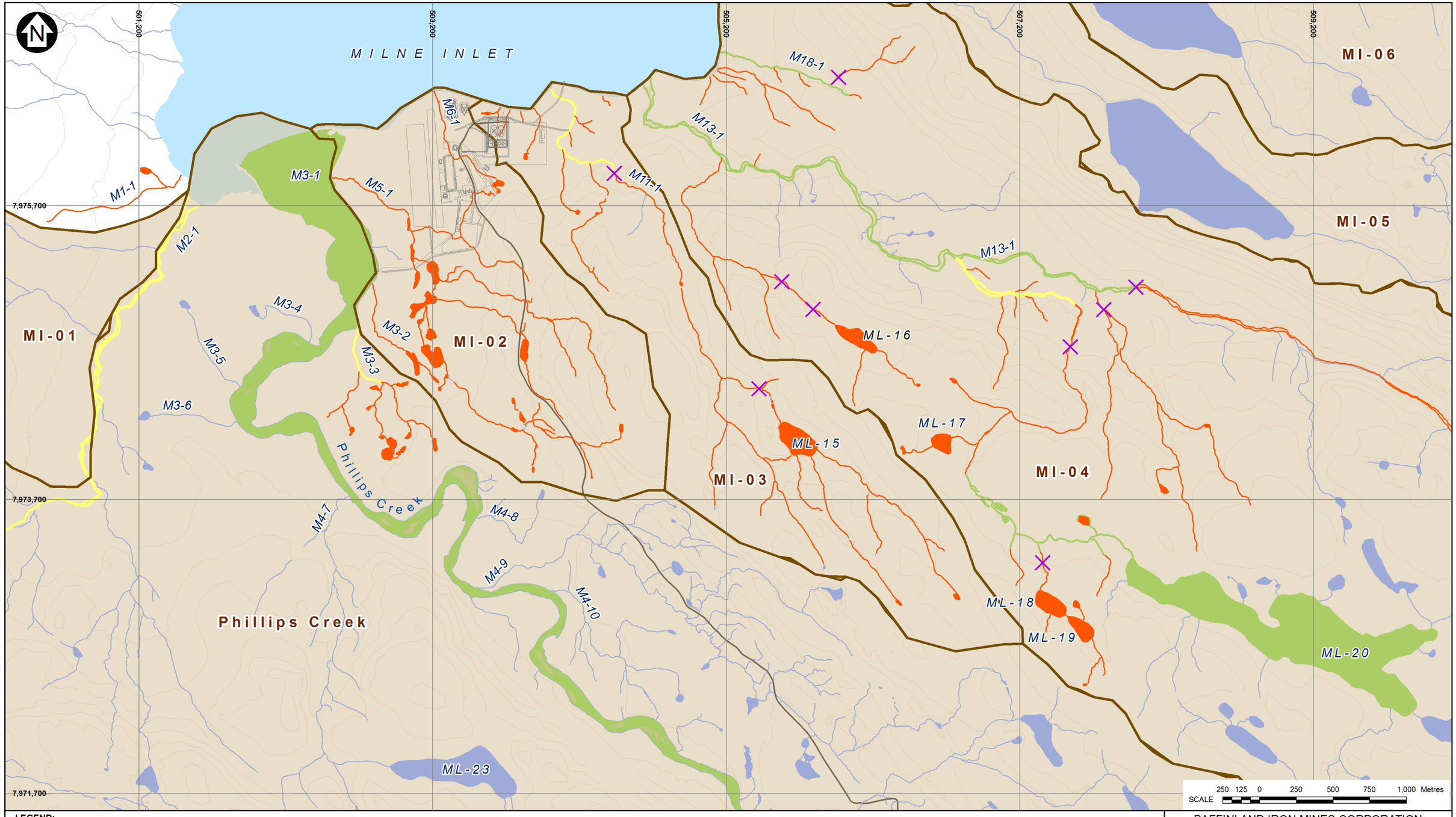
North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO. 102-181/25

REF NO. 12

FIGURE: 7-4.1

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LEGEND:

STATUS OF ARCTIC CHAR
- PRESENT
- POTENTIAL
- NOT PRESENT
- UNKNOWN

- MILNE INLET TOTE ROAD
- LOCAL STUDY AREA CATCHMENTS
- INFRASTRUCTURE (CONSTRUCTION AND OPERATION)
- WATER
- FISH BARRIER (CONFIRMED)

NOTES:

1. BASE MAP 1:50,000: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
3. CONTOUR INTERVAL IS 50 M AND IS IN METRES.
4. LOCAL STUDY AREA CATCHMENTS PROVIDED BY KNIGHT PIESOLD.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ARCTIC CHAR DISTRIBUTION IN FRESH WATER AT MILNE PORT

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO. 102-181/25

REF NO. 12

FIGURE: 7-4.2

Path: G:\MARYRIV_GDB\EIS_GDB\EIS\UpdatedMapping\Volume 7\7-4-2.mxd

Only Arctic Char were captured during fish surveys conducted in the Milne Port Area. Of the five headwater lakes surveyed Char were captured only in ML-20 (Figure 7-4.2). Small numbers were captured in the coastal reaches of M13-1 and M18-1. Their colouration differs from those captured in streams supporting known or probable land-locked populations. This difference, combined with a lack of access to upstream overwintering sites, suggests that Char in the coastal reaches are likely entering the streams from Milne Inlet. Adults have been captured in Milne Inlet (Volume 8, Appendix 8A1; Stewart and MacDonald 1981) and known anadromous populations have been identified in the nearby Robertson (Stewart and MacDonald 1981) and Tugaat (Read 2004) rivers. These two rivers are the probable sources of anadromous Arctic Char that use the lower reaches of Milne Port Area streams for summer foraging.

Although fish were not captured, Phillips Creek and streams M11-1 and M02-1 provide habitat similar to streams M13-1 and M18-1 and could also potentially support limited summer foraging use by anadromous juvenile and/or adult Char from Milne Inlet. Phillips Creek, in particular, provides an abundance of suitable habitat. Although not captured during current surveys, Ninespine Sticklebacks were observed in a small stream in the nearby Robertson River catchment (Stewart and MacDonald 1981).

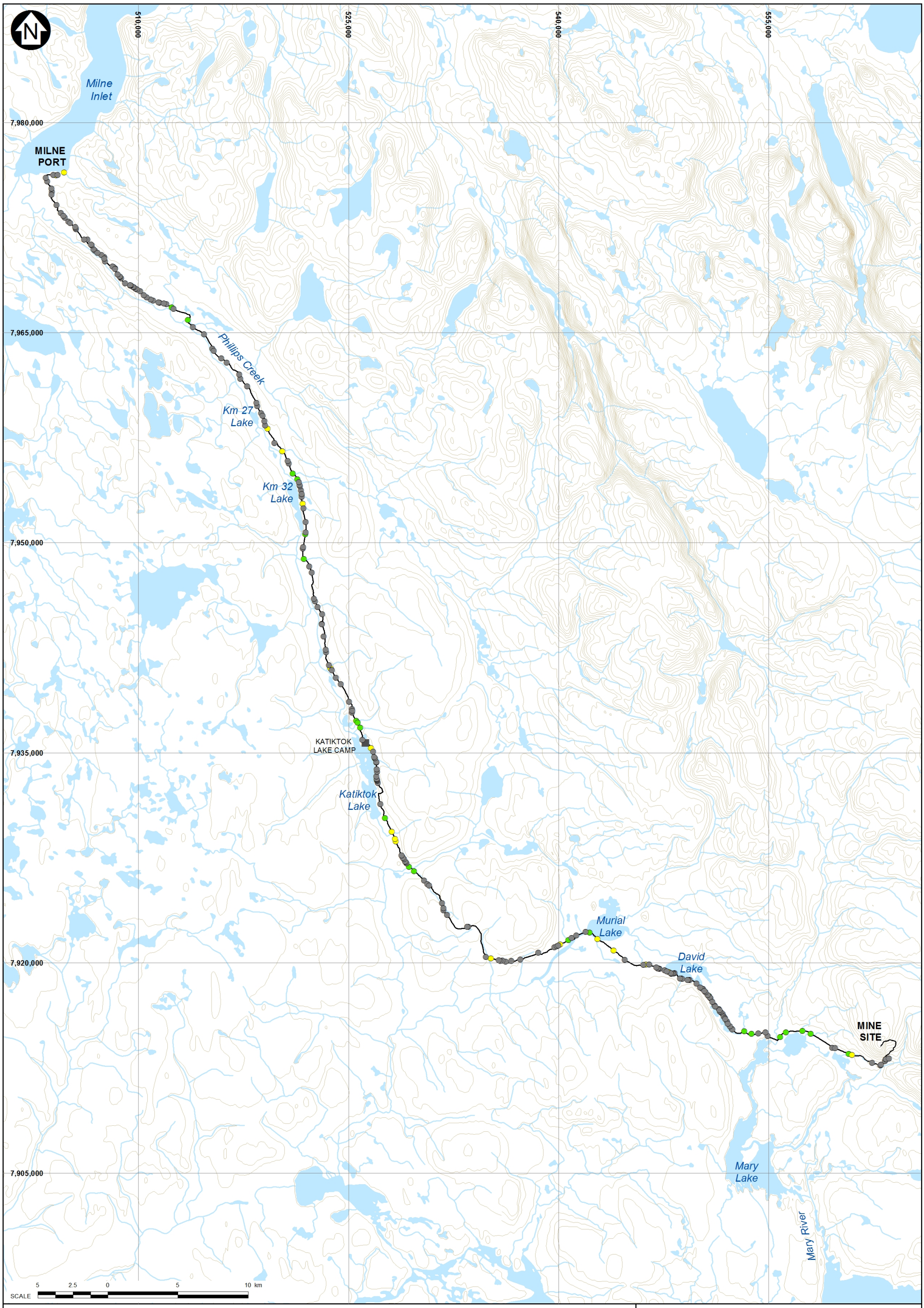
4.2.4 Milne Inlet Tote Road LSA

The Milne Inlet Tote Road runs approximately 105 km from the Milne Port Area to the Mine Area (Figure 7-1.3). Designated as public use, the road was upgraded by Baffinland in 2007 to facilitate haul road travel as part of a Bulk Sampling Program. Twenty-five habitat alteration, disruption or destruction (HADD) sites that would be created as a result of the upgrade were identified. However, following the completion of detailed 2009 and 2010 studies, three of these HADD sites (CV-040, CV-048, and CV-094) were determined to be non fish-bearing and were removed from calculations.

The purposes of the Milne Inlet Tote Road environmental studies (2006-2011) were to identify and describe fish habitat in watercourses crossed by the Milne Inlet Tote Road and determine the extent of fish use of available habitat upstream and downstream of the crossings. Monitoring studies were conducted following completion of road upgrades and the Bulk Sampling Program to enhance, and compare to, information collected during baseline studies.

Little IQ information was provided with regard to freshwater environments in the vicinity of the Milne Inlet Tote Road. The presence of Arctic Char was noted in Muriel and McQuat lakes (Figure 7-4.1). There does not appear to be any previous scientific survey data for this area.

A total of 248 watercourse crossings were identified along the Milne Inlet Tote Road during the initial surveys prior to road upgrades (Figure 7-4.3). Streams within the first 15 km from the Milne Inlet terminus typically flow directly into Milne Inlet or into the reach of Phillips Creek downstream of an impassable set of falls. These streams often lack persistent flows, contain an abundance of barriers separating them from potential overwintering habitat, and are largely non fish-bearing.



LEGEND:

- IMPORTANT FISH HABITAT
- MARGINAL FISH HABITAT
- NOT FISH BEARING HABITAT
- TOTE ROAD (EXISTING)
- CONTOUR
- WATER

NOTES:

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2. CONTOUR INTERVAL IS 20 AND IS IN METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE INLET TOTE ROAD HABITAT CROSSINGS

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO.	REF NO.
102-181/25	12

FIGURE 7-4.3

Path: \\terastation\GIS\Projects\Other\Mary River Freshwater\2010\Genrtd_Data\Report_Maps\ToteRD

Streams crossed from km 15 to km 61 (Phillips Creek catchment upstream of the falls) have fewer barriers, are accessible from overwintering lakes (Figure 7-4.3), and are typically characterized by smaller substrate sizes with riffle/pool habitat. Fish habitat is more abundant in this zone. Two lakes (at km 27 and km 32) provide suitable overwintering and nearshore juvenile Arctic Char habitat. The zone between km 61 and km 75 is part of the upper Ravn River catchment and, like streams in the first 15 km of the Milne Inlet Tote Road, consists largely of intermittent or ephemeral drainages that are not fish-bearing and contain many barriers. The area between km 75 and km 83 is a relatively broad, flat terrain characterized by largely sandy watercourses that flow into or out of Muriel Lake (Figure 7-4.3), providing relatively abundant fish habitat.

Watercourses crossed by the remaining 20 km of the Milne Inlet Tote Road are mainly part of the Mary River sub-catchment. This region includes many spring run-off drainages providing no fish habitat, but also several large streams in close proximity to Arctic Char overwintering lakes (e.g., Mary Lake, Camp Lake), providing abundant fish habitat (Figure 7-4.3). Cobble/sand substrata and riffle/pool habitat dominates with water velocities occasionally exceeding 1.0 m/s. There are few downstream barriers.

Ninespine Sticklebacks are relatively uncommon in the LSA (captured at only 11 of 248 crossings). No streams along the Milne Inlet Tote Road have sufficient depth for survival of incubating Arctic char eggs over winter and are therefore used only as open-water rearing/foraging habitat and movement corridors. Within the first 15 km from Milne Inlet, Char were captured or suspected to occur only in two streams that flow directly into Milne Inlet (total catch = 5 fish); these are thought to be anadromous fish from Milne Inlet using the streams for foraging during summer. Juveniles were captured at 18 crossings (11 of Important quality) between km 15 and km 61 along the Tote Road. Both of the surveyed lakes in this section of the Tote Road support populations with the presence of young-of-the-year (YOY), suggesting the occurrence of spawning. Only two streams in the zone between km 61 and km 75 support Char use near the crossings. Three crossings between km 75 and km 83 were classified as Marginal and two as Important. Twelve watercourses along the remainder of the Milne Inlet Tote Road provide fish habitat (nine were Important). Several of these streams are tributaries to large lakes and appear to support large numbers of rearing YOY and juvenile Arctic Char.

4.2.5 Mine LSA

The majority of the baseline studies undertaken for the Project were conducted in the Mine LSA (2005-2010). Programs included collection of information on:

- Aquatic habitat (streams and lakes);
- Primary producers (phytoplankton, periphyton, and aquatic plants);
- Secondary producers (zooplankton, invertebrate drift, and benthic invertebrates);
- Fish communities and populations;
- Fish condition;
- Fish movements; and
- Metals in Arctic Char tissues.

The baseline field programs involved characterization of the biological communities and their habitat in waterbodies in the Mine LSA and surrounding area including five lakes (Sheardown Lake NW and SE, Camp Lake, Mary Lake, Angajurjualuk Lake, and the Candidate Reference Lake), small tributary streams, and the Mary and Tom rivers (Figure 7-1.4).

Aquatic Habitat

The lakes investigated in the Mine LSA are relatively shallow (mean water depth ranges from 4.0 to 13.0 m), clear (high Secchi Disk depth and corresponding maximum depth of light penetration estimated to be 12 m), with substrate dominated by sand interspersed with patches of cobble/ boulder. Macrophytes, which rarely occur and are sparsely distributed, appear to be predominantly macroalgae (e.g., *Chara* spp.) with the exception of Mary Lake where water crowfoot (*Ranunculus* sp.) and aquatic moss have been observed.

The Mine LSA includes perennial, intermittent and ephemeral streams, but all LSA streams freeze to the bottom in winter. Perennial streams generally consist of riffle habitat, with occasional pools. Substrate is often dominated by cobble, with sand, gravel and boulders present in varying amounts. Streams are generally shallow (<0.5 m deep) with, particularly during lower flow periods, extremely shallow (<0.1 m deep) sections that limit connectivity between upstream and downstream reaches. Intermittent and ephemeral streams provide marginal to no habitat for fish. In general, stream width and depth decreased substantially between high and low flow periods surveyed over the baseline studies. Riparian vegetation is limited, and generally consists of moss and grass and, in some locations, willows.

The majority of Camp Lake inflows are small, ephemeral streams providing limited or no aquatic habitat. Five inflows were identified as providing important aquatic habitat. Several larger perennial and intermittent streams provide habitat for fish, but the presence of barriers within the first 5 km upstream of Camp Lake limits the availability of habitat. Fish-bearing streams are generally shallow with predominantly riffle/pool morphology, cobble substrates, and relatively limited cover. Under low flows, upstream movements of Arctic Char may be impeded at some locations by a combination of shallow water and natural obstructions.

Perennial and intermittent streams are similarly uncommon among Sheardown Lake inflows. Only four support multiple trophic levels of aquatic biota and only one (Tributary 1) is of substantial size. Tributary 1 is the primary open-water rearing habitat for juveniles from Sheardown Lake and it provides a relatively large amount of habitat for other aquatic biota. Much of the available Sheardown Lake inflow habitat is shallow riffle or cascade/pool habitat over a predominantly cobble substrate. Barriers limit the extent of upstream access for fish in Sheardown Lake inflows. As with Camp Lake inflows, Char movements in Sheardown Lake inflows may be impeded at some locations due to shallow water and the presence of natural obstructions. Numerous, small, intermittent and ephemeral tributaries are also present, none of which provide sufficient aquatic habitat to support fish populations and provide very limited habitat for other biota.

Mary Lake has two large inflows: the Tom River entering the north basin and the Mary River entering the south basin (Figure 7-1.4). Five additional tributaries, two in the north basin and three in the south, provide sufficient aquatic habitat for multiple trophic levels. However, the composition of available habitat in these streams differs from other surveyed lake systems, with sand and gravel, macrophytes, and areas of standing water more abundant in the lower reaches of Mary Lake tributaries. As with the other lakes in the LSA, the majority of the remaining inflows are small and provide limited aquatic habitat and, even in fish-bearing streams, available habitat is generally limited to the lower 4-5 km due to upstream barriers.

The Mary and Tom rivers are the largest LSA streams, both originating north of the Mine Site and flowing south west into Mary Lake (Figure 7-1.4); the Mary River then continues into Angajurjualuk Lake. Waterfall barriers in the Mary and Tom rivers limit fish access to approximately the lower 15 and 6 km of the rivers, respectively. The lower reaches (approximately 1 km) of both streams are depositional environments dominated by sand and run/flat habitat with no cover. These areas provide limited aquatic habitat for local

biota. Upstream reaches of the Mary and Tom rivers have more diverse habitat with a combination of riffle/run/pool habitat over cobble boulder/gravel substrata and more abundant cover.

Of the two potential candidate reference streams that were surveyed for habitat, Candidate Reference Stream 2 is most similar to the Mary River with primarily shallow depths, cobble substrates, and riffle habitat characteristics.

Primary Producers

Lakes in the Mine LSA (Camp, Sheardown, Mary and Candidate Reference lakes) are characterized by low primary productivity (i.e., low chlorophyll *a* concentrations and phytoplankton biomass) as is typical in Arctic aquatic ecosystems. Lake-wide mean concentrations of chlorophyll *a* measured in the open-water season indicate a trophic status of ultra-oligotrophic to oligotrophic. Means of chlorophyll *a* and biomass for 2007-2008 were similar between lakes ranging between 0.2 and 0.7 µg/L and 122 and 204 mg/m^3, respectively. A total of 82 species of phytoplankton were recorded in the Mine LSA lakes in 2007 and 2008. Phytoplankton biomass was dominated by diatoms (Bacillariophyceae) at most sites and times; *Cyclotella* and *Melosira* were ubiquitous and relatively abundant across the lakes.

Like lakes, streams in the Mine LSA are characterized by low phytoplankton productivity (i.e., low chlorophyll *a* concentrations) with mean concentrations of chlorophyll *a* ranging from <0.2 µg/L to 4.5 µg/L across sites. Overall, means for the Mary and Tom rivers, and tributaries to Sheardown Lake were less than 1 µg/L and similar to means observed in lakes. Applying the stream trophic classification scheme of Dodds *et al.* (1998) streams in the Mine LSA are oligotrophic on the basis of phytoplankton chlorophyll *a*.

Periphyton densities were highest in the tributaries to Sheardown and Camp lakes and lowest in the Mary and Tom rivers. Most individual measurements and all site means of periphyton chlorophyll *a* were <100 mg/m^2. Application of the trophic categorization scheme proposed by Dodds *et al.* (1998) for streams indicates that some streams or areas of streams in the Mine LSA would be considered oligotrophic while others mesotrophic on the basis of benthic chlorophyll *a*.

Secondary Producers

A total of nine crustacean zooplankton taxa were identified in the Mine LSA lakes during the open-water seasons of 2007 and 2008. Overall mean total zooplankton density (seasons and years combined) is highest in Sheardown Lake NW (15,922 individuals/m^3), followed by Sheardown Lake SE (11,852 individuals/m^3), Camp Lake (11,125 individuals/m^3), and Mary Lake (3,939 individuals/m^3). Copepoda, particularly Cyclopoida, comprise the majority of the zooplankton collected from Mine LSA lakes with *Cyclops scutifer* and *Diaptomus minutus* being the predominant species identified.

Macroinvertebrate density for the 2006-2008 period varied among lakes in the Mine LSA and was highest in Sheardown Lake SE (8,229 individuals/m^2), followed by Mary Lake (3,270 individuals/m^2), Sheardown Lake NW (2,488 individuals/m^2), and Camp Lake (2,122 individuals/m^2). Within all but Camp Lake (where euphotic/littoral zone was not sampled), the highest mean density occurred in areas falling within the euphotic/littoral zone. The higher densities of macroinvertebrates in the littoral zone generally reflect higher productivity (via photosynthetic and detrital foodweb pathways). A total of 45 macroinvertebrate taxa were identified at the genus level. All lakes are considered moderately diverse, with a variety of insect genera represented. Overall, macroinvertebrate density in lakes is dominated by Chironominae larvae (mainly *Micropsectra* and *Stictochironomus*). The benthic communities of the Mine LSA lakes are comparable in many respects to the communities of other small lakes in the Canadian Arctic and subarctic,

and are typical of oligotrophic Arctic lakes. Drifting macroinvertebrate density varied among Mine LSA tributaries and among sampling times within a tributary for the 2007-2008 period. Overall mean total drifting macroinvertebrate density (seasons and years combined) was highest in tributaries to Sheardown Lake (87 individuals/m^3), followed by tributaries to Camp (67 individuals/m^3) and Mary (10 individuals/m^3) lakes. Overall, drift density is dominated by Orthocladiinae larvae in tributaries to Camp (67 %), Sheardown (91 %), and Mary lakes (34 %); 21 macroinvertebrate families were identified in drift traps deployed at the mouths of tributaries. Drifting invertebrate densities in Mine LSA streams are similar to those observed in streams in northern Alaskan Arctic and subarctic streams (Miller and Stout 1989). Chironomids typically dominate the community of Arctic and subarctic streams.

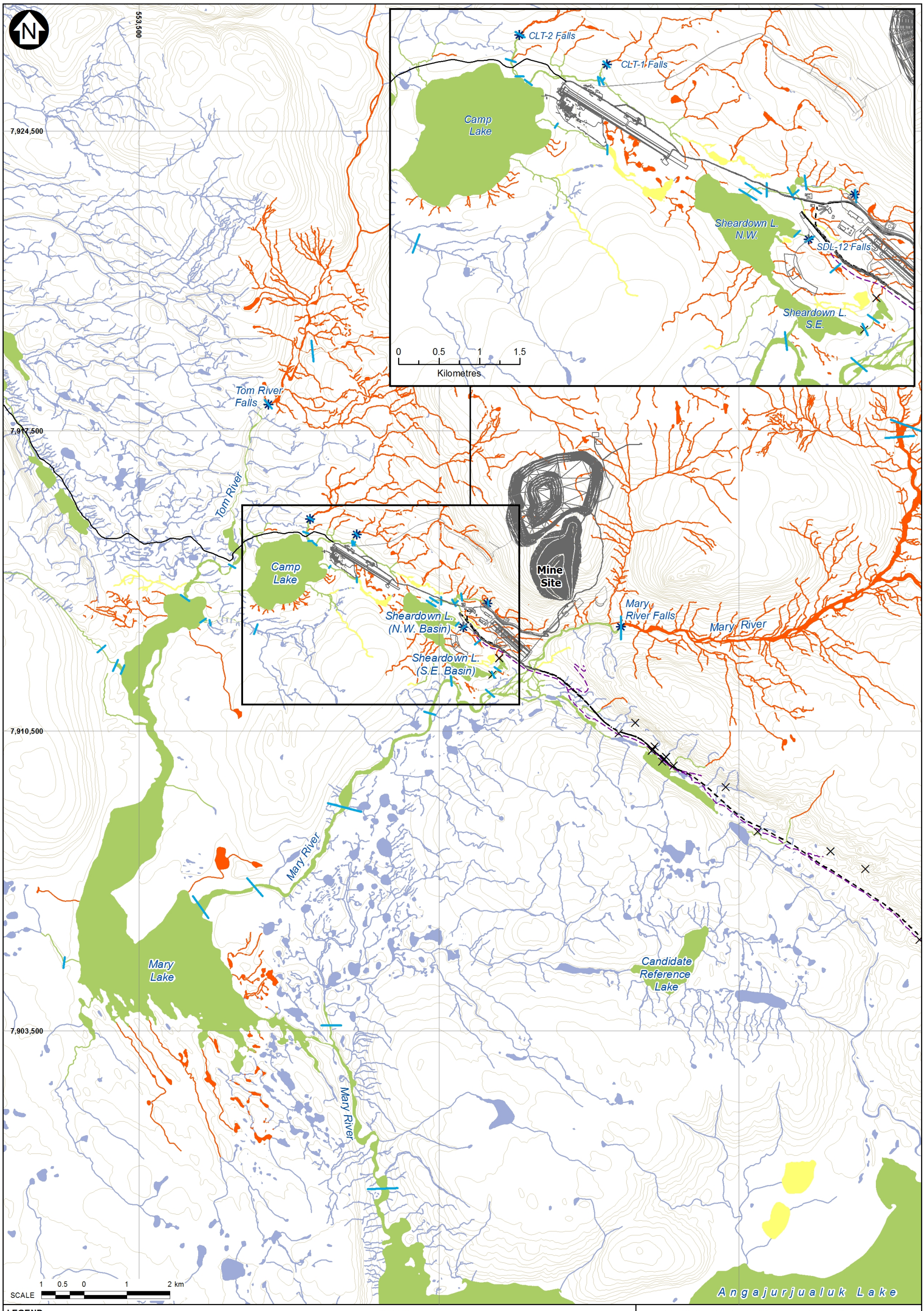
Macroinvertebrate density for the 2006-2008 period varied among Mine LSA streams and was highest in Sheardown Lake tributaries (1,422 individuals/m^2), followed by Camp Lake tributaries (515 individuals/m^2), the Tom River (346 individuals/m^2), and the Mary River (341 individuals/m^2). A total of 62 macroinvertebrate genera were recorded. The Mary and Tom rivers are considered moderately diverse, whereas the Camp Lake and Sheardown Lake tributaries are relatively more diverse, each with a variety of insect genera represented. Overall, macroinvertebrate density is dominated by Orthocladiinae larvae (mainly *Cricotopus*, *Tokunagaia*, and *Orthocladius* [*Euorthocladius*]) at all sites. According to the classification of Beaufort Sea drainage streams by Craig and McCart (1975), the densities of macroinvertebrates in Mine LSA streams are low to moderate (i.e., in the range of approximately 100 to 1,000 individuals/m^2). The composition of the benthic macroinvertebrate community in Mine LSA streams is typical of tundra streams found in other parts of the Arctic (Oswood 1989).

Fish Populations and Movements

IQ collected as part of the Project indicated that Mine LSA waterbodies contain land-locked Arctic Char, with sea-run (i.e., anadromous) populations restricted to downstream waterbodies in the Ravn River system. It was generally felt that land-locked Char within the Mine Area overwinter in lakes. Mary Lake was stated to support a population; however, no specific IQ was indicated with respect to populations within Camp and Sheardown lakes.

Arctic Char and Ninespine Stickleback are the only fish species found within the Mine LSA and surrounding area. Char were the dominant species, accounting for at least 98.6 % of the overall catch from all surveyed Mine Area lakes. The results of surveys in tributaries to the surveyed lakes indicated that this is also typically the dominant riverine species.

Char were found to be widely distributed in Mine Area lakes and streams (Figure 7-4.4). Overall gillnet catch-per-unit-effort (CPUE) was highest in the north arm of Mary Lake, followed by Sheardown Lake SE, Angajurjualuk Lake, Mary Lake S, Sheardown Lake NW, and Camp Lake (Figure 7-4.5). Shoreline electrofishing catches of juveniles varied, but overall CPUE was highest in Sheardown Lake NW, followed by Sheardown Lake SE, Angajurjualuk Lake, Camp Lake, Mary Lake north, and Mary Lake south (Figure 7-4.6).



LEGEND:

STATUS OF ARCTIC CHAR
- PRESENT
- PROBABLE
- NOT PRESENT
- UNKNOWN

- FISH BARRIER
- FALLS
- REACH BOUNDARIES
- MILNE INLET TOTE ROAD (EXISTING)
- RAILWAY ALIGNMENT (PROPOSED)
- CONSTRUCTION ACCESS ROAD (PROPOSED)
- INFRASTRUCTURE

NOTES:

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4. PROPOSED RAILWAY CONSTRUCTION ACCESS ROAD ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC. DRAWING NO.: RAILWAY ALIGNMENT AND CONSTRUCTION ACCESS RD - MARY RIVER STEENSBY 2010 -12AUG2010.dwg
5. MINE SITE INFRASTRUCTURE PROVIDED BY AMEC DRAWING NO.: MINE SITE - CONSTRUCTION PHASE - 01 -MAR 09 2009.dwg
6. CONTOUR INTERVAL IS 50 M AND IS IN METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ARCTIC CHAR DISTRIBUTION AT MINE SITE

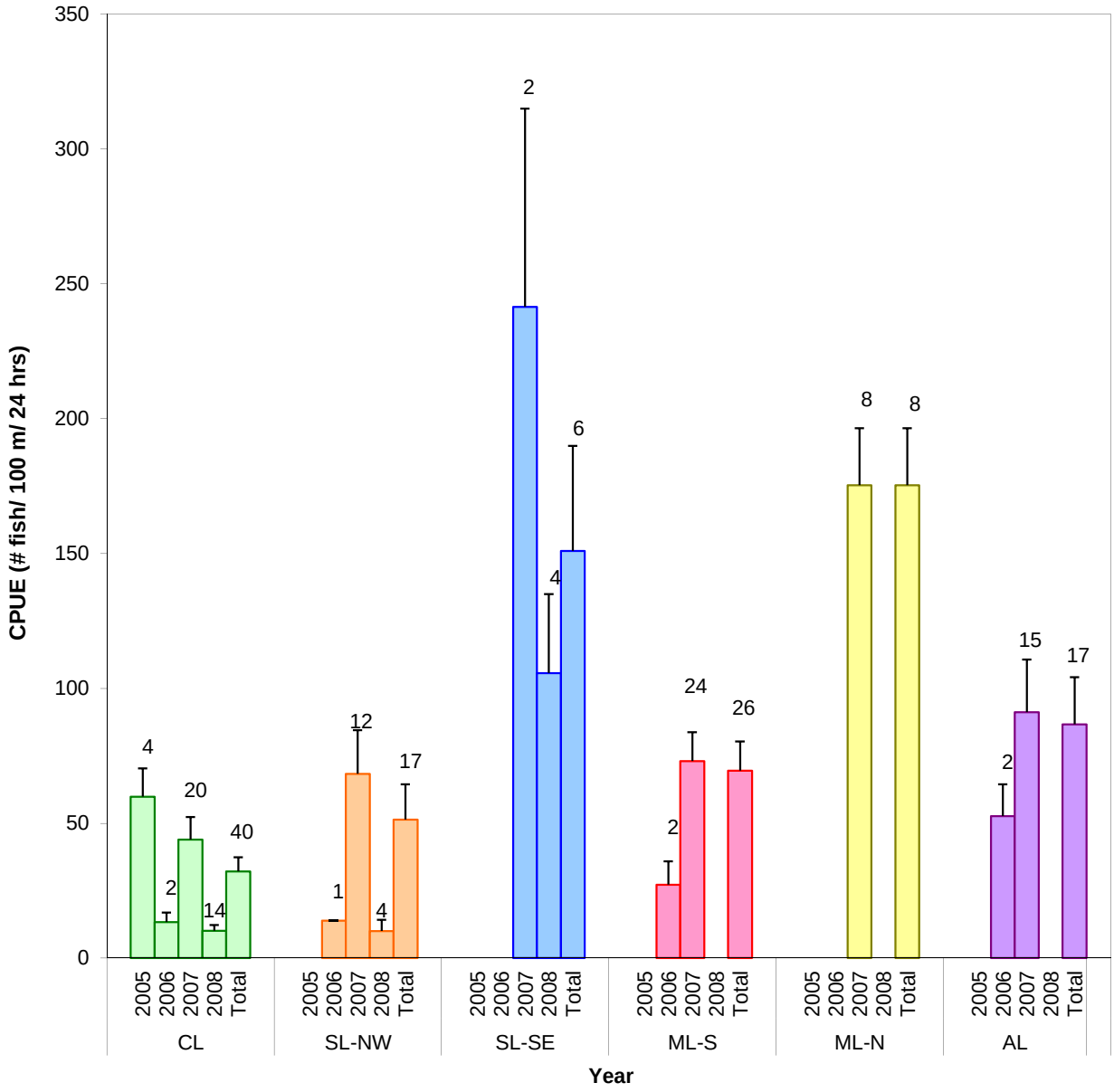
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Aquatic Environment Specialists

P/A NO. 102-181/25

REF NO. 12

FIGURE 7-4.4

Path: \\terastation\GIS\MARYRIV_GDB\EIS_GDB\EIS_Figures_2010EIS_Figures\MXD\MR_Stream Habitat



NOTES:

1. Mean catch-per-unit-effort (CPUE) for Arctic Char captured in gill nets set in the Mine Site area lakes from 2005 to 2008.
2. Numbers above the error bars indicate the number of gillnet sets sites each year.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'10	ISSUED WITH REPORT	MJ	MC	OC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

GILL NET CPUE FOR ARCTIC CHAR IN MINE SITE LAKES

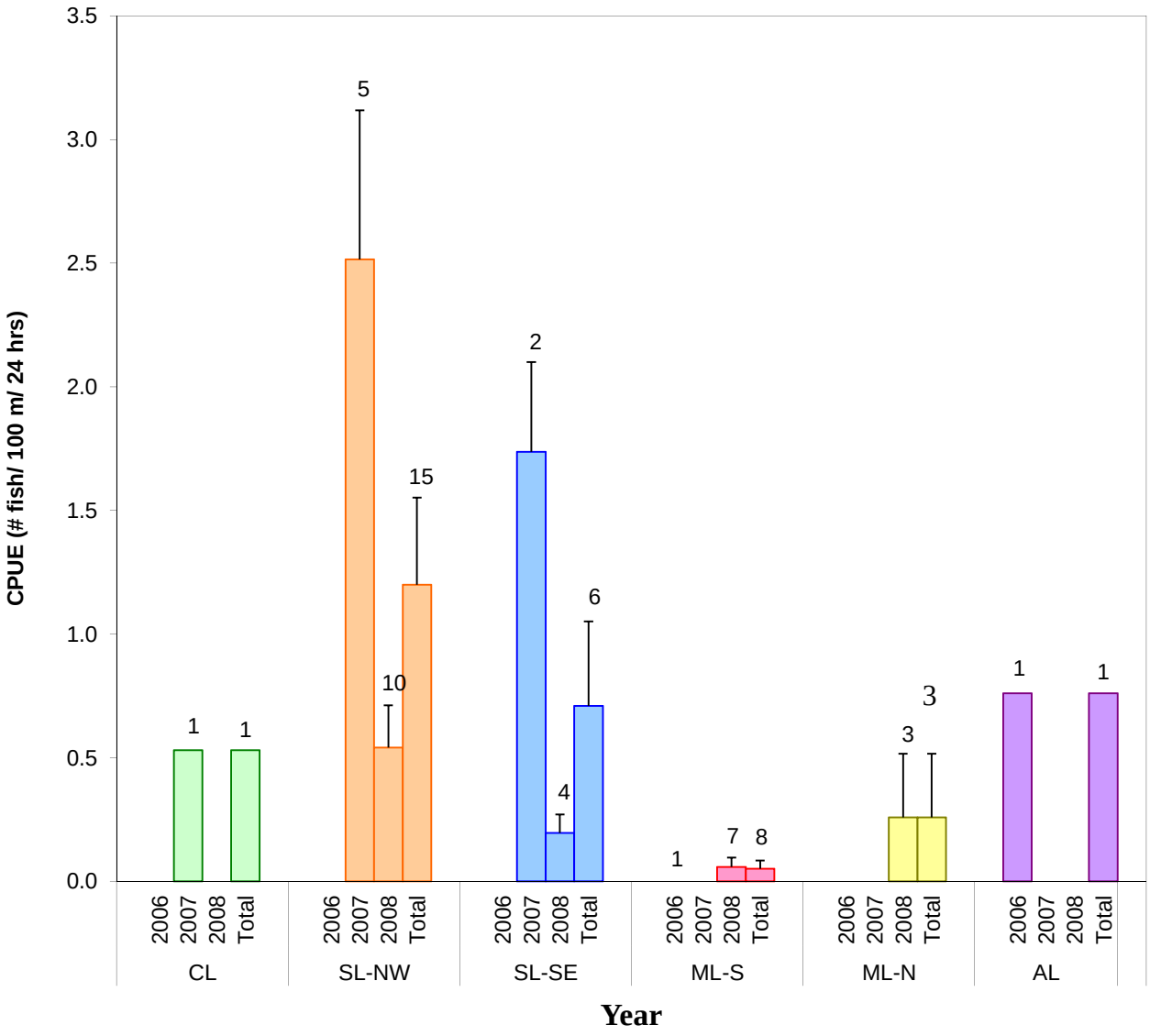
Knight Piésold CONSULTING

P/A NO. NB102-181/25

REF. NO. 12

FIGURE 7-4.5

REV 0



NOTES:

1. Mean catch-per-unit-effort (CPUE) for Arctic Char captured during electrofishing surveys in the Mine Site lakes from 2005 to 2008.
2. Numbers above the error bars indicate the number of gillnet sets sites each year.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'10	ISSUED WITH REPORT	MJ	MC	OC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ELECTROFISHING CPUE FOR ARCTIC CHAR IN MINE SITE LAKES

Knight Piésold CONSULTING

P/A NO. NB102-181/25

REF. NO. 12

FIGURE 7-4.6

REV 0

Arctic Char were captured in all four surveyed Camp Lake tributaries, the two Sheardown Lake NW tributaries, the two Sheardown Lake SE tributaries, three of the four tributaries to the north basin of Mary Lake (Mary Lake N), and two of the three tributaries to the south basin of Mary Lake (Mary Lake S). Char were captured in six of the eight Mary River reaches sampled and between Mary Lake and Tom River Falls in the Tom River. None were captured upstream of the falls in the Mary or Tom rivers (Figure 7-4.4).

The maximum age ranged from 17 to 25 years. The overall ratio of male to female gillnet-caught was 0.96:1. The proportion of fish that were maturing to spawn in the current year ranged from 12.7 % in summer 2007 to 93.9 % in fall 2008. The diet of fish captured in Mine Area lakes was primarily chironomids, with other invertebrates and small Char consumed at lower frequencies.

As in most high Arctic populations, Char in the Mine Area are believed to restrict their spawning to lakes where depths are sufficient for overwinter egg incubation. Information collected during field studies suggested they spawn in Sheardown and Camp lakes and may spawn in Mary and Angajurjualuk lakes.

Data indicate that they use all the major lakes, many of the tributaries to these lakes, and the Mary and Tom rivers for rearing and foraging during the open-water period. Among the lakes, catches of adults and larger juveniles were highest in the southeast basin of Sheardown Lake and lowest in Camp Lake (Figure 7-4.5). Catches of smaller juveniles and YOY were highest in Sheardown Lake NW and lowest in the south basin of Mary Lake (Figure 7-4.6).

Juvenile, YOY and, to a lesser extent, adults move upstream into the smaller tributaries to access rearing and foraging habitat in spring, remaining throughout the open-water season. Stream habitat where Char were captured in surveyed streams is illustrated in Figure 7-4.4. Some of the more productive tributaries in terms of rearing and foraging habitat included Camp Lake Tributary 1, Camp Lake Tributary 2, Sheardown Lake Tributary 1, Sheardown Lake Tributary 7, Mary Lake North Tributary 1, Mary River, and Tom River. In most of these tributaries, the fish use the entire reach between the lake into which the tributary flows and the first impassable barrier, and are found primarily in cobble and boulder habitat where cover is available.

Overwintering habitat within the Mine Area appears to be restricted to the four main surveyed lakes. None of the streams or rivers in the Mine Area are considered to provide overwintering habitat, as all freeze solid (see Volume 7, Appendix 7A). Overwintering habitat is abundant in the four surveyed lakes, with the possible exception of the generally shallower Mary Lake N. Winter sampling in Camp and Sheardown lakes confirmed the presence of overwintering adults.

In general, movement data collected from Mine Area lakes and streams suggest that Char larger than approximately 250 mm do not move large distances, preferring to spend the majority of their life within a particular lake, although some movement has been documented between lakes via larger rivers during summer. Juveniles overwinter in lakes and move either to the nearshore zones of lakes or into the smaller tributaries during spring and move back into the lakes during summer or fall. Fish within the Mine Area may be classified as non-anadromous freshwater residents.

Metals in Fish

In 2006-2007, 102 Arctic Char ranging from 5 to 25 years of age and 165 to 751 mm in length were captured and analysed for metals in liver and/or muscle tissues. In 2008, 30 juveniles ranging from 2-5 years and from 63-150 mm in length were captured from the Mary River and analysed for metals in liver and muscle In general, results were similar across lakes and the Mary River in terms of metals consistently detected or not detected. With one exception (mercury), metals consistently detected in muscle and liver

were essential elements such as calcium, potassium and zinc. Several metals were detected in all liver samples of fish captured from lakes (cadmium, cobalt, molybdenum, selenium, sodium and thallium) but not in juvenile fish captured from the Mary River.

All measured concentrations of lead and arsenic were within the Canadian Food Inspection Agency (CFIA) guidelines (0.5 µg/g w.w. for lead; 3.5 µg/g w.w. for arsenic) in the Mine Area. As mercury bioaccumulates and biomagnifies, it is generally highest in larger, older fish and in species that occupy a higher trophic position (i.e., top predators). Mercury concentrations in muscle and liver (excluding those of juvenile fish) were positively correlated to fish fork length and age.

Arithmetic and length-standardized mean concentrations of mercury in Arctic Char muscle were relatively similar across lakes, but both values were highest in Angajurjualuk Lake. Concentrations of mercury in juveniles were notably lower than in larger fish captured from the lakes. Collectively, of the fish captured in lakes (age range of 5 to 25 years),14 % of muscle samples exceeded the Government of Canada (2010) guideline for the commercial marketing of fish (0.5 µg/g w.w.) and 29 % exceeded the previously published Health Canada (Wheatley 1984) guideline for subsistence consumption (0.2 µg/g w.w.). Mercury concentrations are commonly higher in land-locked Char relative to anadromous populations (Lockhart *et al.* 2005) and frequently above the Health Canada subsistence guideline of 0.2 µg/g (w.w.) in Arctic fish (e.g., Gantner *et al.* 2010). Concentrations of mercury in muscle of fish collected in the Mine Area fall within the ranges observed in 27 populations of land-locked Arctic Char sampled across remote lakes of the Canadian Arctic (Gantner *et al.* 2010) and from land-locked fish collected from six lakes in the Canadian Arctic archipelago (Muir *et al.* 2005). The arithmetic mean concentrations of mercury in muscle of fish from the Mine Area lakes was lower than the mean reported by Gantner *et al.* (2010) for Radar Lake, Baffin Island, despite similarity in mean fork lengths between these populations.

4.2.6 Railway LSA

The 149 km railway will connect the Mine Site to Steensby Port (Figure 7-1.5). The railway corridor, which will include a construction access road, several spur roads to access rock quarries and four construction camps, will traverse three major watersheds. From the mine site to approximately km 69 the line will traverse numerous watercourses that drain generally westward as part of the Ravn River watershed. From km 69 to approximately km 127 the line will pass through the Cockburn River watershed that flows southward to Steensby Inlet. The remainder of the line will lie within the Ikpikitturjuaq River watershed that drains southwestward and empties into Ikpikitturjuaq Bay, north of the Steensby Port site.

The access road will run adjacent to the railway for most of its length, with several minor deviations and two major deviations, one at Cockburn Lake and one to the north of the Ravn River crossing (Figure 7-1.5). Construction camps will be located north of the Ravn River crossing (Ravn River Camp), at Mid-Rail Camp Lake (Mid-Rail Camp), on the east side of the middle basin of Cockburn Lake (Cockburn Tunnels Camp), and near the southern end of Cockburn Lake (Cockburn South Camp) (Figure 7-1.5).

Field studies were initiated within the Railway/Access Road LSA in 2007 and continued in 2008, 2010, and 2011.

Railway/Access Road Stream Crossings

A total of 224 sites were surveyed at potential railway crossings, or where the railway and construction access road crossings will be adjacent (Figure 7-4.7). These included 65 sites (29 %) that were confirmed or suspected to be Arctic Char habitat. Ninespine Stickleback habitat was confirmed or suspected at 60

streams (27 %). A total of 49 streams (22 %) were assessed as fish habitat for both species, and 149 streams (67 %) were designated as having no fish habitat. Excluding the Cockburn Lake and Mary and Ravn river crossings, Char habitat was limited to summer rearing and feeding habitat for YOY and juveniles. Forty-seven sites (21 %) were assessed as Important, most of them in the Ravn and Cockburn river watersheds. Eighteen sites (8 %), most in the Ikpikitturjuaq and Ravn river watersheds, were considered to provide Marginal habitat.

A total of 96 potential access road crossing sites were surveyed along the access road alignment, excluding sites where the access road and railway crossings will be adjacent. These included 24 (25 %) that were confirmed or suspected to be Arctic Char habitat. Ninespine Stickleback habitat was confirmed or suspected at 27 streams (28 %). A total of 24 streams (25 %) were assessed as fish habitat for both species, and 69 streams (72 %) were designated as having no fish habitat. Excluding the Mary and Ravn river crossings, habitat was limited to summer rearing and feeding habitat for YOY and juveniles. Fifteen sites (16 %) were assessed as Important, most of them in the Ravn River watershed. Nine sites (9 %) were considered to provide Marginal habitat, most in the Ravn River watershed.

Cockburn Lake

Cockburn Lake is a narrow lake, approximately 37 km long, confined within a steep-sided valley. It comprises three basins separated by two narrow and relatively shallow channels (Figure 7-4.7). The middle basin is by far the largest (approximately 18.6 km long and 394.4 km^2), while the south basin (approximately 7.8 km long and 11.1 km^2) and north basin (approximately 5.7 km long and 9.5 km^2) are substantially smaller. The north basin has maximum and mean depths of 192 m and 29.8 m, respectively. The middle has a maximum depth of 195 m and a mean depth of 34.7 m. The south basin has maximum and mean depths of 61.4 m and 21.5 m, respectively (for the portion of the basin that was surveyed).

Acoustic depth and substrate data collection was focused along shorelines adjacent to the proposed railway and access road alignments. Six discrete substrate types were identified. Boulder and cobble substrates with clay or pebble matrices comprised about 94 % of the nearshore habitat mapped in the north and middle basins. Areas mapped in the south basin were dominated by fines (i.e., sand, silt, and clay), with coarser rock substrates (i.e., boulder, cobble, gravel) generally confined to nearshore areas. Nearshore substrate composed of boulder and cobble would provide cover and feeding habitat for juvenile Arctic Char and possibly Ninespine Stickleback.

Gillnetting was conducted in the fall of 2008, at five sites located in the vicinity of the Cockburn Lake railway crossing. CPUE was highest, 85-86 fish/100 m/24 hrs, at two nearshore sites (4-5 m depths), while average CPUE at three deeper sites was less than 10 fish/100 m/24 hrs.

MILNE INLET TOTE ROAD

MINE SITE

Camp Lake

560,000

595,000

7,910,000

Mary Lake

RAVN RIVER CAMP

Angajurjualuk Lake

MID-RAIL CAMP

7,875,000

Mid-rail Camp Lake

Cockburn Lake

7,840,000

Cockburn Lake

COCKBURN TUNNELS CAMP

Cockburn Lake

COCKBURN SOUTH CAMP

STEENSBY INLET

STEENSBY PORT

Milne Inlet

BAFFIN ISLAND

Mine Site

Steensby Inlet

SCALE 5 2.5 0 5 10 15 km

LEGEND:

- RAILWAY CROSSING
- ACCESS ROAD CROSSINGS
  - ADJACENT TO RAIL CROSSING
  - DIVERGENT FROM RAIL CROSSING
- MILNE INLET TOTE ROAD (EXISTING)
- RAILWAY ALIGNMENT (PROPOSED)
- CONSTRUCTION ACCESS ROAD (PROPOSED)
- INFRASTRUCTURE
- WATER

NOTES:

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FISH HABITAT INTERACTIONS ALONG RAILWAY

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO. 102-181/25

REF NO. 12

FIGURE 7-4.7

Railway/Access Road Lake Encroachments

A total of 46 potential encroachment sites were surveyed between 2007 and 2010, including 19 (41 %) that were confirmed or suspected to be Arctic Char habitat. Ninespine Stickleback habitat was confirmed or suspected at 25 sites (54 %). A total of 17 sites (37 %) were confirmed or suspected to provide habitat for both species, and 18 sites (39 %) were designated as having no fish habitat. Encroachment sites identified as Char habitat generally are shallow nearshore sites with habitat suitable for feeding and rearing. No sites were identified as potential spawning or overwintering sites, and no sites were identified where feeding and rearing habitat is limited in a given waterbody (i.e., critical).

Construction Camps

Ravn Camp Lake has a surface area of 1.9 km^2 and at the time of the 2010 survey had a maximum and mean depth of 50.0 m and 14.5 m, and a volume of 27.5 million m^3. The east basin, which includes the water withdrawal site, is both the largest and the deepest. The lake substrate is dominated by sand and silt/clay/sand and no potential spawning areas were identified.

Mid-Rail Camp is located near the railway alignment, approximately 60 km from the Mine Site and 20 km south of the Ravn River Camp site (Figure 7-4.7). Mid-Rail Camp Lake has a surface area of 1.8 km^2 and a maximum and mean depth of 14.4 m and 4.2 m, respectively, for the portion of the lake that was surveyed. The lake Volume was estimated to be 7.6 million m^3. The Mid-Rail Camp area is relatively flat and local surface water flow patterns are complex and in places indefinite.

A total of four Arctic Char were captured in a gill net set in Mid-Rail Camp Lake in 2008. Juvenile Arctic Char were observed in nearshore areas of this lake, but were generally absent from the shallow lakes to the south of Mid-Rail Camp Lake. Mid-Rail Camp Lake and several other lakes in the area also support Stickleback.

The Cockburn Tunnels Camp is located on the east side of Cockburn Lake, approximately midway down the middle basin (Figure 7-4.7). Bathymetry and substrate mapping surveys were conducted along the eastern shore of Cockburn Lake, including the area adjacent to the Cockburn Tunnels Camp, in 2007.

The Cockburn South Camp is located on the east side of Cockburn Lake, near the south end of the lake and approximately 20 km from the Steensby Port site (Figure 7-4.7). Substrates in the south basin of Cockburn Lake are dominated by fines (sand, silt and clay), with coarser rock substrates (boulder, cobble and gravel) generally confined to nearshore areas at depths less than 3 m. No potential Arctic Char spawning areas were located in the vicinity of Cockburn South Camp, although nearshore habitats composed of boulder and cobble would provide cover and feeding habitat for juveniles and possibly for Ninespine Stickleback.

Although not directly associated with the camp, two access road crossings within the camp footprint (AR-021 and AR-021a) were assessed. These were classified as Marginal and No Fish Habitat for Arctic Char for AR-021 and AR-021a, respectively.

4.2.7 Steensby Port LSA

The Steensby Port LSA consists of numerous lakes and streams in small, coastal watersheds and various components of larger catchments such as the watersheds of the Cockburn and Ikpikitturjuaq Rivers (Figure 7-1.5). Most of the freshwater in this region lies in areas of relatively low relief with perennial or intermittent outflows to the sea. Aquatic biota and habitat baseline studies at the Steensby Port LSA were largely conducted from 2007 to 2010. Studies included surveys to determine fish presence/absence and distribution, fish barriers, and habitat use. Information on primary production (i.e., phytoplankton) was

obtained in 2008 at selected lakes in conjunction with water quality sampling and from one lake in 2011; results of the latter sampling are pending.

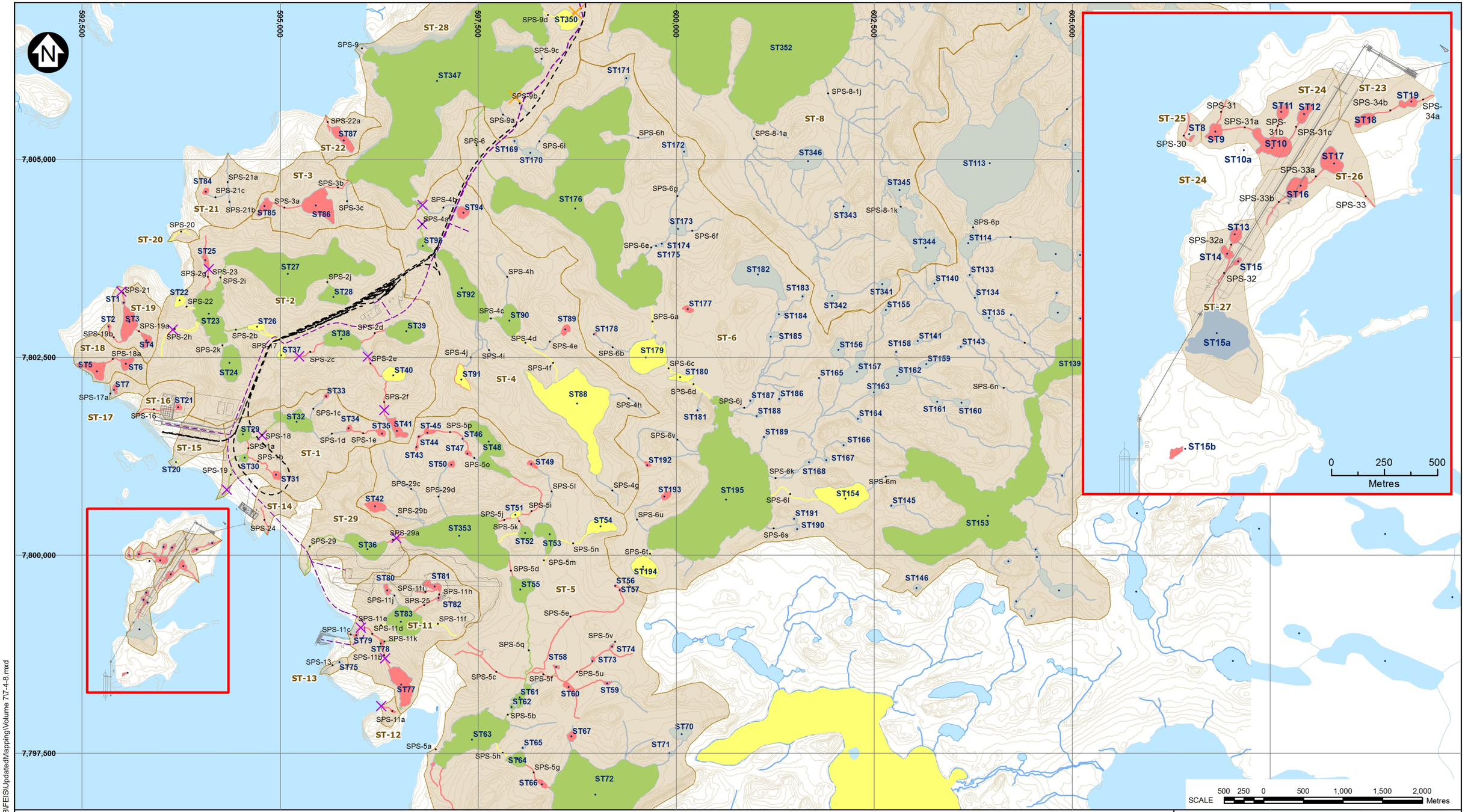
Information from the IQ study indicated the presence of Arctic Char in three lakes including Ikpikitturjuaq Lake (ST-347), its largest upstream lake (ST-176) and Lake ST-352 (Figure 7-4.8). Arctic Char were identified as being abundant in Ikpikitturjuaq Lake during summer with anadromy via the Ikpikitturjuaq River. Both Ikpikitturjuaq Lake and Lake ST-352 were identified as important for fish and as drinking water sources by five Igloolik IQ study participants. Although not surveyed as part of this Project, test fisheries conducted on nearby rivers in the Steensby Inlet area, including the Ravn, Cockburn and Ikpikitturjuaq rivers, identified the presence of anadromous populations of Char (Kroeker 1986, 1987).

Generally, the majority of available fish habitat in the Steensby Port LSA is lacustrine and is found exclusively on the mainland; freshwater ponds on the island are not fish-bearing. There are relatively few large streams, in particular those with a predominance of cobble/riffle habitat, relative to other LSAs. In addition, most of the available fish habitat in the surveyed area can be found in only four catchments (ST-02, 04, 05, and 06). Nearshore substrates in a large number of the lakes in the surveyed area are predominantly gravel or smaller in size. Most catchments on the mainland contain a minimum of one lake with apparently sufficient depth to provide overwintering habitat for both fish species.

A large proportion of surveyed streams were identified as non fish-bearing based on a lack of sufficient flows and/or connectivity with probable suitable overwintering locations. Of the remaining streams with suitable fish habitat, most are characterized by fine substrates. Barriers to fish movements are present in most catchments, but are more common in smaller drainages along the coast (Figure 7-4.8). With the exception of the Ikpikitturjuaq River, there appears to be a general lack of connectivity with the marine environment, and therefore little anadromy. Primary production of Steensby Port LSA lakes is low. Chlorophyll *a* concentrations measured in 2008 ranged from <0.2 µg/L to 5.5 µg/L near the water surface and indicate a trophic status ranging from ultra-oligotrophic to borderline oligotrophic/mesotrophic.

Both freshwater fish species were observed throughout the Steensby Port LSA. However, in contrast to other LSAs, Ninespine Sticklebacks were more widespread and abundant than Arctic Char in many catchments. Three entire watersheds (ST-03, 18, and 19) were found to support only Ninespine Stickleback. Both species were captured or observed more commonly in lakes than in streams and were generally absent from small, coastal, mainland and island catchments despite the presence of apparently suitable spawning, overwintering, and/or rearing habitat in many waterbodies.

The broader distribution of Ninespine Stickleback relative to Arctic Char in many Steensby watersheds may be related to the predominance of fine substrates and low flow/lack of connectivity. Many of these areas are suitable for multiple life history stages of Ninespine Stickleback, but may limit movements of and use by Arctic Char, which prefer larger substrate sizes.



LEGEND:

STATUS OF ARCTIC CHAR

- PRESENT
- POTENTIAL
- NOT PRESENT
- UNKNOWN

- RAILWAY ALIGNMENT (PROPOSED)
- CONSTRUCTION ACCESS ROAD (PROPOSED)
- LOCAL STUDY AREA CATCHMENTS
- INFRASTRUCTURE
- WATER

- FISH BARRIER (CONFIRMED)
- FISH BARRIER (REMOTELY SENSED)

NOTES:

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5. CONTOUR INTERVAL IS 5 AND IS IN METRES.
6. LOCAL STUDY AREA CATCHMENTS PROVIDED BY KNIGHT PIESOLD.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ARCTIC CHAR DISTRIBUTION IN FRESH WATER AT STEENSBY PORT

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO.	REF NO.
102-181/25	12

FIGURE:7-4.8

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4.3 ISSUES SCOPING

Scoping of the potential effects of the Project on freshwater aquatic biota and habitat was conducted over several years and involved extensive community consultations, technical workshops, data collection and literature review. These scoping exercises provided the foundation for identifying the design of baseline studies, Study Area boundaries, valued ecosystem components (VECs)/Key indicators, issues and Project-related linkages, and impact assessment considerations for freshwater aquatic biota and habitat. Specifically, scoping activities included:

- Literature review (baseline conditions) - Scientific literature and Inuit Traditional Knowledge was identified and reviewed, most notably for the LSAs and RSA and for other Arctic freshwater ecosystems in general to assist with data interpretation and provision of context;
- Literature review (key issues related to Project impacts and VECs/Key indicators) - Other project environmental impact statements (EISs) and EIS review comments were compiled and reviewed, with an emphasis on recent Nunavut projects;
- Literature review of recent aquatic effects monitoring programs, with an emphasis on Arctic mining projects to assist in identifying key impacts, indicators, thresholds, and baseline study design;
- Consideration of *Fisheries Act* Metal Mining Effluent Regulations (MMER) and Environmental Effects Monitoring (EEM) requirements, as well as EEM guidance documents;
- Numerous discussions with and site visits by DFO, Environment Canada, and GN biologists over the period of 2007 through 2011;
- Consultation with the communities of (listed in alphabetical order) Arctic Bay, Clyde River, Hall Beach, Igloolik and Pond Inlet, as described in Volume 2, Section 1;
- Inuit knowledge studies carried out in the same communities above;
- A Mary River Project team scoping meeting held in November 2007 and other aquatic team meetings;
- Review of scientific literature pertaining to resident aquatic biota biology/life history and toxicology; and
- The conduct of freshwater aquatic biota and habitat baseline studies for the Project (i.e., Project baseline studies) over the period of 2005 to 2010.

As described in Volume 2, Section 3.0, VECs are valued components of the natural biophysical environment and are aspects of the environment that have been identified as of importance to a particular region or community. Freshwater aquatic biota and habitat was identified as the VEC for this component of the Project, in concordance with Nunavut Impact Review Board (NIRB) EIS guidelines (Section 7.2.1, p. 35).

To focus the EIS, key indicators were identified for the VEC freshwater biota and habitat through:

- Review of the NIRB environmental impact statement guidelines;
- Collection and consideration of baseline data for the freshwater environment (e.g., species presence/abundance and distribution);
- Literature review;
- Consideration of SARA species and COSEWIC species in the Study Areas;
- An environmental team scoping exercise in November 2007;
- Identification of linkages between the Project and aquatic biota;

- Consideration of species of ecological importance;
- Consideration of species of social importance;
- Consultation with stakeholders as described in Volume 2, Section 1;
- Consideration of species sensitivity;
- Consideration of potential bioindicators of environmental disturbance; and
- Consideration of recent EISs in Nunavut and elsewhere in Canada.

Based on these considerations, Arctic Char was identified as the key indicator for freshwater aquatic biota and habitat. They are abundant and widely distributed in the LSAs and the RSA, are socially important, are ecologically important, and are good general bioindicators of environmental condition.

Other components considered in the assessment included effects of the Project on Arctic Char habitat and lower trophic level biota. Both of these environmental components are of importance to the health and integrity of Arctic Char populations and Project-related effects that could in turn affect them. Effects of the Project on fish habitat will also be addressed through a *Fisheries Act* Authorization and an associated no net loss plan (NNLP).

4.3.1 Scoping Completed

As described in Volume 2, Section 3.5.3, potential effects of the Project were addressed as either Key Issues or as Subjects of Note. Key issues are defined as "interactions that are of substantial public interest and/or of potentially high environmental importance or consequence and, consequently require rigorous investigation and analysis in the EIS." Key issues were assessed in detail in the assessment.

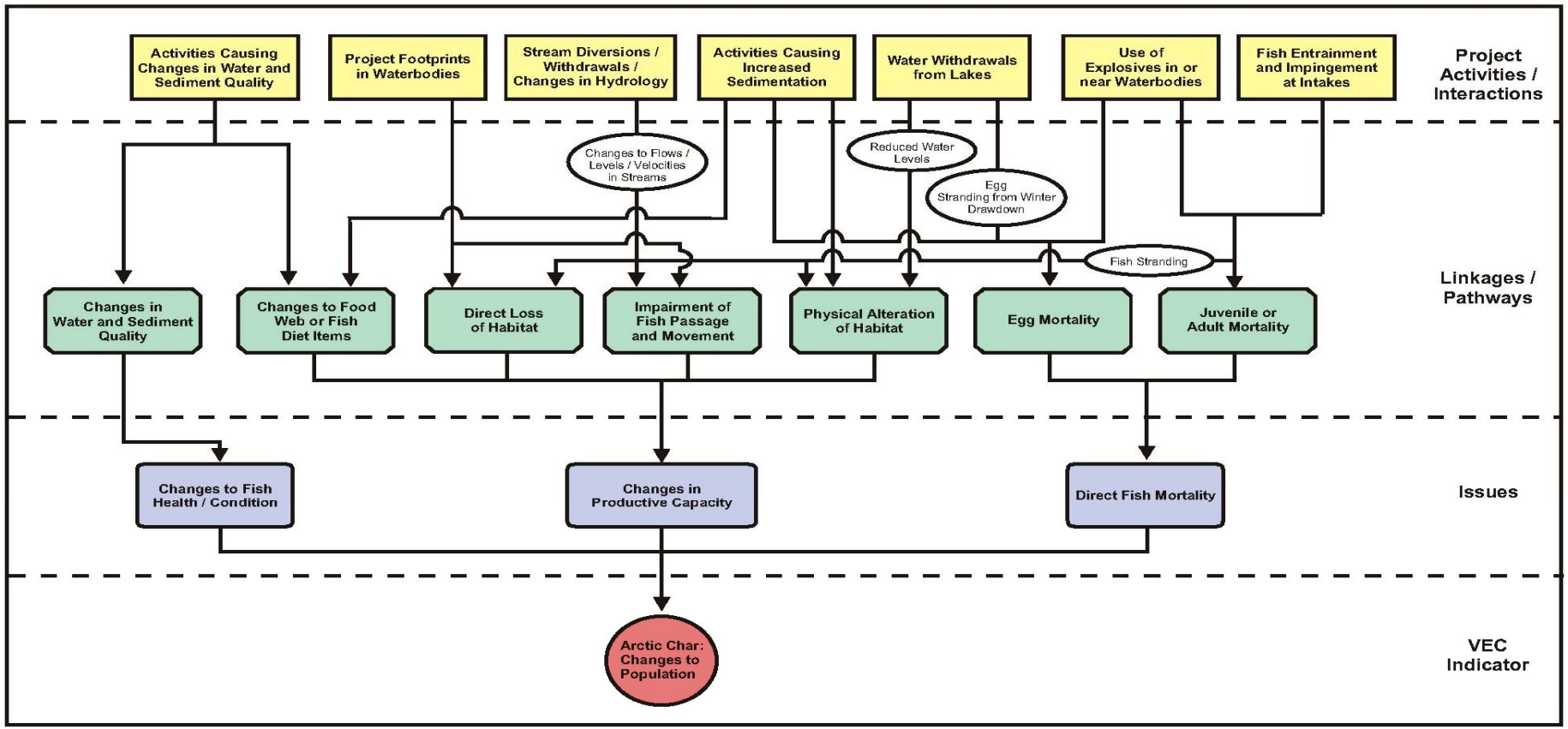
Subjects of Note are defined as interactions "that are less likely to be of notable environmental importance or consequence" and "which can be addressed through application of standard, proven, mitigation or prevention approaches." Subjects of Note are addressed with brevity in order to focus the assessment on key issues and were not carried through the entire assessment.

In accordance with Volume 2, Section 3.5.3, potential interactions between the Project and the key indicator (Arctic Char) were rated as Level 1 (Subject of Note) or Level 2 (Key Issue). The following Sections provide an overview of Key Issues and pathways of effects and Subjects of Note.

Key Issues and Pathways

The primary question respecting potential effects of the Project is: "What effect would the Project have on Arctic Char populations, movements, and health/condition?" Potential linkages between the Project components/activities and Arctic Char are presented graphically in Figure 7-4.9. These linkage pathways fall into three key issues:

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



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

LINKAGE DIAGRAM ILLUSTRATING PROJECT ACTIVITIES/PATHWAYS OF POTENTIAL EFFECTS - ARCTIC CHAR

NORTH/SOUTH CONSULTANTS INC.	P/A NO. NB102-181/25	REF. NO. 12
	FIGURE 7-4.9	REV 0

Assessments of potential Project-related effects on water quantity and water and sediment quality are presented in Sections 2.0 and 3.0, respectively. The impact assessments for these components represented key inputs to the assessment of Project effects on freshwater aquatic biota and habitat.

Key Issue #1: Potential Effects on Arctic Char Health and Condition

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 considered in the assessment are based on the residual effects identified in the water and sediment quality assessment. Linkages considered in the assessment include three general categories:

- Point source discharges (treated sewage effluent, Waste Rock Stockpile runoff, ore stockpile runoff, mine pit water and 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. Potential effects of the Project on direct mortality are considered under Key Issue #3 and/or as Subjects of Note.

Key Issue #2: Potential effects on Arctic Char habitat

Project activities with the potential to affect Arctic Char habitat were assessed, including:

- Placement of Project infrastructure in waterbodies (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 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); and
- 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).

Key Issue #3: Potential effects on direct mortality of Arctic Char

Project-related activities with the potential to cause direct mortality of Arctic Char considered in the assessment include:

- Effects of sedimentation on mortality of eggs;
- Potential egg stranding related to winter drawdown at water source lakes; and
- Potential fish stranding related to water diversions and/or alterations in discharge or water levels.

Precise linkages and potential effects of the Project on Arctic Char vary between the LSAs and Project phases. The effects assessment describes these potential effects for each LSA and Project phase in the effects assessment. Section 4.5 provides a detailed assessment of the effects of the Project on the key indicator (Arctic Char) and considers effects on non-indicator biota.

4.4 SUBJECTS OF NOTE

Several Project activities have the potential to affect Arctic Char but will be managed and mitigated through adherence to federal guidelines and/or standard, well-established mitigation methods, and through detailed management plans. These Subjects of Note are described below.

Fish Entrainment and Impingement at Water Intakes

As described in Section 2.3.2, water will be withdrawn from a number of waterbodies across the LSAs to support construction, operation, and closure phases of the Project as summarized in Table 7-4.1.

Table 7-4.1 Water Withdrawal Locations during Project Construction, Operation and Closure

Project LSA	Waterbody	Project Phase	Seasonal or Year-Round[1]
Milne Port LSA	Phillips Creek	Construction, Operation, and Closure	Open-Water Season
	Km 32 Lake	Construction, Operation, and Closure	Winter
Mine LSA	Camp Lake	Construction, Operation, and Closure	Year-round
Railway/Access Road LSA	Ravn Camp Lake	Construction	Open-Water Season
	MidRail Camp Lake	Construction	Winter
	Cockburn Lake	Construction	Year-round
Steensby Port LSA	Lake ST353	Construction	Year-round
	Lake ST347	Construction, Operation and Closure	Year-round

NOTE(S):
1. OPEN-WATER SEASON: JUNE-SEPTEMBER, WINTER: OCTOBER-MAY.

The potential for entrainment and impingement of fish due to water intakes will be mitigated through adherence to the DFO Freshwater Intake End-Of-Pipe Fish Screen Guideline (DFO 1995). Intakes will also be located to avoid spawning habitat to prevent entrainment of eggs.

Potential Effects of Blasting on Arctic Char

As described in Volume 3 (Sections 2.0 and 3.0), blasting will be conducted across the LSAs to support Construction and Operation phases of the Project. DFO "Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters" (Wright and Hopky 1998) are intended "to provide information to proponents on the conservation and protection of fish, marine mammals, and their habitat from impacts arising from the use of confined or unconfined explosives in or near Canadian fisheries waters." As indicated by Wright and Hopky (1998), "the detonation of explosives in or adjacent to fish habitat has been demonstrated to cause disturbance, injury and/or death to fish and marine mammals, and/or the harmful alteration, disruption or destruction of their habitats, sometimes at a considerable distance from the point of

detonation." Scientific literature indicates that detonation of explosives may cause injuries and mortalities to fish, including:

- Swimbladder rupture (Aplin 1947, Falk and Lawrence 1973, Ferguson 1962, Fitch and Young 1948, Gaspin 1975, Houghton and Munday 1987, McAnuff *et al.* 1994, Roguski and Nagata 1970, Teleki and Chamberlain 1978);
- Broken ribs (Aplin 1947, Fitch and Young 1948, Indrambarya 1949, Roguski and Nagata 1970);
- Ruptured blood vessels (Coker and Hollis 1950, Cronin 1948, Ferguson 1962, Indrambarya 1949, Kearns and Boyd 1965, Paterson and Turner 1968, Sverdrup *et al.* 1994);
- Ocular protrusion (Coker and Hollis 1950, Kearns and Boyd 1965, Thompson 1958);
- Kidney damage (Houghton and Munday 1987, Linton *et al.* 1985, Roguski and Nagata 1970, Sakaguchi *et al.* 1976,Wiley *et al.* 1981,Yelverton *et al.* 1975);
- Distension and rupture of abdominal walls (Houghton and Munday 1987, Linton *et al.* 1985, Roguski and Nagata 1970, Thomson 1958, Yelverton *et al.* 1975); and
- Vibrations from the detonation of explosives may cause damage to incubating eggs (Wright 1982).

Effects of blasting on free-swimming Arctic Char and their eggs will be mitigated through development of a detailed blasting management plan, which will follow DFO blasting guidelines (Wright and Hopky 1998). If issues associated with meeting the DFO blasting guidelines are identified, these will be discussed with DFO prior to undertaking of blasting activities. Additionally, Baffinland will stay current with ongoing research studies (e.g. Godard *et al.* 2008) and policy development that flows from such work.

Fishing

While harvesting will be permitted by Inuit who work at the sites, it is assumed the level of effort will be negligible because of the work schedule (little leisure time available) and the travel required for individuals to leave the safety zones around each worksite. The experience during exploration has shown that few site employees have exercised any effort at fishing, hunting or trapping, which provides support that this assumption is a reasonable one. Additional discussion on land use and harvesting effects of the Project is provided in Volume 4, Section 10.

Potential Effects of Stream Crossing Construction on Stranding of Arctic Char

Construction of stream crossings for the Railway and Access Road has the potential to cause stranding of Arctic Char due to the need for isolation of the watercourses. These effects will be mitigated through the use of appropriate timing windows for construction when possible and through fish salvage operations when required.

DFO has issued an Operational Statement (OS) detailing the conditions under which clear-span (i.e., single-span) bridges can be constructed without causing negative effects to fish or aquatic and riparian habitats. Adhering to the conditions and protective measures provided in this OS wherever possible will ensure the protection of fish and fish habitat, and will avoid conditions under which fish stranding could occur. Where multi-span or single-span bridge installation will unavoidably require abutment or support pier encroachments on beds or banks below the ordinary high water mark, appropriate mitigation measures will avoid fish mortality due to stranding. Instream structures will be constructed in isolation (e.g., caissons or coffer dams) and any fish stranded within these structures will be captured and returned to the stream

unharmed (i.e., salvaged). Similarly, open water culvert installations in fish-bearing streams will use well established stream isolation methods, and all stranded fish will be salvaged.

Placement of Project Footprints in Arctic Char Habitat and Potential for Mortality of Eggs

Potential for direct mortality of Arctic Char eggs due to placement of Project encroachments in waterbodies will be mitigated through avoidance of infrastructure placement on spawning habitat and adherence to appropriate timing windows. Mitigation measures for all construction activities in fish-bearing waters will be provided in a detailed management plan (Appendix 3B, Attachment 5).

Spills, Accidents and Malfunctions

Introduction of contaminants through spills, accidents and malfunctions have the potential to affect water and sediment quality and therefore fish health and condition. Potential effects of this pathway are considered to have a low likelihood of occurrence due to the extensive mitigation and adaptive management plans, as described in detail in assessed in Volume 9, Section 3.0.

Potential for Acute Toxicity to Arctic Char

The Project is not expected to result in acutely toxic conditions due to adherence to effluent discharge criteria, including the requirement to avoid acute toxicity at end-of-pipe and to meet MMERs, and implementation of various mitigation measures that would limit or avoid changes in water quality conditions in waters frequented by Arctic Char. Water quality and effluent quality monitoring will also be conducted throughout the Project LSAs to provide a mechanism for addressing unforeseen issues and supporting adaptive management.

Borrow and Quarry Sites

Borrow and quarry sites will be located at a minimum distance of 33 m from waterbodies (Volume 3 Appendix 3B, Attachment 6), and effects are not considered further. Potential indirect effects of development of quarry and borrow sites (i.e., through effects on water quality) are considered under non-point sources in Key Issue #1. Potential effects of quarry and borrow site access roads on fish habitat are considered on Key Issue #2 for the Railway/Access Road LSA.

4.5 ARCTIC CHAR

4.5.1 Assessment Methods

A description of the general assessment methodology employed for the environmental impact assessment (EIA) is provided in Volume 2, Section 3.6. The approach for the assessment of effects on Arctic Char as a key indicator involved using the existing baseline environment as the foundation for assessing potential effects of the Project, in conjunction with the use of key questions to focus the assessment. As described in Volume 2, Section 3.6, the assessment involved the following basic steps:

- Definition of the RSA and LSAs;
- Description of the baseline conditions within the study areas;
- Identification of Project activities with the potential to interact with Arctic Char;
- Identification of interactions between the Project and Arctic Char (i.e., linkages);
- Identification of mitigation activities to avoid or minimize effects on Arctic Char;
- Assessment of potential effects of the Project on Arctic Char;
- Description of residual effects of the Project on Arctic Char;

- Evaluation of significance of the Project and identification of Level of Confidence in the predictions; and
- Description of monitoring and follow-up.

The process was iterative as additional mitigation by design was identified through the effects assessment process.

Criteria used for defining the magnitude of residual effects on the indicator for freshwater biota and habitat were developed in specific consideration of ecological relevance for this VEC, available thresholds, and site-specific information. These criteria are presented in Tables 7-4.2 to 7-4.5 and are described below.

Table 7-4.2 Criteria for Determination of the Magnitude of Effect of Changes in Water Quality on Arctic Char Health and Condition

Level	Descriptor	Criteria[1,2,3]
Not Assessed (Level 0)	Negligible	Water quality change within CCME PAL guidelines or other water quality thresholds
Level I	Low	Water quality change 1-10 times the CCME PAL guidelines or other water quality thresholds
Level II	Medium	Water quality change 10-100 times the CCME PAL guidelines or other water quality thresholds
Level III	High	Water quality change >100 the CCME PAL guidelines or other water quality thresholds

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL FACTORS/SCIENTIFIC JUDGEMENT.
2. OTHER PUBLISHED WATER QUALITY GUIDELINES OR THRESHOLDS WERE APPLIED FOR PARAMETERS FOR WHICH THERE ARE NO CCME PAL WATER QUALITY GUIDELINES.
3. INCLUDES SITE-SPECIFIC WATER QUALITY OBJECTIVES FOR ALUMINUM, CHROMIUM, COPPER, AND IRON.

Table 7-4.3 Criteria for Determination of the Magnitude of Effect of Changes in Sediment Quality on Arctic Char Health and Condition

Level	Descriptor	Criteria[1,2]
Not Assessed (Level 0)	Negligible	Sediment quality change within sediment quality guidelines (Ontario LEL and CCME ISQG)
Level I	Low	Sediment quality change greater than CCME ISQG or Ontario LEL but less than CCME PEL or Ontario SEL
Level II	Medium	Sediment quality change 1-10 times than CCME PEL or Ontario SEL
Level III	High	Sediment quality change >10 times than CCME PEL or Ontario SEL

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL FACTORS/SCIENTIFIC JUDGEMENT.
2. OTHER PUBLISHED SEDIMENT QUALITY GUIDELINES OR THRESHOLDS WERE APPLIED FOR PARAMETERS FOR WHICH THERE ARE NO CCME PAL SEDIMENT QUALITY GUIDELINES.

Table 7-4.4 Criteria for Determination of the Magnitude of Effect on Arctic Char Habitat

Level	Descriptor	Criteria[1]
Not Assessed (Level 0)	Negligible	Negligible: <1 % reduction in productive capacity
Level I	Low	Low: 1-10 % reduction in productive capacity
Level II	Medium	Moderate: 10-20 % reduction in productive capacity
Level III	High	>20 % reduction in productive capacity

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL CONTEXT/SCIENTIFIC JUDGEMENT.

Table 7-4.5 Criteria for Determination of the Magnitude of Effect on Direct Mortality of Arctic Char

Level	Descriptor	Criteria [1]
Not assessed further	Negligible	Sedimentation rate < 1 mm/year (Fudge and Bodaly, 1984)
Level III	High	Sedimentation rate > 1 mm/year (Fudge and Bodaly, 1984)

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL FACTORS/SCIENTIFIC JUDGEMENT.

Key Issue #1: Effects on Arctic Char health and condition

This issue relates to the pathway of water and/or sediment quality changes and is therefore based on comparisons to Canadian Council of Ministers of the Enviornment (CCME) water and/or sediment quality guidelines and other water and sediment quality thresholds identified and applied in the water and sediment quality impact assessment (see Section 3.4). These thresholds are collectively referred to hereafter as "water quality thresholds."

Results of the water quality effects assessment, summarized in Tables 7-3.12, 7-3.14, and 7-3.25, were carried forward to the assessment of effects on Arctic Char. Project-related water quality changes predicted to remain within water quality thresholds (see Section 3.4.2), were considered to have a negligible effect on fish health and condition and were not assessed further here. Where predicted Project-related changes indicated the potential for exceedances of water quality thresholds, effects were assessed.

The magnitude of effects of changes in water quality on Arctic Char health and condition were ranked in consideration of water quality thresholds (Table 7-4.2). Exceedances were ranked in terms of order of magnitude, ranging from up to one order of magnitude to two orders of magnitude and higher, above water quality thresholds. This approach provides a quantifiable estimation of the magnitude of potential effects and the criteria are related to orders of magnitude of predicted change (Table 7-4.2). The overall premise incorporates the method of CCME water quality guideline derivation as it recognizes that CCME guidelines are typically developed on the basis of safety factors, generally ranging from 10 to 100 (CCME 1999; updated to 2012). Typically CCME protection of aquatic life (PAL) water quality guidelines are derived by identifying the lowest effect Level (LOEL) for aquatic biota reported in the scientific literature for a given substance, and dividing the LOEL by a factor of 10 or 100 to provide additional conservatism (i.e., safety factor).

Additionally, as CCME criteria are often derived with limited information generated from a limited number of aquatic species, and because the site-specific applicability of the guidelines may vary between sites, consideration was also granted to the scientific literature itself and site-specific information to more accurately consider impacts within the Study Areas. This is consistent with the general guidance provided by the CCME:

"Canadian water quality guidelines for aquatic life are not restricted to a particular (biotic) species, but species-specific information is provided in the respective fact sheets, and, more detailed, in the supporting documents, so that the water quality manager and other users may determine the appropriateness of the guideline for the protection and enhancement of local species. It is possible that the guidelines are over- or under-protective at sites with unique conditions. For example, the most sensitive species that occurs at a site may be more or less sensitive than the most sensitive species represented in the toxicological data set that was used to derive the guidelines. Similarly, a substance may be more or less toxic in site water (i.e., due to factors such as pH, water hardness, complexing agents, etc.) than it is under the range of conditions that is represented in the toxicological data set. In some cases, natural background concentrations of a substance may exceed the guideline without any apparent effect on biota (i.e., if the substance is not present in a bioavailable form). Under these circumstances, it might be necessary to modify the WQGs [water quality guidelines] to account for conditions that occur at the site. Although the Canadian Water Quality Guidelines are broadly used within Canada and elsewhere to assess and manage water quality conditions, they should not be regarded as blanket values for national environmental quality (CCME 1999). Variations in environmental conditions across the country have the potential to influence the applicability of the Canadian Water Quality Guidelines. More specifically, factors such as elevated natural background levels of COPCs [contaminants of potential concern], the atypical levels of water quality variables that influence the bioavailability and/or toxicity of COPCs, and the sensitivity ranges of resident species can limit the applicability of generic WQGs. Therefore, it may be necessary to establish site-specific WQOs that account for such variations in environmental conditions."

Potential effects of Project-related water quality changes on Arctic Char health and condition were also characterized in consideration of site-specific information collected during the baseline studies, scientific literature, knowledge of Char biology, distribution/movements, habitat use, and spatial and temporal magnitude of the predicted water quality changes.

Arctic Char are more tolerant than other fish species to low pH and iron and aluminum (Poleo and Bjerkely 2000, Poleo *et al.* 1997) and there is some indication that they may in fact acclimate to elevated aluminum concentrations and acidic conditions (Poleo and Bjerkely 2000). Therefore, small exceedances of water quality thresholds may have a lower impact on their health and condition than for other fish species, including other salmonids.

Frequency of effects related to Arctic Char health and condition was defined in consideration of the duration, magnitude, and frequency of the exceedance of a water quality threshold. That is, these three criteria collectively affect the ability of biota to recover from sub-lethal changes in water quality. Infrequent, low magnitude exceedances of water quality thresholds were considered to have infrequent effects as organisms would be expected to readily recover. Conversely, high magnitude effects on water quality, regardless of the frequency of occurrence, would have a more prolonged (frequent or continuous) effect on biota.

Sediment quality thresholds applied for the assessment of effects on aquatic biota and habitat included CCME interim sediment quality guidelines (ISQGs) and probable effect levels (PELs) where available. In

addition, Ontario lowest effect levels (LELs) and severe effect levels (SELs) were applied for iron and nickel. Magnitude of effects were based on the level of exceedences above the ISQG (or LEL) and the PELs (or SELs) as summarized in Table 7-4.3. This approach recognizes the derivation of SQGs where the ISQG represents the value below which effects on aquatic biota are expected to occur rarely and the PEL represents the value above which effects to aquatic biota are expected to occur frequently. The CCME SQGs are recommended to be applied to the upper 5 cm of sediment (CCME 1999; updated to 2012).

Key Issue #2: Effects on Arctic Char habitat

Arctic Char habitat may be altered, disrupted or destroyed as a result of the Project. Habitat is defined here as the physical conditions required for life history stages and other biota in the ecosystem that form the basis of the food web in which Arctic Char are a component (i.e., productive capacity). Effects were defined in terms of "productive capacity" to address guidance provided in DFO (1998) respecting effects on fish habitat. Productive capacity may be defined as the natural ability of habitat to support or produce fish and other aquatic organisms upon which fish depend (DFO 1986). The magnitude of potential effects of the Project on Char habitat was defined as indicated in Table 7-4.4 for each LSA. Reductions of <1 % were considered to be negligible and were not assessed further.

Consideration was also given to the quality and usage of various habitats, in conjunction with the overall availability of similar habitat to the affected population, when assigning a magnitude ranking. For example, loss of a portion of low quality and abundant rearing habitat was considered to have a lower magnitude of effect than loss of limiting habitat, such as spawning habitat.

Of particular note is the role played by the DFO approach to issuance of Fisheries Authorizations, i.e. that there be no net loss of productive fish habitat. By definition therefore, the development and implementation of a Fish Habitat Compensation Plan will provide a mitigation measure that assures there will be a negligible residual environmental effect of the Project on fish habitat.

Key Issue #3: Effects on direct mortality of Arctic Char

Potential effects of the Project on direct mortality of Arctic Char were assessed, for pathways of effect not identified as Subjects of Note. The potential for egg stranding in relation to winter water withdrawals and consequent lake level reductions was assessed, but in all cases it was considered that the potential for egg mortality was negligible since predicted water level reductions were small and are expected to be within the natural range of variability.

The magnitude of potential effects on the direct mortality of Arctic Char was defined using a published threshold for defining effects of sedimentation on fish eggs, as indicated in Table 7-4.5. Fudge and Bodaly (1984) and Wyatt *et al.* (2010) identified significant adverse effects on Lake Whitefish (*Coregonus clupeaformis*) and Rainbow Smelt (*Osmerus mordax*) eggs, respectively, where 1 mm or more of sediment had accumulated on the eggs directly. While sediment deposition on Arctic Char eggs will be lower than that predicted as an annual rate of deposition, predicted annual rates of sedimentation due to the Project were compared to this threshold to be conservative.

Due to the nature of this impact pathway, the magnitude of effects was only identified as either "negligible" where the threshold is predicted to High where this threshold may be exceeded. Effects identified as Negligible were not assessed further.

Determination of Significance

The general approach for the determination of significance and identification of the Level of Confidence is described in Volume 2, Section 3.8. The determination of significance of residual effects was based on the overall effects to Arctic Char populations.

In brief, the primary criteria for defining the significance of residual effects were magnitude and reversibility, while secondary criteria included the geographic extent, frequency, and duration of residual effects. Effects ranked with a Level III magnitude and/or reversibility were considered to have a greater likelihood of significance. Reversibility was defined from the perspective of Arctic Char populations, rather than the direct reversibility of the physical activity leading to residual effects. Specifically, reversibility considered the ability of populations to recover from residual effects. The determination of significance considered the environmental sensitivity of Char populations and general ecological context related to the effect.

4.5.2 Potential Effects and Proposed Mitigation

The following provides an assessment of potential effects of the Project on Arctic Char within each of the five LSAs. General mitigation is described in Section 4.5.2.1 and throughout the assessment, where applicable.

4.5.2.1 General Mitigation

Extensive mitigation measures will be implemented throughout all Project phases to avoid or reduce the magnitude of effects of Project-related activities on the freshwater environment. Volume 2, Section 3.9 outlines the processes for monitoring and reporting on the effectiveness of mitigation measures and introducing corrective action as required. This process is achieved through the use of specific Environmental Mitigation and Monitoring Plans (EMMPs), each of which focuses on a specific VEC and outlines how monitoring results are used to refine or modify the design and implementation of mitigation measures and management activities (operating procedures). The general organization and content of the EMMPs is presented in Volume 10, while the detailed content of each EMMP is presented in Appendix 10D. General mitigation measures applied during water withdrawal, water diversion, and effluent discharge activities are provided in Volume 7, Section 2.3.2.2. Sections 3.4.2 (Volume 7) provides a detailed breakdown of mitigation measures that would avoid or reduce effects on water quality from aqueous non-point source emissions, aqueous point source emissions, and airborne emissions. All of these measures also serve to mitigate Project-related effects on Arctic Char and fish habitat.

Additional mitigation that may be applied includes, but is not necessarily limited to:

- The use of timing windows to avoid interactions with critical Arctic Char life history stages and/or avoid effects in areas that are only used seasonally by Arctic Char;
- Mitigation by design including avoidance and reduction of Project footprints where there is interaction with Arctic Char habitat;
- Isolation of construction works in waterbodies, including use of stream diversions;
- Conduct of fish salvage operations where required to avoid fish stranding;
- Adherence to the DFO Freshwater intake end-of-pipe fish screen guideline for water intakes (DFO 1995);
- Adherence to DFO blasting guidelines (Wright and Hopky 1998);
- Adherence to the DFO protocol for water withdrawal from ice-covered waterbodies in the Northwest Territories and Nunavut (DFO 2010);

- The use of applicable BMPs and/or guidelines developed by various regulatory authorities for the protection of aquatic habitat (e.g., Nunavut Operational Statements prepared by DFO); and
- Adherence to sediment and erosion control measures outlined in Appendix 10D-2.

Considerable effort was directed at mitigating effects identified through the assessment process, through modifications to the Project description. That is, mitigation by design was a critical component throughout the process.

4.5.3 Milne Port LSA

Key Issue #1: Effects on Arctic Char health and condition

Potential effects in the Milne Port LSA would result from changes in water and sediment quality, which are described in Section 3.4 in detail. The freshwater distribution of Arctic Char in the Milne Port LSA is limited, hence potential effects on health and condition as a consequence of water quality changes, are limited. There will be no point sources discharged to freshwater habitat in the Milne Port LSA and this pathway is not considered further.

4.5.3.1 Dust Deposition

Section 3.4.2 indicates that effects of the Project on dust in the Milne Port LSA will be negligible during Project Operation but that low magnitude exceedances of CCME PAL guidelines may occur during Construction in association with fugitive dust. Effects on Arctic Char are therefore considered to be of low magnitude (Level I), frequent (Level III), short-term (Level I), reversible (Level I), and confined to portions of the LSA (Level I).

4.5.3.2 Aqueous Non-Point Sources

Aqueous non-point sources with the potential to cause exceedances of water quality thresholds in the Milne Port LSA, as described in Section 3.4.2, are summarized in Table 7-4.6. There is little potential for aqueous non-point sources to affect Arctic Char in the LSA due to the limited distribution of this species in the Potential Development Area. The lower reach of drainage M-11 has been identified to provide low quality habitat, and water quality in this drainage may be affected by Project infrastructure. Other watersheds may be affected by infrastructure and associated aqueous non-point sources in the Milne Port LSA, including streams M5-1 and M6-1, neither of which is fish-bearing. Therefore potential effects would be limited to indirect effects on Phillips Creek, downstream of the mouth of Stream M5-1. Arctic Char have not been captured in Phillips Creek and it is believed that the area either does not support them or provides marginal habitat. In addition, effects on non-point sources introduced via Stream M5-1 would be attenuated by the large flow of Phillips Creek.

Risk of exposure of Arctic Char to exceedances of CCME PAL water quality guidelines are considered extremely low; however, to be conservative, effects related to this pathway have been identified as of low magnitude (Level I). Effects will be of medium term duration (Level II), infrequent (Level I), partially reversible (Level II) and confined to the LSA (Level I).

Table 7-4.6 Summary of Aqueous Non-point Sources that May Cause Exceedances of Water Quality Thresholds in the Milne Port LSA and Associated Project Phases

Project Activity	Indicators	Project Phase
Ground Preparation and Earthworks	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Site Water Management	pH, TSS, metals, nutrients and hydrocarbons	Construction, Operation, and Closure
Laydown Areas	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Quarries and Borrow Sources	pH, TSS, metals, nutrients and hydrocarbons	Construction
Airstrip and Airstrip Use	TSS and Petroleum Hydrocarbons	Construction, Operation, and Closure

Key Issue #2: Effects on Arctic Char habitat

Potential effects of the Project on Arctic Char habitat in the Milne Port LSA relate to several pathways of effect, including:

- Loss of habitat from Project footprints;
- Loss of habitat due to water withdrawals;
- Water diversion; and
- Effects on the productive capacity (i.e., lower trophic level biota) of habitat.

4.5.3.3 Project Footprints

The Milne Port facility will include infrastructure components situated on existing waterbodies. The proposed location of the camp area and airstrip will occupy the headwaters of the small intermittent stream M5-1, including portions of several shallow ponds. Placement of fuel storage and laydown areas will also affect several ephemeral coastal drainages and a small intermittent stream (M6-1). With the exception of M11-1, all affected streams are non fish-bearing. Stream M11-1 is a small perennial stream with limited potential to provide low quality rearing habitat, but upstream access is limited by a fish passage barrier located approximately 1 km from the coast. Arctic Char use of coastal streams in the Milne Port area is minimal; habitats that will be directly affected are all either non fish-bearing or of marginal importance. Project infrastructure will be removed at Closure to the extent that is feasible and practical. All infrastructure that directly affects watercourses will be removed and drainage will be restored to ensure long-term stability.

Water requirements for the Milne Port facility for Construction, Operation and Closure will be drawn from Phillips Creek in the open-water season and from km 32 Lake in winter. Both will involve an instream footprint for the water intake. The water intake structures will be based on a jetty design involving placement of an aggregate embankment that will extend into the waterbody as far as is required to reach appropriate depth. It is expected that each embankment will displace an area of stream or lake bottom equivalent to approximately 450 m^2. The outer edge and toe of the embankment will be rip-rapped for stability, and rip-rap material of appropriate size will be selected to encourage colonization by lower trophic level biota (e.g., attached algae, benthic invertebrates) and fish use. Water intake structures will be removed at closure.

Effects related to Project footprints in the Milne Port LSA on Arctic Char habitat are expected to be negligible and are not considered further.

4.5.3.4 Water Withdrawals

As described in Section 2.3, water will continue to be drawn from Phillips Creek in the open-water season and from km 32 Lake in winter during the Construction, Operation, and Closure periods.

As described in Section 2.3, water withdrawals from km 32 Lake in winter will reduce water levels by approximately 0.9 and 0.4 cm over the Construction and Operation phases of the Project, respectively, and are predicted to remain within the DFO winter water withdrawal guideline. Water requirements for the Closure phase have not been identified but are anticipated to be equal to or less than requirements during Construction and Operation. This reduction in water level is expected to be within the natural range of water level and ice thickness variations and would likely not be detectable (i.e., less than quantifiable limits). Therefore the effect is considered to be negligible and is not assessed further.

Effects of water withdrawals from km 32 Lake are predicted to result in negligible changes (i.e., less than quantifiable limits; reductions of 0.04 % to 0.02 % of mean June discharge during Construction and Operation, respectively) in discharge of the lake outflow (see Section 2.3). This effect is therefore considered to be negligible and is not assessed further.

Withdrawals in Phillips Creek will be greatest during the Construction period. Predicted changes in discharge at the mouth of Phillips Creek and from km 32 Lake collectively are <1 % of mean monthly discharges (estimated range of 0.00 % in July to a maximum of 0.25 % in October). Effects are predicted to be lower (0.00 % to 0.11 % reduction in mean monthly discharge) during the Operation period. These reductions are predicted to result in negligible changes (i.e., less than quantifiable limits) in discharge.

Arctic Char have not been captured in Phillips Creek and it is believed the area either does not support them or provides marginal habitat. In consideration of the risk to fish and the predicted magnitude of effects related to water withdrawals in Phillips Creek, effects on habitat are expected to be negligible and are not considered further.

4.5.3.5 Water Diversions

Drainages containing Project infrastructure are largely devoid of Arctic Char and therefore, no direct effects will be caused by water diversions.

4.5.3.6 Effects on Lower Trophic Level Biota and Productive Capacity

The Project may affect lower trophic level biota in waterbodies that will be affected by aqueous non-point sources, dust deposition, Project footprints, and water withdrawals. Aqueous non-point sources are expected to have small effects on primary and secondary producers due to the predicted magnitude of exceedances (less than an order of magnitude above PAL guidelines) and because effects are expected to be relatively localized. These effects would also be largely confined to waterbodies that do not support Arctic Char (i.e., Streams M5-1 and M6-1).

Similarly, Project footprints in waterbodies that support Char are few, small, and localized (see Section 4.5.3.3 for details) and are therefore expected to have a negligible effect on lower trophic level biota within the LSA. Project footprints are expected to reduce the abundance of lower trophic level biota in some waterbodies (streams M5-1 and M6-1, which do not support Arctic Char) through direct loss of habitat.

Effects of water withdrawals on lower trophic level biota are expected to be negligible due to the magnitude of changes in water levels and flows, as described in Section 4.5.3.4.

Indirect, downstream effects of the Project on lower trophic level biota in Stream M5-1 could potentially affect the productive capacity of habitat in Phillips Creek through reductions in the supply of organic materials. It is believed the area either does not support Char or provides marginal habitat, so these effects are considered negligible. Similarly, effects on lower trophic level biota in Stream M11-1 are considered negligible as this stream provides low quality habitat. The combined effects of water withdrawals, the effect of Project footprints, and aqueous non-point sources on the productive capacity of Arctic Char habitat are considered to be negligible and are not assessed further.

Key Issue #3: Effects on direct mortality of Arctic Char

Potential effects of the Project on direct mortality of Arctic Char are limited to potential for stranding of eggs due to water withdrawals.

4.5.3.7 Drawdown Effects and Potential for Egg Stranding

Phillips Creek freezes solid in winter and therefore does not support spawning. Water withdrawals would be limited to the open-water season.

As described in Section 2.3.3, withdrawals from km 32 Lake in winter will reduce water levels by approximately 0.9 cm over the Construction period and by approximately 0.4 cm during the Operation period, and are predicted to remain within the DFO winter water withdrawal guideline. Effects are anticipated to be no greater during Closure. This reduction in water level is not expected to result in egg stranding, as it is expected to be within the natural range of water level and/or ice thickness variations and would likely not be detectable. Therefore the effect of water withdrawals is considered to be negligible and is not assessed further.

4.5.4 Milne Inlet Tote Road LSA

Key Issue #1: Effects on Arctic Char health and condition

Arctic Char health and condition may be affected by Project-related effects on water and sediment quality, described in detail in Section 3.4.2. Residual water quality effects that were assessed for potential effects in this LSA are restricted to aqueous non-point sources and potentially by fugitive dust during the Construction period. Section 3.4.2 indicates that dust deposition will have a negligible effect on water quality during operation and is not discussed further here. There will be no point source discharges in this LSA.

4.5.4.1 Dust Deposition

Section 3.4.2 indicates that effects of the Project on dust in the Milne Inlet Tote Road LSA will be negligible during Operation but that low magnitude exceedances of CCME PAL guidelines may occur during Construction. Effects on Arctic Char are therefore considered to be of low magnitude (Level I), frequent (Level III), short-term (Level I), reversible (Level I), and confined to portions of the LSA (Level I).

4.5.4.2 Aqueous Non-Point Sources

Non-point source linkages are summarized in Table 7-4.7.

Table 7-4.7 Summary of Aqueous Non-point Sources that May Cause Exceedances of Water Quality Thresholds in the Milne Inlet Tote Road LSA

Project Activity	Indicators	Project Phase
Ground Preparation and Earthworks	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Site Water Management	pH, TSS, metals, nutrients and hydrocarbons	Construction, Operation, and Closure
Laydown Areas	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Quarries and Borrow Sources	pH, TSS, metals, nutrients and hydrocarbons	Construction

As indicated in the water quality assessment (Section 3.4.2), Construction, Operation and Closure may result in periodic exceedances of water quality thresholds for TSS, petroleum hydrocarbons, nutrients, pH and metals in waterbodies along the Milne Inlet Tote Road corridor due to aqueous non-point sources. Overall, effects are primarily related to the potential introduction of non-point source contaminants associated with road operation. Other effects may include water quality changes (e.g., increases in ammonia, nitrate, TSS, and metals and decreased pH) near quarries and borrow sources and areas of blasting; the water quality assessment indicates that these activities may cause periodic exceedances of water quality thresholds.

Effects on Arctic Char are expected to be of low magnitude (i.e., exceedances expected to remain within an order of magnitude of the thresholds and therefore Level I) due to implementation of mitigation measures during Construction, Operation, and Closure in combination with water quality monitoring. Effects are also likely to be relatively localized in the vicinity of non-point sources (Level I). Effects will be infrequent (Level I) and partially reversible (Level II).

Key Issue #2: Effects on Arctic Char habitat

Potential effects on Arctic Char habitat include Project footprints in habitat, effects related to water withdrawals, and changes in the productive capacity of habitat related to effects on lower trophic level biota.

4.5.4.3 Project Footprints

As described in Volume 3, Section 2.3, no work other than routine maintenance and some improvements to stream crossings are planned for the Milne Inlet Tote Road; therefore, there will be no new footprints in the LSA.

4.5.4.4 Water Withdrawals

Potential effects of water withdrawals in support of the Milne Port Site are considered under the Milne Port LSA (Section 4.5.3).

4.5.4.5 Effects on Productive Capacity of Arctic Char Habitat

The potential effects of the Project on lower trophic level biota, and ultimately on Arctic Char, in the Milne Inlet Tote Road LSA relate to non-point source effects on water and sediment quality and water withdrawals, The effects of water withdrawals on lower trophic level biota are considered within the assessment for the Milne Port LSA.

Localized reductions in productive capacity may occur during the Construction, Operation and Closure phases due to water quality changes associated with aqueous non-point sources and during Construction due to fugitive dust. Section 3.4.2 indicates that low level exceedances of water quality thresholds may occur; these exceedances are expected to be relatively localized (i.e., in the vicinity of the non-point sources and construction activities, such as areas immediately adjacent to the Milne Inlet Tote Road). Effects on lower trophic level biota (i.e., primary and secondary producers) are predicted to be negligible due to the predicted magnitude of exceedences (less than an order of magnitude above PAL guidelines) and because effects are expected to be relatively localized.

Overall, the Project is predicted to have a negligible effect on the productive capacity of Arctic Char habitat in the Milne Tote Road LSA.

Key Issue #3: Effects on direct mortality of Arctic Char

Potential for the Project to cause direct mortality of Arctic Char is limited to the potential for egg stranding due to water withdrawals in winter. Effects related to water withdrawals at km 32 Lake are considered to be negligible and are discussed in Section 4.5.3.

4.5.5 Mine Site LSA

Key Issue #1: Effects on Arctic Char health and condition

As indicated in Section 3.4.2, the Project is expected to cause changes in water quality in the Mine LSA during Construction, Operation and Closure, which in turn could potentially affect Arctic Char health and condition. Briefly, residual effects of the Project on water quality in the Mine LSA identified in Section 3.4.2 are related to the following major linkages:

- Introduction of dust to surface waters (i.e., airborne emissions);
- Release of point sources to surface waters (including treated sewage effluent, Waste Rock Stockpile runoff, ore stockpile runoff, drilling runoff, and Open Pit water and Run of Mine stockpile runoff); and
- Aqueous non-point sources.

4.5.5.1 Introduction of Dust to Surface Waters

The water quality assessment indicates the potential for fugitive dust to cause low level exceedances of CCME PAL guidelines during the Construction period. A low magnitude (Level I), frequent (Level II), short-term (Level I), reversible (Level I) effect is predicted for Arctic Char for this pathway.

The air quality assessment (Volume 5, Section 2.6.3) presents estimates of deposition of total suspended particulates associated with the generation and dispersion of dust in the Mine LSA over the Project Operation period. This assessment indicates that deposition would occur in Camp and Sheardown lakes, portions of the Mary River, and numerous small tributaries to these waterbodies (see Appendix 5C-5). Section 3.4.2 describes the effects of dust deposition on water and sediment quality.

The water quality assessment indicates that introduction of dust to the watersheds in the Mine Area within the zone of dust deposition may result in exceedances of the CCME water quality guideline for TSS (5 mg/L above background) in small tributary streams, including Camp Lake Tributaries 1 and 2 and Sheardown Lake Tributaries 1, 9 and 12, which support Arctic Char, the Mary River, and tributaries to the Mary River that do not support Arctic Char.

The highest rates of deposition in the Mine Area will occur south/southwest of the Open Pit and Waste Rock Stockpile. The upper reaches of Sheardown Lake Tributaries 1, 9, and 12 and Camp Lake Tributaries 1

and 2 will be diverted during Operation; consequently dust (TSS) that is deposited in the headwaters will be diverted to the associated stormwater management ponds, where it will be allowed to settle. Discharge of runoff from these ponds will be subject to MMER and TSS will therefore remain below 15 mg/L (as a monthly mean) at the end-of-pipe. Dust will be introduced to these small tributaries downstream of the diversions as well as to the Mary River and to Sheardown and Camp lakes and will increase TSS in these waterbodies, most notably during the snowmelt period and spring freshet when dust that has accumulated over winter is transported to the aquatic environment.

The water quality assessment (Section 3.4.2) presents estimates of increases in TSS within the various watersheds in the Mine LSA associated with dust deposition before mitigation. The estimated increases are highest for Sheardown and Camp Lake tributaries and in drainage MR-12, which does not support Arctic Char; TSS is expected to exceed the CCME PAL guideline during the spring freshet in these streams and potentially periodically over the remainder of the open-water season. Exceedances of the CCME PAL guideline for TSS are also expected to occur in Camp and Sheardown Lakes near the mouths of tributaries, primarily during the spring freshet. TSS may also exceed the CCME PAL guideline in the Mary River due to dust deposition, although effects would be much lower than in small tributary streams. As described in Section 3.4.2, a Stormwater Management Plan will be developed to mitigate effects of dust deposition on the freshwater environment, targeting the most affected catchments. Section 3.4.2 indicates that with mitigation, it is expected that TSS concentrations would be reduced to the range of 5 to 50 mg/L in small tributaries with a target thresholds in the receiving environment of 15 mg/L. Effects of dust on TSS are therefore expected to have a Level I magnitude of effect on Arctic Char health and condition. As point source effluents will be subject to MMERs, the collective effects of these discharges and dust deposition would still result in overall increases in TSS on the order of 5-50 mg/L, depending on discharge of the receiving environment and timing.

Cadmium and iron may also exceed CCME PAL guidelines in tributary streams where and when TSS is increased on the order of 15 mg/L (see Section 3.4.2). The magnitude of the exceedences is expected to be low (Level I).

With implementation of mitigation measures, it is expected that increases in TSS (and potentially iron and cadmium) will result in a Level I magnitude effect in tributaries to Camp and Sheardown lakes during the spring freshet, with lower and less frequent exceedences over the remainder of the open-water period. Level I effects are also expected for areas of Camp and Sheardown lakes around tributary mouths and some areas of the Mary River. Effects will be of medium duration (Level II), frequent (Level III), partially reversible (Level II), and confined to the LSA (Level I).

As discussed in Section 3.4.2, if all dust introduced to the Sheardown and Camp lake watersheds accumulated in the lakes – an overly conservative scenario for the reasons discussed in Section 3.4.2 – annual sedimentation rates are estimated to be 0.54 and 0.24 mm, respectively. This would equate to total deposition over the Operation of the Project of approximately 11 and 5 mm in Sheardown and Camp lakes, respectively. Dust introduced to the Mary River and smaller tributaries to Camp and Sheardown lakes may be deposited in low velocity areas, however the majority of the dust introduced to lotic environments is expected to be transported to downstream lakes. Small tributaries are dominated by cobble substrate and are generally not depositional. Some deposition may occur in the Mary River in areas that currently contain finer substrates; however, high flows during the spring freshet, when the majority of dust is expected to be introduced to these systems, is expected to limit deposition in the streams. Dust introduced to the Mary River is therefore expected to be transported to Mary Lake and to settle largely in the vicinity of the

river mouth; finer substrate is relatively abundant in Mary Lake, including the vicinity of the mouth of the Mary River, suggesting that this area is likely to be affected by sedimentation of dust.

Settling of dust in Mine LSA lakes and potentially streams would result in the accumulation of a thin layer of surficial sediments that would contain elevated concentrations of metals that are major components of the ore. Comparison of the chemical composition of ore samples to sediment quality guidelines (SQGs) indicates that concentrations of chromium, copper, lead, and zinc are lower than the CCME ISQG and would therefore not result in an exceedance of the PAL ISQG or PEL guidelines. Concentrations of arsenic and cadmium are higher than the CCME PEL, iron is higher than the Ontario SEL, and nickel exceeds the Ontario LEL but not the SEL (see Section 3.4.2). These increases would be classified as of moderate, high, and low magnitude, respectively, based on the criteria presented in Table 7-4.3. However, as the effects of dust deposition are predicted to be restricted to a thin surficial layer in depositional areas (primarily deeper areas of lakes), and the CCME SQGs are recommended to be applied to the upper 5 cm of sediments, effects of this pathway on Arctic Char have been ranked as of low magnitude for arsenic and cadmium, of moderate magnitude for iron, and negligible for nickel. Effects on sediment quality will be long-term (Level III), continuous (Level III), and limited to portions of the LSA (Level I).

4.5.5.2 Discharge of Treated Sewage Effluent to Sheardown Lake

As described in Section 3.4.2, treated sewage effluent will be discharged to Sheardown Lake NW over the Construction period. Treated sewage effluent is predicted to cause a localized increase in total phosphorus (TP) and total Kjeldahl nitrogen (TKN) in the immediate vicinity of the outfall. Localized increases in TP may have indirect effects on Arctic Char through alterations in productive capacity (i.e., eutrophication); this linkage is considered below under Key Issue #2 (i.e., effects on habitat). However, as nutrients are not toxic, the overall magnitude of effects is ranked as negligible.

4.5.5.3 Discharge of Treated Sewage Effluent to the Mary River

Section 3.4.2.2 indicates that discharge of treated sewage effluent to the Mary River during Project Operation and Closure will not result in exceedances of CCME PAL guidelines for TSS, ammonia, TP and pH, and increases in biochemical oxygen demand (BOD) and TKN would not be detectable in the fully mixed condition in the Mary River. Discharge of BOD to the Mary River is predicted to have a negligible effect on dissolved oxygen (DO) in the Mary River.

Effects of this effluent on Arctic Char health and condition are considered to be negligible.

4.5.5.4 Discharge of West Waste Rock Stockpile Runoff

During Operations the West Waste Rock Stockpile runoff will flow through a controlled discharge point to Camp Lake Tributary 1 continuously over the open-water season. Runoff will continue during Closure and post-Closure, as water diversions will be maintained over these phases.

As described in Section 3.4.2, mercury, cadmium and selenium are predicted to exceed CCME PAL guidelines in the fully mixed condition in Camp Lake Tributary 1 (downstream of the falls on Camp Lake Tributary 1) under mean flows. Of these, modeling indicates that the fully mixed concentrations of cadmium and selenium are within the range of 1-10 times the CCME PAL from the fish barrier to the mouth of the stream, but mercury may exceed the CCME PAL at the upstream extent of fish habitat by a factor of 13 in a portion of the stream. Concentrations of these metals are predicted to be higher under low flow conditions and additional metals (copper and silver) may approach or exceed CCME PAL in dry years over at least a portion of the stream.

Effects of West Waste Rock Stockpile runoff on water quality will extend into Camp Lake, with greatest effects near the mouth of the tributary. A mass balance model for the whole lake indicates that mercury and selenium may slightly exceed CCME PAL guidelines in the fully mixed lake (see Section 3.4.2). Effects downstream of Camp Lake would be attenuated by dilution from the Tom River, and effects on Mary Lake are identified as negligible.

As described in Section 3.4, modeling was based on the results of geochemical testing of waste rock samples and a number of metals, including mercury, selenium, copper, arsenic, cadmium, chromium, silver, and thallium were infrequently detected in the rock samples. Similarly, cadmium, mercury, selenium and silver were either rarely or never detected in Camp Lake Tributary 1 during the baseline studies and actual environmental concentrations cannot be quantified. For these substances, particularly mercury and selenium, modeling is considered to be highly conservative due to the uncertainty regarding actual concentrations of these substances in the waste rock and receiving environment; actual effects on water quality are expected to be lower than those presented in Section 3.4.2.

Juvenile Arctic Char will be the primary receptor exposed to runoff, since streams within the LSA where effects will be greatest are used almost exclusively by juveniles for rearing and foraging. Five tributaries to Camp Lake and the Camp Lake outflow provide juvenile rearing and foraging habitat, with Tributaries 1 and 2 being relatively productive. The area of habitat affected by the waste rock drainage in Camp Lake Tributary begins at the falls and extends downstream to the mouth and represents approximately 17 % of known and potential juvenile rearing and foraging habitat provided by the five tributaries. In addition, Camp Lake provides an estimated 109,710 m^2 of rearing and foraging habitat (defined as 0-2 m deep in nearshore (< 10 m deep) zone). Fish habitat in Camp Lake Tributary 1 represents approximately 12.2 % of the total available in this drainage.

Overall, effects of water quality changes due to discharge of the West Waste Rock Stockpile runoff on Arctic Char health and condition are considered to be of Low to Medium magnitude during Operation, Closure and post-Closure, and would primarily affect Camp Lake Tributary 1, with lower level effects in Camp Lake. Aquatic Effects Monitoring, including EEM, will identify potential effects as they arise and adaptive management will eliminate the risk of exceeding predicted effect levels. Baffinland is exploring options for re-testing or additional testing to obtain a dataset of true measurements for those parameters that have been infrequently or not detected in waste rock samples and/or surface waters. As noted above, the water quality modeling results are highly conservative and actual effects are expected to be lower.

4.5.5.5 Mary River Water Quality: Effects of Waste Rock, Ore, and Pit Water and Run of Mine Stockpile Runoff and Drilling Runoff

Various runoff and wastewater streams will be discharged to the Mary River or its tributaries, all of which have the potential to affect Arctic Char health and condition through effects on water and/or sediment quality. Effects related to discharge of treated sewage effluent to the Mary River are ranked as negligible and are not considered further (see Section 4.5.5.3). Effects related to discharge of waste rock (east stockpile), ore, pit water, Run-of-Mine stockpile runoff and drilling runoff to the Mary River are assessed below. Locations of these discharges are identified in Figure 3-2.3.

Runoff from the ore stockpile and Run of Mine stockpile will be released to the Mary River during Construction and Operation. Runoff from the East Waste Rock Stockpile and pit water will be released to the Mary River through Operation, Closure, and post-Closure. Effluents associated with exploration drilling during Construction and Operation will be contained in sumps and limited runoff will reach the Mary River.

During Operation, pit water will be directed to the East Waste Rock Stockpile and the combined will be released to a non-fish bearing tributary of the Mary River (drainage MR-12). During Closure and post-Closure, runoff from the East Waste Rock Stockpile will continue to drain to the Mary River. As described in Section 2.3.2.5, the Open Pit will require an estimated 85 to 147 years to fill, following which water will naturally drain to the Mary River.

Juvenile Arctic Char would be the primary receptor exposed to these runoffs since the Mary River is used mostly by juveniles for rearing and foraging, although the habitat is of low quality compared to the smaller tributaries in the LSA.

As described in Section 3.4.2, mercury is predicted to exceed, and selenium and silver are expected to be near, the CCME PAL guidelines in the Mary River in the fully mixed condition downstream of Mary River Falls (a fish barrier) due to combined discharge of the East Waste Rock Stockpile and pit water during Project Operation under mean and low flow conditions. Exceedances are expected to be higher in the immediate receiving environment (tributary to Mary River) but this stream does not support fish.

During Closure and post-Closure while the pit is filling, only East Waste Rock Stockpile runoff will be released to the Mary River. Over this period, effects on water quality and thus on Arctic Char are expected to be similar to the Operation period. Effects on water quality once the pit is filled and begins to drain to the Mary River indicate similar effects as during Project Operation, although concentrations of mercury, selenium, and silver will be marginally higher.

Ore and Run-of-Mine stockpile runoff will be released to the Mary River downstream of East Waste Rock Stockpile runoff and pit water, but upstream of the outflow of Sheardown Lake. As described in Section 3.4.2, these flows are predicted to result in small changes in metal concentrations in the Mary River beyond that projected upstream. Water quality modeling indicates that concentrations of mercury, selenium and silver will be slightly lower than upstream but will still either approach (selenium and silver) or exceed (mercury) CCME PAL guidelines. Effects of discharges on water quality in the Mary River are predicted to be relatively similar under mean and low flow conditions. It is expected that concentrations would decrease below guidelines in Mary Lake.

As discussed in Section 3.4.2 and Section 4.5.5.4 above, the water quality modeling predictions for a number of metals are conservative, as they are based on geochemical testing and baseline water quality sampling in surface waters in which metals were infrequently detected.

Exploration drilling runoff released by the exploration drilling program since 2004 has resulted in elevated conductivity and chloride concentrations in the Mary River. The water quality assessment indicates that this activity, which will continue during the Operation phase, may continue to result in low magnitude exceedances of the CCME PAL guideline for chloride.

Effects of East Waste Rock Stockpile, Ore Stockpile, pit water, and ROM Stockpile point sources on water quality in the Mary River are conservatively predicted to result in Level I magnitude effects on Arctic Char that would occur over Operation, Closure, and post-Closure periods. Effects would be frequent (Level III), of long-term duration (Level III), partially reversible (Level II) and confined to the LSA (Level I).

4.5.5.6 Aqueous Non-Point Sources

A number of non-point sources may affect water quality in the Mine LSA during Construction, Operation and Closure, as described in Section 3.4.2. Table 7-4.8 summarizes non-point sources that have the potential to result in exceedances of water quality thresholds for TSS, metals, pH, nutrients, and hydrocarbons in the

Mine LSA. Some of the sources will originate in areas devoid of Arctic Char habitat; these include the NPSs associated with explosives manufacture and truck wash. Section 3.4.2 indicates exceedances of water quality thresholds will be small (i.e., less than one order of magnitude above thresholds) and effects on Arctic Char health and condition are therefore ranked as of low magnitude.

Table 7-4.8 Summary of Aqueous Non-point Sources that may Cause Exceedances of Water Quality Thresholds in the Mine LSA

Project Activity	Indicator	Project Phase
Ground Preparation and Earthworks	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Site Water Management	pH, TSS, metals, nutrients and hydrocarbons	Construction, Operation, and Closure
Laydown Areas	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Explosives	pH, TSS, metals, nutrients and hydrocarbons	Construction and Operation
Quarries and Borrow Sources	pH, TSS, metals, nutrients and hydrocarbons	Construction
Airstrip and Airstrip Use - Runoff	TSS and petroleum hydrocarbons	Construction, Operation, Closure

Key Issue #2: Effects on Arctic Char habitat

As indicated in Section 4.3, Arctic Char habitat may be affected by several pathways, including increased sedimentation rates due to introduction of dust, loss of habitat due to Project footprints in waterbodies, water withdrawals, and stream diversions, and alterations in water levels and flows that may reduce available habitat in lakes or impede access to stream and/or lake habitat through changes in stream hydrology. Additionally, direct or indirect effects on lower trophic level biota and thus on the food web may also affect habitat through alterations to productive capacity.

4.5.5.7 Sedimentation Pathway

Increased sedimentation has the potential to alter preferred spawning habitat for Arctic Char (see Section 4.2.5 for a description of these areas). The primary pathway with the potential to increase sedimentation of spawning habitat in the Mine LSA is related to dust deposition. Effects on sedimentation in general are expected to be small due to implementation of mitigation measures, including sediment and erosion control, and water management such as settling ponds. Potential alteration of spawning habitat in relation to increased sedimentation is limited to effects within LSA lakes, as spawning is not supported in streams. If all dust introduced to the Sheardown and Camp lake watersheds accumulated in the lakes – an overly conservative scenario for the reasons discussed in Section 4.5.5.1 – annual sedimentation rates are estimated to be 0.54 and 0.24 mm, respectively. This would equate to total deposition over the Operation of the Project of approximately 11 and 5 mm in Sheardown and Camp lakes, respectively.

Arctic Char spawning habitat is limited to LSA lakes and preferred spawning habitat is typically confined to the nearshore zone (2 - 10 m deep) where wave action during the open-water period will limit sedimentation. The nearshore areas of Camp Lake and Sheardown Lake NW are dominated by sand and to a lesser extent gravel/pebble substrate, with finer substrates dispersed primarily in deeper offshore areas, indicating accumulation of fine dust would likely occur in the deeper areas of the lakes. Dust deposited within Camp

Lake Tributary 1 and the nearshore area of Camp Lake in the spring of 2008 during the Bulk Sampling Program was visibly reduced in these areas over the open-water period. These observations provide additional evidence that nearshore habitat is not likely to accumulate dust. Fine substrate has not been observed in Sheardown Lake SE; this may indicate a relatively low abundance, lack of detection during field programs, or that little settling of fines occurs in the lake.

Some deposition of sediments may occur in Mary Lake as a result of increases in TSS caused by discharge of point and non-point sources and deposition of dust within the Mary River. Mary Lake contains a relatively high proportion of finer substrate; consequently settling in the nearshore area (as well as more profundal areas) near the mouth of the Mary River is likely. However, the 2-10 m depth interval in Mary Lake is dominated by fine substrate and therefore the general composition of the habitat would not be altered by settling of dust. Overall, the effects of sedimentation during Project Operation on preferred Arctic Char spawning habitat (i.e., coarser substrates) in the Mine LSA are expected to be of low magnitude.

4.5.5.8 Direct Loss of Habitat due to Project Footprints in Waterbodies:

Potential sources of direct loss of Arctic Char habitat in the Mine LSA relating to Project footprints include:

- Installation of a permanent water intake at Camp Lake;
- Installation of treated sewage effluent, east and West Waste Rock Stockpile, ore stockpile, and pit water and Run of Mine stockpile outfalls;
- Enlargement of the Mine Site airstrip; and
- Laydown areas and other infrastructure.

Existing footprints in waterbodies placed during the Bulk Sampling Program include access road stream crossings and a sewage outfall in Sheardown Lake NW. Footprints associated with railway stream crossings are included in the Railway/Access Road LSA.

Point sources that would be discharged to the Mary River or to one of its tributaries include runoff from the East Waste Rock Stockpile, pit water, Ore Stockpile, and Run of Mine Stockpile, drilling runoff, and treated sewage effluent. None of these point sources will involve an in-stream footprint in Arctic Char habitat.

Water requirements for Mine facilities for Construction, Operation and Closure will be drawn from Camp Lake. The water intake structure will be based on a jetty design involving placement of an aggregate embankment into the waterbody as far as is required to reach appropriate depth. It is expected that the embankment will displace an area of lake bottom equivalent to approximately 450 m^2. The outer edge and toe of the embankment will be rip-rapped for stability, and rip-rap material of appropriate size will be selected to encourage colonization by lower trophic level biota (e.g., attached algae, benthic invertebrates) and fish use. The structure will be removed at closure.

The Camp Lake water intake structure will displace <1 % of available nearshore habitat in Camp Lake and is therefore considered to be of negligible magnitude.

Expansion of the Mine Site airstrip is expected to displace approximately 266 m^2 of aquatic habitat in Camp Lake Tributary 1-1b. Although Arctic Char have been captured in this tributary, the habitat is considered marginal and the effect is considered negligable.

Laydown areas will be located north of Sheardown Lake NW during the Construction period. These areas will avoid footprints in Char habitat (i.e., Sheardown Lake Tributary 1) and will adhere to an adjacent 33 m buffer. Therefore this activity will have no effect on habitat.

Additional infrastructure, including the railway line, the railway terminus and fuel storage cells, may affect instream habitat in Sheardown Lake Tributary 1-1b. Although efforts will be made to avoid as much instream habitat as possible, it is estimated that approximately 1,166 m^2 of low quality aquatic habitat will be displaced. This amount, combined with the amount of habitat in Sheardown Lake Tributary 1 lost as a result of stream diversions, is expected to result in a total loss of approximately 4.8 % of the habitat in Sheardown Lake Tributary 1 (Table 6, Appendix 10D-7X). Given the low quality of this habitat, this effect is considered of low magnitude.

Overall, effects related to Project footprints in the Mine LSA on Arctic Char habitat are expected to be low magnitude.

4.5.5.9 Water Withdrawals

Water will be withdrawn from Camp Lake in the Mine LSA during Construction, Operation and Closure, with peak consumption coinciding with the peak Construction phase (see Sections 2.3.2.5 and 2.3.3.2). The hydrology impact assessment indicates a reduction of 8cm and 2 cm in winter lake level and a 0.8 and 0.2 % reduction of total under-ice lake volume during Construction and Operation, respectively, due to water withdrawals (see Sections 2.3.2.5 and 2.3.3.2). Withdrawal volumes for the Closure phase have not been identified but are expected to be less than the maximum withdrawals during Construction and Operation. Withdrawals will remain notably lower than the NT and Nunavut DFO Protocol for winter water withdrawals from ice-covered waterbodies (DFO 2010). These reductions would not be readily discernible from the natural range of water level fluctuations and/or ice thickness; hence effects on Arctic Char habitat are considered negligible.

As described in Sections 2.3.2.5 and 2.3.3.2, discharge of the Camp Lake outflow will be affected by water withdrawals from Camp Lake, Waste Rock Stockpile and Open Pit Diversions of Camp Lake Tributaries 1 and 2, and discharge of the West Waste Rock Stockpile pond discharge. The collective effects of direct water withdrawals from the lake and effects of water diversions and discharge on the Camp Lake outflow are considered below.

4.5.5.10 Stream Diversions, Runoff Pond Discharges, and Water Withdrawals

There will be several stream diversions in the Mine LSA, primarily associated with the collection and discharge of runoff from waste rock and ore stockpiles (see above). Issues that have not been addressed are Subjects of Note such as laydown areas, camps, airstrips, and other mine use areas that may intercept runoff; these will be addressed in the Stormwater Management Plan. Stream diversions associated with ore stockpiles will be in place during Operation and removed during Closure. Diversions associated with the Open Pit and Waste Rock Stockpiles will be maintained through post-closure. The pit will fill in 85-147 years, following which it will discharge to the Mary River.

Camp Lake Tributaries

Diversion of runoff from the West Waste Rock Stockpile and open pit will alter discharge in the MR-08 sub-basin (Camp Lake Tributary 2) in the Tom River watershed (see Section 2.3.3.2). Reduction in mean monthly flows is predicted to be 15-32 % throughout the open-water period during Operation, Closure and post-Closure (Table 7-2.19). This reduction is predicted for a location at the fish barrier; however, due to the apparent absence of any substantial inflows between the fish barrier and Camp Lake, this is expected to be a fairly accurate estimate of the approximate reduction in flows at its confluence with Camp Lake. Hydraulic modelling of the reach of this tributary between the fish barrier and the mouth found that, based on an

average of monthly June to September flows for the mean flow condition, a total of 257 m^2 (3.6 %) of the available direct fish habitat (used by, or available to, Arctic Char) would be lost (Table 6 of Appendix 10D-7X, and Table 8 of Appendix 3 within Appendix 10D-7X). An estimated 3.6 % of the indirect fish habitat (supporting lower trophic level production) above the fish barrier would also be lost (Table 6 of Appendix 10D-7X, and Table 11 of Appendix 3 within Appendix 10D-7X).

Reductions in stream discharge also have the potential to create barriers to upstream and downstream fish movements and would affect the quality of Arctic Char habitat. Potential barriers under reduced flow scenarios were located within Camp Lake Tributary 1, Camp Lake Tributary 2, and Sheardown Lake Tributary 1 downstream of existing impassable barriers. At these locations, several transects were established and physical measurements were taken to allow the modelling of maximum depth within these stream sections under baseline and operation conditions for the mean year and 10 year dry year flow scenarios (Appendix 7C). At the identified potential barrier in Camp Lake Tributary 2, the minimum maximum depth predicted is 0.10 m in a 10-year dry September flow (Appendix 7C). As Project Operation does not reduce this flow, no depth reduction is predicted. The maximum depth reduction is predicted under July mean flows, where maximum depth is reduced from 0.44 m to 0.39 m (Appendix 7C). The amount of change over the course of the open water period is not expected to impede Arctic Char access to habitat in Camp Lake Tributary 2.

Flows within sub-basin MR-10 (Camp Lake Tributary 1) will be affected by diversion of runoff from the West Waste Rock Stockpile and Open Pit and West Waste Rock Stockpile Pond discharge. Alterations to discharge at the impassable fish barrier are expected to be an 8 % reduction in flows during July and a 25-39 % increase in flows during June, August and September during Operation and Closure, and a 7-22 % increase in flows throughout the open water period during post-Closure (Table 7.2.19). Hydraulic modelling of the reach between the fish barrier and the mouth predicted that an 8 % reduction in flows during July for the Operation and Closure phases will result in a loss of 128 m^2, or 1.8 % of the available direct fish habitat (Table 6 of Appendix 10D-7X, and Table 7 of Appendix 3 within Appendix 10D-7X). An estimated 1.8 % of the indirect fish habitat above the fish barrier would also be lost due to the flow reduction (Table 6 of Appendix 10D-7X, and Table 10 of Appendix 3 within Appendix 10D-7X). The predicted small reduction in flow during July is not expected to produce any additional barriers and, consequently, will not affect Arctic Char accessibility to habitat in Camp Lake Tributary 1.

Reductions in sub-watershed MR-08 discharge would have a low magnitude effect on the quantity of Arctic Char habitat. Reductions in sub-watershed MR-10 discharge in July during Operation and Closure would have a similar low magnitude effect.

Camp Lake and Camp Lake Outflow

Camp Lake water withdrawals are expected to result in a reduction of 1-6 % of the Camp Lake outflow during Construction (Table 7-2.21). During Operation and Closure, the combined effects of West Waste Rock and Open Pit diversions, West Waste Rock Stockpile runoff discharge, and Camp Lake water withdrawals are expected to result in a reduction of the outflow between 1 % and 9 % during June and July, respectively, and an increase of 4 % and 3 % during August and September, respectively (Table 7-2.22). During post-Closure, the combined effect of West Waste Rock and Open Pit diversions and West Waste Rock Stockpile Pond discharge will result in a reduction of the outflow between 1 % and 3 % (Table 7-2.22). The combined effects of these activities result in a maximum reduction of 0.012 m in the water level of Camp Lake and the Camp Lake outflow channel over the open-water period during Project Operation.

Given the small absolute change in water level in Camp Lake and the outflow channel, these flow alterations would be expected to have a negligible effect on the quantity of Arctic Char habitat in the Camp Lake outflow channel and Camp Lake itself.

Tom River and Tom River Tributary

The effect of the West Waste Rock Stockpile diversion is expected to have a 0.5-0.6 % reduction in the flows of MR-07 upstream of its confluence with the Tom River (Table 7-2.19). As this confluence is above the site of a fish barrier, the minimal alteration in flow will have no effect on the quantity of Arctic Char habitat upstream. Farther downstream, at the confluence of the Camp Lake outflow and the Tom River, combined effects of West Waste Rock and Open Pit diversions, West Waste Rock Stockpile runoff discharge, and Camp Lake water withdrawals, which will coincide during the Operation and Closure periods, are expected to result in alterations to discharge in the Tom River ranging from a reduction of 0.7 % in July to an increase of 0.2 % in August (Table 7-2.22); effects are expected to be slightly lower during post-Closure (Table 7-2.22). These flow alterations are not expected to be detectable, and effects on Arctic Char habitat in the Tom River are therefore considered to be negligible.

Sheardown Lake Tributaries

Three Arctic Char-bearing tributaries to Sheardown Lake will be affected by Open Pit and/or ore stockpile diversions. Tributary 1, Tributary 9, and Tributary 12 will experience flow reductions of 21-35 %, 29 % and 15 %, respectively, over the open-water season (Table 7-2.19) during Operation and Closure. Post-closure, Tributary 1 will continue to experience a reduction in flows of 6-20 % throughout the open-water period due to the Open Pit Diversion (Table 7-2.19). As Ore Stockpile diversions will be removed at Closure, the effects to tributaries 9 and 12 will occur only during Operation and Closure.

Hydraulic modelling of Sheardown Lake Tributary 1 found that, based on an average of monthly June to September flows for the mean flow condition, a total of 327 m^2, or 4.7 % of the available direct fish habitat would be lost due to this flow reduction during Project Operation (Table 9 of Appendix 3 within Appendix 10D-7X). The amount of indirect fish habitat above the barrier that would also be lost to flow reduction was estimated to be < 5.0 % (Table 6 of Appendix 10D-7X). Hydraulic modeling was not conducted in Sheardown Lake Tributary 1-1b as it was not considered valuable Char habitat. However, based on data provided in Table 7 of Appendix 10D-7X, it was estimated that an additional 83 m^2 of direct fish habitat within this branch of Sheardown Lake Tributary 1 would be lost due to flow reduction (Table 6 of Appendix 10D-7X).

Based on an average of monthly June to September flows for the mean flow condition, flow reductions due to diversions are estimated to result in a loss of direct and indirect fish habitat of 2,157 m^2 (6.4 %) in Sheardown Lake Tributary 9 and a loss of 68 m^2 (4.7 %) in Sheardown Lake Tributary 12 (Table 6 of Appendix 10D-7X and tables 12 and 13 of Appendix 3 within Appendix 10D-7X).

Two potential barriers were identified within Sheardown Lake Tributary 1. At the downstream barrier, the minimum maximum depth predicted under baseline condition is 0.14 m in a 10-year dry September flow (Appendix x). Project Operation is predicted to reduce this depth to 0.13 m. The maximum depth reduction is predicted under 10 year dry August flows, where maximum depth is reduced from 0.18 m to 0.15 m (Appendix x). Although this reduction in water level may affect the upstream movement of larger juveniles, few Char move upstream during August. At the upstream barrier, the minimum maximum depth predicted under the baseline condition is 0.16 m in a 10-year dry September flow. Project Operation is predicted to reduce this depth to 0.15 m. The maximum depth reduction is predicted under mean July flows, where

maximum depth is reduced from 0.36 m to 0.28 m. The amount of change over the course of the open water period is not expected to substantially affect the ability of Arctic Char to access habitat in Sheardown Lake Tributary 1.

Overall, flow reductions are expected to have a low magnitude effect on the quantity of Arctic Char habitat in Sheardown Lake tributaries 1, 9 and 12.

Sheardown Lake and Sheardown Lake Outflow

The combined effect of Open Pit and Ore Stockpile diversions is expected to result in flow reductions of 12-19 % at the confluence of the Sheardown Lake outflow and the Mary River during Operation and Closure (Table 7-2.19). Discharge of the outflow of Sheardown Lake and water levels of Sheardown Lake proper will be affected post-Closure due to the Open Pit diversion; discharge of the outflow is predicted to be reduced by 3-10 %, with the largest relative change occurring in July.

Under pre-Project conditions, water levels in the Sheardown Lake and its outflow are relatively frequently elevated by a backwater effect from the Mary River during the open-water period. This backwater effect is expected to remain under post-Project conditions and would reduce the effect of flow reductions due to diversions on Arctic Char habitat in the Sheardown Lake outflow and Sheardown Lake. Consequently, stream diversions would be expected to have a negligible effect on the quantity of Arctic Char habitat in the Sheardown Lake outflow, and in Sheardown Lake itself.

Mary River

In MR-12 (a fishless tributary to the Mary River), alterations to discharge at the confluence of MR-12 and the Mary River are expected to be a 5-6 % increase in flows throughout the open-water period during operation and closure due to the combined effects of Waste Rock Stockpile and Open Pit diversions and discharge from both (Table 7-2.19). Post-Closure, there will be a flow reduction of 0.5-0.6 % over the open-water period. As this confluence is at the site of a fish barrier, flow alterations will have no effect on the quantity of Arctic Char habitat upstream of this point.

The combined effect of East Waste Rock Stockpile and Open Pit diversions, East Waste Rock Stockpile and ROM pond discharge, and sewage effluent discharge are expected to result in a 0.4 to 0.8 % increase in flows in the Mary River at the effluent discharge location throughout the open-water period during Operation and Closure (Table 7-2.22). Post-Closure there would be a 0.2-0.3 % reduction in flows due to the combined effect of East Waste Rock Stockpile and Open Pit diversions and East Waste Rock Stockpile pond discharge (Table 7-2.22). Further downstream, at the confluence of the Sheardown Lake outflow and the Mary River, flows in the Mary River are expected to increase by 0.1 % to 0.5 % throughout the open-water period during Operation and Closure and fall by 0.5 to 0.7 % during post-Closure (Table 7-2.22).

Flow alterations for Operation, Closure and post-Closure phases are expected to have a negligible effect on the quantity of Arctic Char habitat in the Mary River.

Mary Lake

The combination of minimal changes to the Tom River and Mary River inflows are expected to result in little to no effect on water levels in Mary Lake and, consequently, a negligible effect on the quantity of Arctic Char habitat in Mary Lake.

4.5.5.11 Effects on Lower Trophic Level Biota and Productive Capacity of Arctic Char Habitat

Effects of the Project on lower trophic level biota and the productive capacity of Arctic Char habitat in the Mine LSA relate to direct loss of physical habitat due to Project footprints and alterations in hydrology, effects of dust deposition, non-point sources, and point sources. Beyond the direct reduction in the quantity of habitat in tributary streams downstream of fish barriers, diversions have the potential to further reduce the productive capacity of habitat due to loss and alteration of habitat upstream of the fish barriers. What follows is an assessment of effects on lower trophic level biota as it relates to effects on productive capacity of Arctic Char habitat. Effects of the Project on the loss of direct and indirect habitat are considered in Sections 4.5.5.8 through 4.5.5.10 and are discussed below.

Camp Lake Tributaries

The abundance of lower trophic level biota in Camp Lake Tributary 2 will be affected by dust deposition and water diversions. Lower trophic level biota in Camp Lake Tributary 1 will be affected by dust deposition, discharge of West Waste Rock Stockpile runoff, and by changes in hydrology (collective effect of water diversion and effluent discharge). The remaining tributaries will be affected to lesser degrees by dust deposition over the Construction and Operation periods.

Infrequent, low magnitude exceedences of CCME PAL guidelines due to non-point sources are expected over the LSA.

The magnitude of effects of dust deposition on water quality and in turn on lower trophic level biota in tributaries to Camp Lake are expected to be of low magnitude, with the larger effects expected in drainages to the north. Effects are expected to be greatest during the snowmelt/spring freshet period but may cause or contribute to exceedances of CCME PAL for TSS, cadmium and iron in small streams during the open-water period. It is expected that the majority of dust introduced to streams, notably during the spring freshet, will be transported to downstream lacustrine environments and is not anticipated to settle in the lotic systems, although some deposition may occur in areas that are currently depositional, particularly during lower flow periods. Effects of this pathway on lower trophic level biota are therefore predicted to be of low magnitude (Level I), frequent (Level III), moderate duration (Level II), and partially reversible (Level II).

Reduction in mean monthly flows in Camp Lake Tributary 2 is predicted to be 15-32 % throughout the open-water period for Operation, Closure, and post-Closure phases of the Project. The results of hydraulic modelling indicate that a total of 257 m^2 or 3.6 % of the available direct fish habitat will be lost due to this flow reduction. An estimated 3.6 % of the indirect fish habitat above the fish barrier would also be. Considering habitat loss and effects related to dust collectively, effects of the Project on Camp Lake Tributary 2 are expected to be of Low magnitude (Level I), frequent (Level III), long-term (Level III), and partially reversible (Level II).

Water quality changes in Camp Lake Tributary 1 resulting from discharge of West Waste Rock Stockpile runoff, as described in Section 4.5.5.4, are expected to range from a magnitude of negligible for a number of metals to moderate (Level II magnitude). Considering effects due to point sources and dust deposition on water quality and lower trophic level biota collectively, effects to Camp Lake Tributary 1 are ranked as of Medium magnitude (Level II), long-term (Level III), frequent/continuous (Level III) and partially reversible (Level II).

Alterations to Camp Lake Tributary 1 discharge at the impassable fish barrier are expected to be an 8 % reduction in flows during July and a 25-39 % increase in flows during June, August, and September for

Operation and Closure phases and a 7-22 % increase in flows throughout the open water period during post-Closure. A small reduction in the wetted area of Arctic Char habitat in Camp Lake Tributary 1 (1.8 %) is expected due the combined effect of West Waste Rock Stockpile runoff and water diversion. Loss of indirect habitat upstream equates to 1.8 %.

Overall, effects of the Project on the productive capacity of Arctic Char habitat in Camp Lake Tributary 1 are expected to be of Medium magnitude (Level II), frequent/continuous (Level III), long-term (Level III), and partially reversible (Level II).

Effects in other tributaries to Camp Lake would be restricted to effects on water quality related to dust deposition which would occur over the Construction and Operation periods. Effects are predicted to be of Low magnitude (Level I), moderate duration (Level II), frequent (Level III), and partially reversible (Level II).

Camp Lake

Potential effects on lower trophic level biota in Camp Lake are related to changes in water levels, sedimentation and sediment quality, and water quality.

A negligible change in the quantity of Arctic Char habitat is predicted to occur in Camp Lake and the Camp Lake outflow.

The water quality assessment indicates that CCME PAL guidelines may be exceeded in Camp Lake as result of dust deposition and discharge of West Waste Rock Stockpile runoff. Effects related to the former pathway are expected to be greatest during the spring freshet, when dust that has accumulated over winter is introduced to surface waters, and near the mouths of tributary streams, notably Camp Lake Tributaries 1 and 2. Dust may result in low magnitude exceedences of CCME PAL guidelines for TSS and possibly cadmium and iron. Discharge of the West Waste Rock Stockpile runoff to Camp Lake Tributary 1, which will occur during the Operation, Closure and post-Closure phases, is predicted to result in exceedances of several metals in Camp Lake, notably nearest the tributary mouth. For reasons discussed in Section 4.5.5.4, these predictions are believed to be highly conservative and actual effects on water quality are expected to be lower.

Settling of dust in Mine LSA lakes could result in the accumulation of a thin layer of surficial sediments that contain elevated concentrations of metals that are major components of the ore. As described in Section 3.4.2, iron may exceed the CCME PEL and arsenic and cadmium may exceed the CCME ISQG in these sediments. The limited quantity of deposited dust indicates that the magnitude of effects on sediment quality and in turn lower trophic level biota will range from Negligible to (potentially) Medium. Effects of dust on sedimentation rates and, in turn, on lower trophic level biota are expected to be Negligible.

Collectively, effects of all Project linkage pathways on lower trophic level biota and productive capacity of Arctic Char habitat in Camp Lake are considered to be of Medium magnitude (Level II), frequent/continuous (Level III), long-term (Level III), and partially reversible (Level II). A Medium designation is considered conservative, based on the potential for moderate level effects predicted for water quality in portions of the lake and potentially due to accumulation of iron from dust deposition in lake sediments.

Sheardown Lake Tributaries

Lower trophic level biota and thus productive capacity of Sheardown Lake tributaries will be affected by stream diversions during Operation, Closure and post-Closure and by water quality changes due to dust deposition and/or non-point sources during Construction and Operation.

With mitigation, the magnitude of effects of dust deposition on water quality and in turn on lower trophic level biota in tributaries to Sheardown Lake is expected to be low. Effects of dust deposition on water quality are expected to be greatest during the snowmelt/spring freshet period, and may cause or contribute to exceedances of CCME PAL in small streams over the open-water period. As described in Section 4.5.5.1, it is expected that the majority of dust introduced to streams, notably during the spring freshet, will be transported to downstream lacustrine environments and is not anticipated to settle in the lotic systems, although some deposition may occur in areas that are currently depositional, particularly during lower flow periods. Effects of this pathway on lower trophic level biota are therefore predicted to be of Low magnitude (Level I), frequent (Level III), of moderate duration (Level II), and partially reversible (Level II). Effects of non-point sources on lower trophic level biota are expected to be of Low magnitude (Level I), of moderate duration (Level II), infrequent (Level I), and partially reversible (Level I).

Three Arctic Char-bearing tributaries to Sheardown Lake will be affected by Open Pit and/or ore stockpile diversions. Tributary 1, Tributary 9, and Tributary 12 will experience flow reductions of 21-35 %, 29 % and 15 %, respectively, over the open-water season during Operation and Closure. Post-Closure, Tributary 1 will continue to experience a reduction in flows of 6-20 % throughout the open-water period due to Open Pit Diversion. Since ore stockpile diversions will be removed at Closure, the effects to tributaries 9 and 12 will occur only during the Operation and Closure periods. Based on the results of hydraulic modelling, 4.7 % of the available direct fish habitat will be lost to flow reduction during Operation and Closure. The amount of indirect fish habitat above the fish barrier that will be lost is estimated to be < 5.0 %. Open pit and/or ore stockpile diversions are estimated to result in a loss of 6.4 % of direct and indirect fish habitat in Sheardown Lake Tributary 9 and 4.7 % in Sheardown Lake Tributary 12 during Operation and Closure.

Collectively, effects of all Project linkage pathways on lower trophic level biota and productive capacity of Arctic Char habitat in Sheardown Lake tributaries are considered to be of Low magnitude (Level I), frequent/continuous (Level III), long-term (Level III), and partially reversible (Level II).

Sheardown Lake

Potential Project effects on lower trophic level biota in Sheardown Lake are related to changes in water levels through diversion, changes in sedimentation and sediment quality, and changes to water quality through dust deposition.

The Project is expected to have a negligible effect on the quantity of Arctic Char habitat in Sheardown Lake and its outflow, and therefore changes in hydrology will have a negligible effect on lower trophic level biota.

As described above for Camp Lake, dust may result in exceedances of CCME PAL guidelines, notably for TSS, during Construction and Operation in the LSA waterbodies. Effects are expected to be greatest during the spring freshet, when dust that has accumulated over winter is introduced to surface waters and near the mouths of tributary streams, notably those located to the north of Sheardown Lake.

Settling of dust in Mine LSA lakes will result in the accumulation of a thin layer of surficial sediments containing elevated concentrations of the metals that are major components of ore. As described in Section 4.5.5.1, iron may exceed the CCME PEL and arsenic and cadmium may exceed the CCME ISQG in sediments. The limited quantity of deposited dust indicates that the magnitude of effects on sediment quality and, in turn, lower trophic level biota range from Negligible to potentially Medium. Effects on sedimentation rates and on lower trophic level biota are expected to be negligible.

Collectively, effects of all Project linkage pathways on lower trophic level biota and productive capacity of Arctic Char habitat in Sheardown Lake are considered to be of Medium magnitude (Level II),

frequent/continuous (Level III), long-term (Level III), and partially reversible (Level II). As a conservative approach, a Medium magnitude has been identified, due to the potential for accumulation of iron from dust deposition in lake sediment.

Mary River and Tributaries

As described in Section 3.4.2, runoff and wastewater streams will be discharged to the Mary River or its tributaries; all have the potential to affect lower trophic level biota through changes in water and/or sediment quality. Effects related to discharge of Waste Rock (East Stockpile), ore, pit water and Run of Mine stockpile runoff, and drilling runoff to the Mary River are assessed below. Locations of these discharges are identified in Figure 3-2.3.

As described in Section 3.4.2, mercury, selenium and silver are predicted to exceed slightly the CCME PAL guidelines in the Mary River in the fully mixed condition downstream of Mary River Falls due to combined discharge of the East Waste Rock Stockpile, pit water, ROM, and Ore Stockpile runoff during Project Operation. Effects of pond discharges on water quality are predicted to be relatively similar under mean and low flow conditions. Similar effects are expected during Closure and post-Closure.

Exceedances are expected to be higher in the immediate receiving environment (tributary to Mary River that will receive pit water and East Waste Rock Stockpile runoff) which does not support fish but provides indirect habitat to Arctic Char. The unnamed tributary in drainage MR-12 represents an estimated <5 % of the overall indirect fish habitat for the river (upstream of the falls); effects on lower trophic level biota are therefore deemed to have a negligible effect on the productive capacity of Arctic Char habitat in the Mary River.

Exploration drilling runoff, which has been released during the exploration drilling program since 2004, has resulted in elevated conductivity and chloride concentrations in the Mary River. The water quality assessment indicates that this activity, which will continue during the Operation phase, may continue to result in low magnitude exceedances of the CCME PAL guideline for chloride.

Lower trophic level biota may also be adversely affected by deposition of dust in the Mary River and its tributaries. As discussed in Section 3.4.2, effects of dust deposition within its drainage are expected to result in low magnitude exceedences of PAL guidelines for TSS and for potentially cadmium and iron, which are abundant in the ore. Non-point sources are also predicted to result in infrequent, low magnitude exceedances of CCME PAL guidelines over the Construction and Operation phases of the Project.

Effects of East Waste Rock Stockpile, Ore Stockpile, pit water, drilling runoff, and ROM stockpile point sources, dust deposition, and non-point sources on water quality in the Mary River are predicted to result in Level I magnitude effects on lower trophic level biota that would occur during Construction, Operation, Closure and post-Closure. Overall, effects would be frequent (Level III), long-term (Level III), partially reversible (Level II) and confined to the LSA (Level I).

In MR-12 (a fishless tributary), alterations to discharge at its confluence with the Mary River are expected to result in a 5-6 % increase in flows throughout the open-water period during Operation and Closure due to the combined effects of Waste Rock Stockpile and open pit diversions and East Waste Rock Pond discharge. Post-Closure, there will be a flow reduction of 0.5-0.6 % during the open-water period.

The combined effect of East Waste Rock Stockpile and Open Pit diversions, East Waste Rock, Ore Stockpile and ROM pond discharge, and sewage effluent discharge are expected to result in a 0.4-0.8 % increase in flows at the effluent discharge location throughout the open-water period during Operation and

Closure (Table 7-2.22). Post-Closure there would be a 0.2-0.3 % reduction in flows due to the combined effect of East Waste Rock Stockpile and Open Pit diversions and East Waste Rock Stockpile pond discharge (Table 7-2.22). Farther downstream, at the confluence of the Sheardown Lake outflow and the Mary River, flows in the Mary River are expected to increase by 0.1 % to 0.5 % throughout the open water period during Operation and Closure and reduce by 0.5 to 0.7 % during post-Closure (Table 7-2.22).

Collectively, effects of all Project linkage pathways on lower trophic level biota and productive capacity of Arctic Char habitat in the Mary River are considered to be of Low magnitude (Level I), frequent/continuous (Level III), long-term (Level III), partially reversible (Level II), and confined to the LSA (Level I).

Mary Lake

Lower trophic level biota could be potentially affected by changes in hydrology, sedimentation due to introduction of dust and TSS, and changes in water quality in upstream surface waters. Effects on Mary Lake for each of these linkages are predicted to be negligible and no residual effects on lower trophic level biota are expected.

Key Issue #3: Effects on direct mortality of Arctic Char

Linkages between the Project and the potential for direct mortality of Arctic Char in the Mine LSA are related to sedimentation effects on eggs, effects of winter drawdown of Camp Lake due to water withdrawals, and potential stranding of juveniles by stream diversions.

4.5.5.12 Sedimentation Effects

Increased sedimentation on Arctic Char eggs was considered in relation to effects of dust deposition and all Project-related activities with the potential to increase erosion and/or sedimentation (i.e., general site runoff, point source discharges containing TSS). Effects of the Project on sedimentation in general are expected to be small due to implementation of mitigation measures including sediment and erosion control measures and wastewater management such as settling ponds. Potential effects of increased sedimentation on eggs are limited to LSA lakes, as spawning is not supported in the streams. The water quality assessment (Section 3.4.2) indicates annual sedimentation rates < 1 mm/year in Camp and Sheardown lakes due to dust deposition. Sedimentation rates may vary spatially in the lakes and it is anticipated that higher rates will occur in the deep, offshore areas that currently contain fine substrates. Nearshore areas, which include preferred spawning habitat (depths of 2-10 m with coarse substrate), are dominated by sand and to a lesser extent gravel/pebble, with finer substrate dispersed in deeper offshore areas. Sedimentation of the nearshore areas is expected to be negligible due to wave action, and sedimentation rates are not predicted to exceed 1 mm/year in Mary Lake.

Direct deposition of dust onto Arctic Char eggs would occur in fall before lakes and streams freeze. As this represents a relatively short period of time, direct deposition of dust onto eggs is expected to be well below 1 mm and therefore well below the threshold of effects.

Effects of sedimentation on Arctic Char eggs are predicted to be negligible.

4.5.5.13 Winter Lake Drawdown

As noted in Section 2.3.2.5, withdrawals of surface water from Camp Lake during Construction and Operation will result in a water level reduction of 2-8 cm in winter and 0.2-0.8 % of total under-ice lake volume. Withdrawal volumes for the Closure phase have not been identified but are not expected to exceed the maximum withdrawals during Construction and Operation. These water level reductions would not be

readily discernible from the natural range of water level fluctuations and/or ice thickness, and effects on Arctic Char eggs are considered to be negligible.

4.5.5.14 Stream Diversions

The diversion of flows in two tributaries to Camp Lake and three tributaries to Sheardown Lake during Operation, Closure and post-Closure has the potential to strand juvenile Arctic Char as they move downstream to overwintering habitat in Camp Lake and Sheardown Lake. The reduction of flows in these streams can create impassable barriers to downstream movements. Under low summer and fall flows, impassable barriers currently exist in Sheardown Lake tributaries 9 and 12, may exist in Camp Lake tributaries 1 and 2 and Sheardown Lake Tributary 1, and likely occur throughout the area. A habitat modelling exercise to examine the potential for new barriers to occur as a result of the Project is presented in Appendix 7C. Minimum maximum depth decreased a maximum of 0.03 m under August and September 10-year dry year flows, and a maximum of 0.08 under August and September mean year flows for the three tributaries combined (Appendix 7C). The reduction in minimum maximum depth is not large; however, because these streams are shallow and stranding is presumed to occur occasionally in the baseline environment, there is potential for increased stranding during Operation, Closure and post-Closure. Mitigation for this potential effect could include one or more of:

- Monitoring and salvage of fish as required;
- Channel improvement(s); and
- As a last resort, exclusion of Arctic Char from streams.

With mitigation, this is assessed as a negligible effect on direct mortality of Arctic Char.

4.5.6 Railway/Access Road LSA

Key Issue #1: Effects on Arctic Char health and condition

Project activities in the Railway/Access Road LSA may affect Arctic Char health and condition through effects on water quality mediated through a number of pathways, as described in Section 3.4.2. Specifically, residual water quality effects that are predicted to result in exceedances of water quality thresholds are restricted to aqueous non-point sources and potentially effects of fugitive dust during the Construction phase. Sewage from the construction camps will be trucked off site and will not be discharged in the Railway/Access Road LSA, and there will be no point source discharges in the LSA.

4.5.6.1 Dust Deposition

Section 3.4.2 indicates that effects of dust in the Railway/Access Road LSA will be negligible during Operation but that low magnitude exceedances of CCME PAL guidelines may occur during Construction because of fugitive dust. Effects on Arctic Char are therefore considered to be of Low magnitude (Level I), frequent (Level III), short-term (Level I), reversible (Level I), and confined to portions of the LSA (Level I).

4.5.6.2 Aqueous Non-Point Sources

Table 7-4.9 provides a summary of the aqueous non-point sources that are anticipated to result in infrequent exceedances of water quality thresholds, as described in detail in the water quality assessment (see Section 3.4.2).

Table 7-4.9 Summary of Aqueous Non-point Sources that may Cause Exceedances of Water Quality Thresholds in the Railway/Access Road LSA

Project Activity	Direction and Nature of Interaction	Project Phase
Ground Preparation and Earthworks	pH, TSS, metals, nutrients and hydrocarbons	Construction, Operation, and Closure
Site Water Management	pH, TSS, metals, nutrients and hydrocarbons	Construction, Operation, and Closure
Laydown Areas	pH, TSS, metals, nutrients and hydrocarbons	Construction and Closure
Explosives Use in Quarries, Borrow Sources and Road Alignment	pH, TSS, metals, nutrients and hydrocarbons	Construction
Quarries and Borrow Sources	pH, TSS, metals, nutrients and hydrocarbons	Construction
Tunnelling and Rock Cuts	pH, TSS, metals, nutrients – ammonia, brine and hydrocarbons	Construction
Airstrip and Airstrip Use	TSS and petroleum hydrocarbons	Construction

Potential effects of the Project on Arctic Char health associated with aqueous non-point sources will largely be related to construction and operation activities with the potential to cause exceedances of CCME PAL guidelines for TSS. Construction of stream crossings, lake encroachments, and general infrastructure may introduce sediments to waterbodies. As described in Section 2.4, and in Volume 10, mitigation measures will prevent or reduce effects on sediment and erosion. Other effects include potential exceedances of water quality thresholds associated with release of brine used for tunnelling and rock cuts, general site runoff from the railway, access roads and Project infrastructure, effects associated with development of quarries and borrow pits, and effects caused by release of blasting residues. Infrequent exceedances of water quality thresholds for metals, nutrients (notably ammonia and nitrate associated with ammonium nitrate fuel oil use), and petroleum hydrocarbons may also occur. Effects would be most likely to occur in areas immediately adjacent to construction activities and infrastructure, notably the railway and the access roads near surface waters.

As Arctic Char are not present in all surface waters in the LSA, potential risks are limited to confirmed or potential char habitat. Development of quarries and borrow pits are a low risk as Char are absent from most waterbodies adjacent to these sites. Buffer zones will be established around any adjacent waterbodies that may have Arctic Char. Effects related to tunnelling and rock cuts at Cockburn Lake may include intermittent exceedances of CCME PAL guidelines for TSS, chloride, ammonia, nitrate and petroleum hydrocarbons in the lake and potentially adjacent streams, and salinity may be increased due to the use of brine. Effects related to rock cuts could occur along railway and access road alignment corridors.

Streams crossed by the road or railway or adjacent to the alignments are believed to lack flow in winter, so Arctic Char presence is limited to the open-water season. Therefore effects of water quality changes in streams in the LSA during Construction will be mitigated through the use of timing windows (i.e., construction in the winter) to the extent feasible. Effects related to construction of lake encroachments cannot be fully mitigated through the use of timing windows as fish are present year-round in lakes where habitat is suitable. However, effects in general will be avoided or reduced by mitigation measures that

reduce effects on water quality as described in Section 3.4. Overall, potential effects of water quality changes during the Construction and Operation periods on Arctic Char health and condition will range from Negligible (where water quality thresholds are met) to Low magnitude (where some exceedances of thresholds may occur), of moderate duration (Level II), infrequent (Level I), partially reversible (Level I) and confined to the LSA (Level I).

Key Issue #2: Effects on Arctic Char habitat

Arctic Char habitat may be affected by several pathways in the Railway/Access Road LSA including:

- Construction of footprints in Arctic Char habitat, including stream crossings, lake encroachments and water intake structures, resulting in direct habitat loss;
- Impediments to fish passage at stream crossings resulting in loss of use of connected habitat;
- Loss of habitat due to water level reductions at water source lakes and in outflow streams;
- Sedimentation of Arctic Char habitat; and
- Effects of the Project on lower trophic level biota and altered productive capacity of Arctic Char habitat.

4.5.6.3 Loss of Habitat due to Project Footprints

Project footprints in the Railway/Access Road LSA that would be placed directly in freshwater ecosystems include:

- Stream crossings along the railway and access road;
- Lake encroachments along the railway and access road; and
- Temporary water intakes at Ravn Camp, Mid-Rail Camp, and at the Cockburn Tunnels and Cockburn South camps.

Construction of the railway and access roads will include the installation of 25 bridges and 72 culvert arrays on fish-bearing streams (Figure 7-4.7). This includes all railway crossings and non-adjacent access road crossings. A road crossing adjacent to a railway crossing is counted as one installation. Road crossings will be in place during Construction and will be removed at completion of the railway, and when the crossings are decommissioned drainage will be restored to ensure long-term stability. Railway crossings will be in place until the end of the Operation phase; at Closure all crossing structures will be removed and drainage established for long-term stability.

All LSA streams that support Arctic Char are perennial or intermittent streams with predominantly gravel and cobble/boulder substrates. The largest streams (Mary, Ravn and Ikpikitturjuaq rivers) may provide some summer feeding habitat for adults, but all other streams provide summer juvenile rearing habitat only. No spawning or overwintering habitat exists in any LSA watercourse.

Bridge installations were designed to minimize abutment and pier encroachments on stream channels within normal high water limits, and clear span bridges will be installed wherever feasible. No bridge crossings will involve abutment encroachments on stream channels, but longer crossings over larger streams will require placement of support piers within river channels. In some cases, valley profiles or engineering constraints will also necessitate instream pier placements in smaller streams. Bridges over fish-bearing streams that will include instream structures such as piers and abutments will also be assessed for fish passage requirements. Specifically, water velocities pre- and post-bridge installation will be compared to determine if flow velocities will increase. Where they increase substantially, the channels will be lined with boulders to roughen the channel and alter the velocity profile. If necessary, large boulders will be placed in a staggered formation to provide velocity refugia for fish as they move through the bridge structures (Dillon 2008). In all cases, it is anticipated that instream pier or abutment placements will not alter stream hydraulics to the

extent that fish passage may become an issue, although local flow characteristics may be altered somewhat.

Placement of piers or abutments in stream channels will displace existing habitat, which, in all LSA streams where Arctic Char occur, is considered to be primarily summer juvenile rearing habitat. The largest watercourses Mary and Ravn rivers) may also be movement corridors for adults. Support piers will be placed on concrete pads covered in rip-rap to stabilize the stream bed. Wherever feasible, rip-rap material will be selected to match existing stream bed material to provide potential habitat for lower trophic biota and fish.

The total area of available stream habitat in LSA streams with bridge crossings is calculated to be 5.64 km^2 (564.0 ha). The total area affected by instream placement of bridge piers or abutments will be 9,522 m^2 (1.0 ha), or 0.17 % of the total available habitat. The effect of bridge placements on Arctic Char habitat is expected to be negligible and will not be assessed further.

A detailed discussion of culvert crossing design considerations is provided in Dillon (2008). Culvert stream crossings will consist of single or multiple corrugated steel pipe (CSP) or corrugated structural plate pipes (CSPP) installations, including pipes of 1600 mm or 3000 mm diameter. Open-bottom structures were considered but are not recommended because of geotechnical concerns, and pipe arches were not recommended because of stringent bedding and backfill requirements (Dillon 2008).

All culvert installations were designed on the basis of a 200 year return period flow, and a 10 year three day delay flow was incorporated into culvert designs for all fish-bearing streams (Dillon 2008). The culverts are therefore large relative to normal capacity requirements. All culverts will be imbedded by at least 20 % and those of large diameter may be buried deeper for less channel constriction. To the extent possible, the natural channel width will be maintained within crossing structures.

Maintaining channel width and providing nature-like substrate within culverts will likely result in some lower trophic colonization and habitat use by fish, but for the purposes of this assessment it is assumed that all culvert placements in fish-bearing streams will represent a habitat loss equivalent to the area of natural stream bed occupied. The total area of available stream habitat for Arctic Char in LSA streams with culvert crossings is calculated to be 1,785,213 m^2 (178.5 ha). The total culvert footprint area in those streams will be 24,089 m^2 (2.4 ha), or 1.35 % of the total available habitat.

Railway design is necessarily constrained by the need to maintain a relatively straight alignment. Avoidance of lakes was a key consideration in route selection, but given the profusion of water bodies in some portions of the LSA it was not possible to avoid them all. Consequently, there are a number of locations where the railway will pass in close proximity to a lake, in some cases close enough that the toe of the railway embankment will occupy a portion of lake bed. Although most of these encroachments are in small lakes and non-fish-bearing ponds, encroachments in 31 locations will affect fish habitat, 21 of them with Arctic Char habitat.

A total of 46 potential encroachment sites were surveyed during baseline surveys. The final alignment includes 13 encroachment sites on smaller lakes with Arctic Char and eight sites on Cockburn Lake. Encroachment sites identified as char habitat generally are shallow nearshore sites with habitat that is suitable for feeding and rearing. No sites were identified where the affected habitat is limited in a given waterbody (i.e., critical).

Although encroachment sites in fish-bearing waters will displace existing habitat, the embankment material will be similar to the gravel, cobble and material that comprises the existing nearshore substrates in most of

the affected lakes. In some cases the embankment material will be placed on finer materials, and in all cases it is anticipated that the coarse encroachment material will become ecologically functional over time, colonized by lower level trophic biota and providing rearing and feeding habitat.

Excluding Cockburn Lake, the total available habitat in Arctic Char lakes with anticipated railway encroachments was calculated to be 1,286,023 m^2 (128.6 ha). The total area of displaced habitat will be 17,590 m^2 (1.8 ha), or 1.37 % of available habitat. Since the displaced habitat will all be shallow nearshore water, a more appropriate approach would be to consider the loss of this habitat type relative to available nearshore habitat. The total available nearshore habitat, expressed as shoreline length, in Arctic Char lakes with anticipated railway encroachments was calculated to be 18,002 m. The total displaced habitat in these lakes will be 1,062 m, or 5.90 % of available habitat. Eight small encroachments, with a combined area of 3,720 m^2 (0.4 ha) and a combined shoreline length of 570 m, will occur on Cockburn Lake. Cockburn Lake has a total shoreline length of 100,708 m; therefore, these encroachments will occupy 0.57 % of the overall length. The effects are considered negligible.

All Arctic Char habitat lost to railway construction and operation is seasonal juvenile rearing habitat. Assuming that productive capacity is analogous to available rearing habitat, the effect of direct loss of habitat to culvert footprints is expected to be low.

Water intakes at the construction camps, including Ravn Camp, Mid-Rail Camp, Cockburn Tunnels and Cockburn South camps will be temporary and will include an onshore pump house connected to an offshore screened intake by insulated heat traced pipe buried in the lake bed. The area of lake bottom displaced or disturbed by a temporary intake will vary between locations, but is expected to be less than 50 m^2 per site. Intakes will be located nearshore, at depths that are adequate to prevent ice contact issues. Habitats likely to be affected by intake placements will be littoral habitats, in some cases with the potential to provide fish rearing and feeding habitat. Potential spawning areas will be avoided. The water intakes will be in place only during the Construction phase and will be removed when railway and road construction is complete. Given the relatively small footprints of intake structures relative to available habitat, the effect of water intake footprints on Arctic Char habitat is considered to be negligible and will not be assessed further.

4.5.6.4 Habitat Loss due to Impeded Fish Passage

The ability of fish to successfully pass through a culvert is determined primarily by:

- Swimming performance of the species concerned;
- Water velocity within a culvert and at the culvert inlet and outlet;
- Hydraulic characteristics at the culvert inlet and outlet; and
- Culvert length.

Construction of the railway and access road not adjacent to railway crossings will involve 76 culvert installations on fish-bearing streams, including 64 crossings of streams with juvenile Arctic Char. Where an access road crossing is adjacent to a railway crossing it is counted as one installation. To mitigate potential fish passage issues at these crossings, numerous design features that promote fish passage have been considered and will be incorporated wherever feasible, including the following (from Dillon 2008):

- Culvert will be installed at the same slope as the existing stream.
- Culvert lengths will be minimized.
- Culverts with lengths that exceed 50 m may be considered barriers to fish passage because of the darkness inside. Methods to provide light inside culverts will be examined and considered.

- Culvert velocities will be compared to the velocity in the existing watercourse to determine fish passage potential. This information can be used to reassess design velocities under proposed conditions with the culvert installed.
- With the channelization of flows and conveyance in culverts, the velocity of the flows may increase. This will be mitigated by placing rocks and boulders inside the culverts (stream replication) to provide greater friction, thereby reducing velocities and increasing the flow depth and to provide resting locations for fish. Boulders may be bolted into place.
- Culverts with diameters of 1600 mm and 3000 mm will be embedded by at least 20 % to increase the wetted width at the invert of the culvert. Larger diameter culverts may be buried deeper than 20 % to allow for a larger width for stream replication.
- In culverts on steep slopes, high velocities may result in the movement of rocks inside the culvert. At these locations, baffles, baffle inserts or weirs will be installed to:
    - Assist in keeping rocks inside the culvert;
    - Maintain and increase roughness in order to minimize velocities; and
    - Provide additional resting locations for fish as they move through the culvert.
- Boulders will be placed in a staggered formation downstream of the outlet. This will also provide fish with resting locations.

Employing appropriate design considerations can mitigate many of the issues commonly encountered at culvert stream crossings. However, minimum culvert length and slope are usually determined by local terrain features and can be more challenging to deal with. The railway will traverse areas where natural stream channels are often quite steep, approaching 20 % gradient in some cases. due to railway design requirements, specifically the need to maintain a low railbed gradient, numerous crossings in deep valleys will require relatively high embankments and correspondingly long culverts (up to 178 m). Therefore, despite the fish passage design considerations listed above, fish passage will be unavoidably impeded at some crossings.

Fish passage through culverts can be enhanced by maximizing water conveyance capacity (oversized culverts), embedding culverts and roughening the bed within the culverts (boulder placement), avoiding outlet drops, and providing downstream and upstream resting pools. For long culverts, especially in combination with high gradients, maintaining water velocities that fish can manage for the time it takes to pass through a culvert is not always possible.

The scientific literature provides only limited information on the swimming performance of Arctic Char, particularly juveniles. Peake (2008) presented a review of available information, most based on studies conducted in laboratory swim tunnel respirometers, and suggested 40.0 cm/sec (0.4 m/sec) as a conservative threshold velocity for juvenile passage through culverts. However, information collected along the existing Milne Inlet Tote Road in recent years suggests that this threshold value is overly conservative for local conditions and populations. Culvert velocity data collected between 2008 and 2009 indicate that juveniles are able to pass through culverts with average flow velocities ranging from 0.02 to 2.48 m/sec., where average velocities represent combined data from multiple surveys and multiple barrels, where relevant. In fact, of the 19 Arctic Char bearing Tote Road streams with culverts for which flow data are available, 74 % had average outlet flow velocities exceeding 0.4 m/sec and 5 % had outlet velocities exceeding 2.0 m/sec.

Fish passage can be affected by culvert length where long culverts (swimming distance) combined with flow velocities create conditions that are beyond a fish's swimming capabilities. The flow velocity threshold therefore decreases as culvert length increases. Passage may also be affected by culvert length if fish avoid entering or fully traversing a culvert that is dark inside. Although such avoidance behaviour has not been conclusively demonstrated for Arctic Char at high latitudes, it is considered a potential Project effect. The longest Tote Road culvert for which juvenile fish passage has been confirmed is 66 m (BG-01).

Using the published (Peake 2008) and regional information, the velocity threshold for unimpeded juvenile passage was assumed to be 0.4 m/sec, and velocity thresholds for partial and total fish passage impediment were assumed to be 2.5 m/sec and 3.0 m/sec, respectively. The culvert length threshold for unimpeded fish passage was assumed to be 60 m. For culverts longer than 60 m, partial or total fish passage impediment was assumed, depending on flow velocities and an assumption of some effect of culvert darkness.

A decision matrix was developed to determine which railway crossings could potentially present fish passage issues (Table 7-4.10). This matrix was then applied to Arctic Char bearing streams with Railway and Access Road crossings, using the designed culvert lengths and modelled average flow velocity estimates. The modelled average flow velocity estimates were used rather than the 1 in 10 year 3 day delay period (3Q10) estimates as the former were considered to be more relevant. Use of 3Q10 is a common practice but is more applicable to situations where potential delay of migration is the primary concern (e.g., spawning runs). In this case, all streams with culvert rail or road crossings are used exclusively for summer rearing and feeding, and periodic short term delays to fish movement (e.g., spring freshet; storm events) are considered a negligible effect.

In Table 7-4.10, fish passage is expressed as 'not impeded', 'partially impeded' or 'impeded'. Partial or total fish passage impediment could be due to excessive culvert length or flow velocity, or the synergistic effect of both. The partially impeded designation is intended to capture those sites where high flow conditions could periodically interrupt fish passage or where passage could be limited to larger juvenile size classes which typically exhibit stronger swimming capabilities.

Table 7-4.10 Fish Passage Determination Matrix for Railway and Access Road Culvert Crossings of Streams with Juvenile Arctic Char

Culvert Length (m)	Culvert Flow Velocity (m/sec) per barrel Average Flow Conditions						
	< 0.4	< 1.0	< 1.5	< 2.0	< 2.5	< 3.0	> 3.0
< 40	Y	Y	Y	Y	P	P	N
40 - 60	Y	Y	P	P	P	N	N
60 - 80	P	P	P	P	N	N	N
> 80	P	P	N	N	N	N	N

Y = fish passage not impeded
P = partial impediment to fish passage possible or likely
N = impediment to fish passage likely

Based on this decision matrix, a total of 17 crossings were identified where Arctic Char passage is likely to be impeded, either partially or totally, under average flow conditions. All of these are railway crossings. The access road will be less constrained by gradient requirements and culvert lengths will generally be short enough for effective fish passage. In all cases where partial or total loss of fish passage is anticipated, the

assumption was made that all habitat upstream of the crossing would be affected for the duration of the Project. The estimated area of habitat upstream of these crossings was calculated on the basis stream width, stream order (i.e., Strahler stream classification system) and stream length to the upstream extent of fish accessibility. The total area of available fish habitat was derived by adding the estimated area of downstream habitat to the nearest major river or overwintering lake to facilitate calculations of the percentage of habitat loss.

The total area of available stream habitat for Arctic Char in LSA streams with culvert crossings is calculated to be 1,785,213 m^2 (178.5 ha). The total area of habitat that will become partially or totally inaccessible is 15,185 m^2 (1.52 ha), or 0.85 % of the total available habitat.

The Arctic Char habitat that will be lost is seasonal juvenile rearing habitat. Assuming that productive capacity is analogous to available rearing habitat, the effect of loss of habitat due to impeded fish passage is expected to be negligible.

4.5.6.5 Water Withdrawals

Water will be withdrawn from Ravn Camp Lake, Mid-Rail Camp Lake and Cockburn Lake for use in camps during the Construction period. Water for the Mid-Rail Camp will be withdrawn during the open-water season from the adjacent Mid-Rail Camp Lake but will be supplied from Ravn Camp Lake in winter. Withdrawals at the remaining camp sites will occur year-round.

As indicated in Section 2.3.3.4, water withdrawals will remain within the NT and Nunavut DFO Protocol for winter water withdrawals from ice-covered waterbodies (DFO 2010). The hydrology impact assessment indicates a reduction of 3 cm in winter and 0.2 % of total under-ice lake volume in Ravn Camp Lake. Effects on lake water levels in the open-water season are considered to be negligible (K. Terry, Pers. Comm.). Effects of water withdrawals from Ravn Camp Lake on discharge of the lake outflow are predicted to be negligible (range of 0.05-0.71 % reduction in discharge, with the largest relative change occurring during the high flow period), and effects on Arctic Char habitat are likewise considered to be negligible.

Mid-Rail Camp Lake will serve as the water source for the adjacent camp only during open-water season and therefore does not have the potential to affect under-ice lake volumes or water levels. Effects on lake water levels in the open-water season are considered to be negligible (K. Terry, Pers. Comm.). Withdrawals are predicted to result in 0.53-2.6 % reduction in the discharge of the lake outflow over the open-water season. The largest relative reduction in flow would occur in September when flows are lowest (discharge estimated at 0.04 m^3/s).

Water will be withdrawn at the Cockburn Lake Tunnels and South camps and is predicted to result in reductions in winter water levels of 0.1 cm (0.001 % of total under-ice lake volume) and 0.3 cm (0.02 % of total under-ice lake volume) in the north and south basins, respectively. Effects on lake water levels in the open-water season are considered to be negligible (K. Terry, Pers. Comm.). The cumulative effect of water withdrawals in the north and south basins of Cockburn Lake on the discharge of the lake outflow is less than 0.1 % (ranging from 0.00 % in July to 0.08 % in October).

These reductions in lake water levels and outflow discharges would not be readily discernible from the natural range of water level fluctuations and/or ice thickness during winter and effects on Arctic Char habitat related to water withdrawals are considered to be negligible. Effects of water withdrawals on fish passage in outflow streams are also considered negligible.

Water will also be drawn from various lakes along the railway alignment during the Construction period for dust suppression (see Section 2.3). Locations have not been identified but potential source waterbodies will be visually assessed prior to withdrawal to mitigate potential effects on water quantity. The effects of this activity on Arctic Char habitat are considered negligible.

4.5.6.6 Effects on Stream Hydrology

Construction and operation of the railway, access road and construction camps is not expected to result in measurable effects on stream hydrology.

4.5.6.7 Stream Diversion

Stream diversions within the Railway/Access Road LSA that may potentially affect Arctic Char habitat are limited to the alluvial fan at the south end of Cockburn Lake, near the location of the South Cockburn Camp, where two watersheds (CV123-3 and CV124-1,2,3) converge before entering the lake at different locations. A large alluvial fan has been created here as the streams descend from the surrounding plateau and traverse the relatively flat terrain along the southeast shore of the south basin. The hydrology in this area is complex, as the main channels in both watersheds become extensively braided. The smaller channels are dynamic, changing their courses over time, and there is also an exchange of water between and within watersheds via ephemeral connecting channels during periods of extreme flows.

Three berms will be constructed to contain cross-channel transfers of floodwater, thereby improving crossing integrity by directing excess water to bridge or culvert installations to accommodate it. These berms will not affect overall water quantity but there will be temporary re-distributions of water during high flow events. It is not anticipated that these diversions will have a measurable effect on Arctic Char habitat or productivity.

A second type of diversion will isolate one channel, CV124-1, by directing its flow to CV123-4 and CV124-2. The channel reach downstream of the diversion will become de-watered and fish access to the upstream reach is uncertain. Therefore, as a conservative assessment it is assumed that all of the Arctic Char habitat in this channel (approximately 0.6 ha) will be lost. This habitat loss was already included in the assessment of habitat loss due to impeded fish passage and will not be assessed further here.

4.5.6.8 Sedimentation of Arctic Char Habitat

Increased sedimentation and subsequent alteration of substrate of Arctic Char habitat was considered in relation to effects of dust deposition and all Project activities with the potential to increase sediment/erosion and/or enhance sedimentation, including general site runoff and runoff along railway and road embankments. Alteration of spawning habitat in relation to increased sedimentation is limited to effects within LSA lakes as spawning is not supported in LSA streams.

Effects on sedimentation are expected to be small due to mitigation measures including sediment and erosion control measures during construction and operation of the railway and access road, water management such as the use of settling ponds, and dust management. Culvert crossings will be designed to minimize introduction of sediment from embankment or road drainage, and channel or bank erosion at the inlets, outlets and downstream reaches during the Operation phase. In addition, as previously noted, Arctic Char preferred spawning habitat is generally considered to occur at water depths between 2 and 10 m where wave action generally limits sedimentation. Effects of sedimentation on spawning habitat are considered negligible.

4.5.6.9 Effects on Lower Trophic Level Biota and Productive Capacity of Arctic Char habitat

Effects of the Project on lower trophic level biota and the productive capacity of Arctic Char habitat in the Railway/Access Road LSA relate to direct loss of habitat due to Project footprints, alterations in hydrology, increased sedimentation, and changes in water quality.

Overall effects on productive capacity of habitat are expected to be negligible to small due to the low percentage of habitat affected by Project footprints and water withdrawals, and negligible to small effects of Project Construction, Operation, and Closure on water quality and sedimentation. As indicated in Section 3.4.2, infrequent exceedances of water quality guidelines associated with non-point sources are predicted over the Construction, Operation, and Closure periods. In addition, exceedances of CCME PAL guidelines are predicted for the Project Construction period due to fugitive dust. Therefore, effects on lower trophic level biota are therefore ranked as of Low magnitude (Level I), frequent/continuous (Level III), of moderate duration (Level II), partially reversible (Level II), and would be confined to portions of the LSA (Level I).

4.5.6.10 Summary of Effects on Arctic Char Habitat

Construction, Operation and Closure activities in the Railway/Access Road LSA are expected to result in Negligible to Low magnitude of effects on Arctic Char habitat. A summary of effects related to loss of habitat is provided in Table 7-4.11. Overall, habitat loss due to footprints, encroachments and impeded fish passage will be of low magnitude.

Table 7-4.11 Summary of Project Effects related to loss of Arctic Char Habitat in the Railway/Access Road LSA

Linkage / Pathway	Arctic Char Habitat			Loss of Productive Capacity
	Available	Loss		
	ha	ha	%	
Bridge footprints	564.0	1.0	0.17	Negligible
Culvert footprints	178.5	2.4	1.35	Low
Impeded fish passage		1.5	0.85	Negligible
Cockburn Lake encroachments [1]	100,708	570	0.57	Negligible
Other lake encroachments [1]	18,002	1,062	5.90	Low
NOTES: [1] habitat units given in m (shore length)				

Key Issue #3: Effects on direct mortality of Arctic Char

Linkages between the Project and the potential for direct mortality of Arctic Char in the Railway/Access Road LSA are related to sedimentation effects on eggs, effects of winter drawdown of lakes due to water withdrawals on egg stranding, and direct mortality of eggs due to installation of Project footprints in surface waters.

4.5.6.11 Sedimentation Effects

Potential effects of increased sedimentation on Arctic Char eggs are limited to effects within LSA lakes, as spawning is not supported in streams. Potential effects related to dust deposition are expected to be negligible, and therefore potential effects on Arctic Char eggs are predicted to be negligible. Mitigation may

include adherence to timing windows to avoid effects during the spawning period and other measures to avoid or minimize introduction of sediment to surface waters.

4.5.6.12 Project Footprints

As previously noted, spawning is believed to be restricted to lakes in the LSA and construction of Project footprints in streams therefore does not have the potential to result in direct mortality of Arctic Char eggs. Construction of 13 encroachments in smaller lakes with known or suspected Char habitat could potentially result in mortality of eggs, but spawning is suspected in only three affected lakes. All other lakes with encroachments are too shallow to provide overwintering or spawning habitat, and use is limited to feeding and rearing. In two lakes where spawning is possible or likely, encroachments will be limited to shallow nearshore water where spawning is not possible.

The other two sites are on Cockburn Lake, and only one (LE109-1) has habitat within the encroachment area that could be used for spawning. This encroachment is located at the head of a small bay where potential habitat is limited and spawning is considered unlikely; a survey will be conducted prior to construction to confirm its presence or absence. If spawning be confirmed, the potential for mortalities to eggs at this location would be mitigated to the extent feasible through the use of appropriate timing windows to avoid the spawning and incubation period. This effect is considered to be negligible following mitigation.

4.5.6.13 Winter Lake Drawdown

As described in Section 2.3.5.4, winter water withdrawals from Ravn Camp Lake and Cockburn Lake at both construction camps are predicted to result in small reductions in winter lake water levels (3 and <1 cm, respectively). These reductions are unlikely to affect Arctic Char eggs as the water level changes are expected to be well within the range of natural water level variations and/or ice thickness ranges. Therefore effects on eggs are considered to be negligible.

4.5.7 Steensby Port LSA

Key Issue #1: Effects on Arctic Char health and condition

Arctic Char health and condition may be affected by Project-related changes in water and/or sediment quality in the Steensby Port LSA. Residual water and sediment quality effects described in Section 3.4.2 with the potential to result in exceedances of thresholds include:

- Changes in water and sediment quality in waterbodies due to dust deposition (i.e., airborne emissions); and
- Effects of aqueous non-point sources on water quality.

Ore stockpile runoff and treated sewage effluent will be discharged to the marine environment and will therefore not affect the freshwater environment. The water management pond that collects water diverted from the vicinity of the Ore Offload Area will be discharged to watershed ST-16. This drainage basin is devoid of Arctic Char and drains to the marine environment; effects of this pathway are therefore considered to be negligible and are not considered further.

4.5.7.1 Dust Deposition and Effects on Water Quality

Section 3.4.2 indicates that effects of the Project on dust in the Steensby Port LSA may result in low magnitude exceedances of CCME PAL guidelines during Construction in association with fugitive dust. Effects on Arctic Char are therefore considered to be of low magnitude (Level I), frequent (Level III), short-term (Level I), reversible (Level I), and confined to portions of the LSA (Level I).

The air quality assessment, which includes modeling of the spatial extent and rate of dust deposition in the LSA as described in Volume 5, Section 2.0, indicates that the area affected by TSP deposition would be largely restricted to the Port Island and marine environment. The freshwater bodies on the island are devoid of fish. Dust modeling indicates that some deposition will occur on the mainland but will be restricted to drainages near the coast. A number of watersheds are located within this deposition zone and drain to the marine environment but many of them do not support Arctic Char (i.e., ST-12 through ST-19). Watersheds within the zone of dust deposition that support Char include ST-1, ST-2, ST-29, ST-11, and ST-5. The rate of dust deposition for these areas is relatively low and would affect only portions of watersheds, generally near the outflows of the watersheds. Section 3.4.2 indicates that effects of dust deposition on water quality in the freshwater environment may result in infrequent, low magnitude exceedances of CCME PAL guidelines during Project Operation. Therefore effects on Arctic Char are considered to be of Low magnitude (Level I), infrequent (Level I), of moderate duration (Level II), reversible (Level I), and confined to portions of the LSA (Level I).

4.5.7.2 Non-point Source Effects on Water Quality

Aqueous non-point sources with the potential to cause exceedances of water quality thresholds in the Steensby Port LSA, as described in Section 3.4.2, are summarized in Table 7-4.12.

Table 7-4.12 Summary of Aqueous Non-point Sources that may Cause Exceedances of Water Quality Thresholds in the Steensby Port LSA

Project Activity	Indicator	Project Phase
Ground Preparation and Earthworks	pH, TSS, metals, nutrients, and hydrocarbons	Construction, Operation, and Closure
Site Water Management	pH, TSS, metals, nutrients, and hydrocarbons	Construction, Operation, and Closure
Laydown Areas	pH, TSS, metals, nutrients, and hydrocarbons	Construction and Closure
Explosives	pH, TSS, metals, nutrients, and hydrocarbons	Construction and Operation
Quarries and Borrow Sources	pH, TSS, metals, nutrients, and hydrocarbons	Construction
Airstrip and Airstrip Use - Runoff	TSS and petroleum hydrocarbons	Construction, Operation, Closure

The water quality assessment (Section 3.4.2) indicates that conservatively, these non-point sources may result in infrequent exceedances of water quality thresholds in the LSA. Parameters that may exceed these guidelines include TSS, hydrocarbons, nutrients (i.e., ammonia and nitrate associated with ANFO), and metals. pH may also be affected (i.e., reduced) in the vicinity of quarries and borrow sources. These effects would have a Low magnitude effect on Arctic Char health and condition (i.e., exceedances would be within an order of magnitude of water quality thresholds), where fish are actually present. Effects would be lower in areas of infrequent use, such as streams used as access corridors between higher quality habitat. In general, the greatest risk to Arctic Char health and condition would be in the immediate vicinity of Project infrastructure, notably in high quality habitat and in waterbodies with limited ability for the fish to avoid unfavourable conditions. Some effects on water quality will be restricted to and/or be greatest during the Construction period. However, infrequent exceedances of water quality thresholds are predicted to have the

potential to occur during Construction and Operation and the effect is therefore considered to be of Low magnitude (Level I), infrequent (Level I), partially reversible (Level II), of moderate duration (Level II), and confined to the LSA (Level I).

Key Issue #2: Effects on Arctic Char habitat

Potential linkages between the Project and effects on Arctic Char habitat in the Steensby Port LSA include:

- Loss of Arctic Char habitat from Project footprints (e.g., water intake structures);
- Loss or alteration of Arctic Char habitat due to water level changes (i.e., effects of water withdrawals on lake water levels) and/or stream discharge regimes, including potential effects on fish movements/passage;
- Potential effects of construction of stream crossings on ability of Arctic Char to access upstream habitat (i.e., fish passage);
- Water diversions;
- Effects of increased sedimentation of Arctic Char spawning habitat; and;
- Changes in the productive capacity (i.e., lower trophic level biota) of Arctic Char habitat due to various Project-related pathways of effect.

4.5.7.3 Project Footprints

Effects of Project footprints associated with the railway and/or access road are considered and discussed in Section 4.5.6. Additional footprints in the LSA include Steensby Port Site stream crossings for rail yards and roads, the laydown area for the construction dock, water intakes, and the rotary rail car dumper.

The Camp Area Platform will accommodate several rail lines and an access road. The west end of the platform will span a small stream (SPS-17) that may provide low quality seasonal feeding and rearing habitat for Arctic Char that overwinter in Lake ST23. To maintain flow within this drainage, a 210 m culvert will be installed under the platform to convey water between an upstream pond (ST37) and a downstream pond (ST26) approximately halfway between ST37 and ST23. The total area of low quality habitat between these two ponds is approximately 1,900 m^2 (0.19 ha). The area that will be displaced by the platform and culvert is approximately 1,130 m^2 (1.04 ha), or 60 % of the available habitat. The crossing will be removed at Closure, and flow in the stream channel established for long-term stability.

Stream SPS-19 is a small drainage that connects Lake ST29 to Steensby Inlet. The lake supports resident populations of Arctic Char, and juvenile rearing habitat is provided by SPS-19 and a small connecting pond (ST30). The terminal rail loop and access road will require installation of two culvert crossings on SPS-19. The crossings are not expected to impede fish passage but the culvert placements will result in a loss of habitat for the duration of the Construction and Operation phases. The total area of available stream habitat is approximately 8,000 m^2 (0.80 ha). The area that will be displaced by the culverts is approximately 720 m^2 (0.07 ha), or 9 % of the available habitat. The crossings will be removed at Closure and the resultant stream channel will be established for long-term stability.

The lower reaches of SPS-19 will also be affected by a laydown area during the Construction phase. The stream flow will be maintained during this period and although the laydown area will not encroach on the stream channel, its proximity and associated activity has the potential to disturb fish or fish habitat in the stream. The laydown area will be required only for the duration of the Construction period and any potential effects will therefore be of short duration, and are considered to be negligible.

The Steensby Port Site access road will also cross SPS-29, a small stream that connects Lake ST36 to Steensby Inlet and provides summer rearing and feeding habitat for Arctic Char. A culvert crossing at this location is not expected to impede fish passage but will result in a loss of habitat for the duration of

Construction and Operation. The total area of available stream habitat is approximately 18,480 m^2 (1.85 ha). The area that will be displaced by the culvert is approximately 600 m^2 (0.06 ha), or 3 % of the available habitat. The crossing will be removed at Closure and the resultant stream channel will be established for long-term stability. Temporary construction docks will be located at or near the coastal outlet of SPS-29. The Arctic Char that use this stream are not anadromous and it is likely that the lowermost reach at the coast provides only marginal habitat at best. However, the proximity of the docks has the potential to disturb fish or fish habitat in the stream. Stream SPS-29 also flows adjacent to the construction dock laydown area for much of its length. Although the laydown area will not encroach on the stream channel, its proximity and associated activity has the potential to disturb fish or fish habitat in the stream. The docks will be required only during Construction; any potential effects will therefore be of short duration, and are considered to be negligible.

Two additional small coastal streams, SPS-24 and SPS-11e, will also be affected by various Project activities, but neither stream is fish-bearing. Any potential effects are therefore considered to be negligible.

The remaining Project footprints that would be placed in the aquatic environment in the Steensby Port LSA are limited to installation of drinking water intakes at lakes ST353 and ST347. The intake at ST353 will be a temporary water intake for the Construction period and will include an onshore pump house connected to an offshore screened intake by insulated heat traced pipe buried in the lake bed. The area of lake bottom displaced or disturbed is expected to be less than 50 m^2. The intake will be located nearshore, at a depth that is adequate to prevent ice contact issues. Habitats likely to be affected by the intake placement will be littoral habitat, in some cases with the potential to provide fish rearing and feeding habitat. Potential spawning areas will be avoided.

The intake in Lake ST347 will be a more permanent structure, involving an aggregate embankment extending into the lake as far as is required to reach appropriate depth. It is expected that the embankment will displace an area of stream or lake bottom equivalent to approximately 450 m^2. The outer edge and toe of the embankment will be rip-rapped for stability, and rip-rap material of appropriate size will be selected to encourage lower trophic colonization and fish use. The intake structure will be removed at closure.

Freshwater lakes on the Port Island are devoid of fish and no loss would occur due to infrastructure in this area. Direct loss of Arctic Char habitat due to Project footprints in the Steensby Port LSA amounts to 2,901 m^2 (0.29 ha). Overall, direct habitat loss relative to the total quantity of Arctic Char habitat in the LSA would be negligible.

4.5.7.4 Water Withdrawals

Water will be withdrawn from Lake ST353 during the Construction period at Steensby Port LSA and from Lake ST347 during Construction, Operation and Closure. These withdrawals are predicted to result in decreases of 18 and 2-3 cm in winter lake water levels in lakes ST353 and ST347, respectively (equivalent to a reduction of 5.4 and 0.2-0.4 % of under-ice lake volumes; Section 2.3.3.5). These reductions are not expected to be discernible from natural lake water level fluctuations and/or ice thicknesses, and effects on Arctic Char habitat are therefore considered to be negligible. Water requirements for the Closure phase have not been identified but it is anticipated that requirements would be equal to or, more likely, less than those during Operation.

The two outflow streams for ST535 are not fish-bearing and fish passage and stranding are therefore not an issue. Predicted reductions in the discharge of Lake ST347 outflow (Ikpikitturjuaq River) range from 0.05 to 1.2 % and from 0.03 to 0.7 % during Construction and Operation, respectively. This level of change is not

likely to be detectable and would not be discernible from natural variation in stream discharge, and effects on Arctic Char habitat and fish passage are considered to be negligible.

4.5.7.5 Runoff and Diversions

The diversion at the ore stockpile is located on an island devoid of freshwater fish.

Diversions will be required in the vicinity of the Ore Offload Area and four watersheds will be affected: (1) ST-1; (2) ST-2; (3) ST-15; and (4) ST-16. The latter two watersheds drain to Steensby Inlet and do not support Arctic Char. Watersheds ST-1 and ST-2 do, however, and will experience a reduction in discharge at the outlet of the drainages (i.e., point of entry to marine environment) of 3 % over the open-water season (see Section 2.3.4). Affected waterbodies in watershed ST-1 include two small Char-bearing lakes (ST29 and ST30) and stream SPS-19 (the outflow of the watershed). Diversion will affect Lake ST24 and downstream waterbodies (including ST23, ST22, and SPS-22) in watershed ST-2 which are either known or potential Char habitat. As effects on water levels and flows were assessed for the outflow of the drainages and effects may be larger in upstream waterbodies, a Low magnitude effect (Level I) was identified in the interest of being conservative. The effect is considered to be of moderate duration (Level II), frequent (Level III), reversible (Level I), and confined to the LSA (Level I).

4.5.7.6 Dust Deposition

The Project could potentially affect Arctic Char spawning habitat through sedimentation due to dust deposition. However, the Project is expected to have a negligible effect on sedimentation of Arctic Char spawning habitat due to the relatively low rate of dust deposition predicted, the predicted zone of dust deposition, and because Arctic Char spawning is limited to lakes.

4.5.7.7 Effects on Lower Trophic Level Biota and the Productive Capacity of Arctic Char Habitat

Lower trophic level biota may be adversely affected in lower trophic level biota habitat and/or in indirect habitat in waterbodies containing Project footprints, in surface waters affected by aqueous non-point sources and dust, and areas affected by changes in water levels or discharge. Non-point sources are predicted to result in infrequent, low magnitude exceedances of CCME PAL guidelines over the Project Construction, Operation, and Closure periods. This pathway is therefore considered to have a Low magnitude (Level I), moderate duration (Level II), partially reversible (Level II), and infrequent (Level I) effect on lower trophic level biota and ultimately Arctic Char habitat.

Frequent, low magnitude effects on Arctic Char may occur during Project Construction in association with fugitive dust, as described in Section 3.4.2. In addition, infrequent, low magnitude exceedances of CCME PAL guidelines may occur during Project Operation in association with dust deposition, in drainages located within the zone of dust deposition. However, as described in Section 4.5.7.1, many of these drainages do not provide direct or indirect habitat.

Effects of water withdrawals and footprints in waterbodies on the quantity of aquatic habitat are considered to be negligible and effects on lower trophic level biota and the productive capacity of Arctic Char habitat are also deemed to be negligible.

Diversions in drainages ST-1 and ST-2 are conservatively identified to result in a low magnitude effect on the quantity of habitat and are thus considered to have a low magnitude of effect on lower trophic level biota and productive capacity. These effects would be of moderate duration (Level II), continuous (Level III), and reversible (Level I).

Overall, the magnitude of effects on the productive capacity of Arctic Char habitat in the Steensby Port LSA would range from Negligible in waterbodies unaffected by these pathways to Low in waterbodies affected by diversions, water withdrawals, footprints, and/or non-point sources. Collectively effects are considered to be of moderate duration (Level II), Low magnitude (Level I), partially reversible (Level II), and continuous (Level III).

Key Issue #3: Effects on direct mortality of Arctic Char

Linkages between the Project and the potential for direct mortality of Arctic Char considered for the Steensby Port LSA include:

- Effects of sedimentation on Arctic Char eggs; and
- Effects of winter drawdown of water source lakes due to water withdrawals and potential for stranding of eggs.

4.5.7.8 Dust Deposition

The Project could potentially affect Arctic Char eggs through sedimentation due to dust deposition. However, the Project is expected to have a negligible effect on sedimentation of Arctic Char eggs due to the relatively low rate of dust deposition predicted, the predicted zone of dust deposition, and because Arctic Char spawning is limited to lakes.

4.5.7.9 Winter Lake Drawdown

As noted above, water will be withdrawn from Lake ST353 during Construction and from Lake ST347 during Construction, Operation and Closure. Withdrawals are predicted to result in small (18 and 2-3 cm, respectively) reductions in winter lake water levels. These reductions are unlikely to affect Arctic Char eggs in Lake ST352 or ST347 as these reductions are well within the range of natural water level variations and/or ice thickness. Therefore effects are considered to be negligible in Lake ST352 and ST347.

4.5.8 Assessment of Residual Effects

Residual effects of the Project on Arctic Char within each of the five LSAs are summarized in Tables 7-4.13 to 7-4.17. Effects identified as Negligible are not considered to be residual effects. The following provides an overall assessment of residual effects to Arctic Char within each of the five LSAs related to the various linkage pathways and an assessment of the significance of the residual effects.

Table 7-4.13 Milne Port LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Arctic Char health and condition	Effects of Non-Point Sources on Water Quality	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality).	Level I	Level II	Level I	Level I	Level II
	Effects of Fugitive Dust on Water Quality During Construction	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level I	Level III	Level I	Level I
Effects on Arctic Char habitat	All linkages	Negative effect on Productive Capacity of Arctic Char Habitat	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies.	No Residual Effects				
Effects on Arctic Char Mortality	All linkages	Direct mortality of Arctic Char	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies. • Avoidance of Project footprints in Arctic Char spawning habitat.	No Residual Effects				

Table 7-4.14 Milne Inlet Tote Road LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Arctic Char health and condition	Effects of Non-Point Sources on Water Quality	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See water and sediment quality assessment (Section 3.4) for detailed mitigation	Level I	Level II	Level I	Level I	Level II
	Effects of Fugitive Dust on Water Quality During Construction	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level I	Level III	Level I	Level I
Effects on Arctic Char habitat	All linkages	Negative effect on Productive Capacity of Arctic Char Habitat	• Mitigation measures to avoid or minimize effects on water and sediment quality (see Section 3.4) • Mitigation measures to avoid or minimize Project footprints in waterbodies	No residual effects				
Effects on Arctic Char Mortality	All linkages	Direct mortality of Arctic Char	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies. • Avoidance of Project footprints in Arctic Char spawning habitat.	No Residual Effects				

Table 7-4.15 Mine LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Arctic Char health and condition	Ore and Waste Rock Dust Generation and Dispersion: water quality changes	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level II	Level II	Level I	Level II
	Ore and Waste Rock Dust Generation and Dispersion: sediment quality changes	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level II	Level III	Level III	Level I	Level II
	Discharge of West Waste Rock Stockpile Runoff to Camp Lake Tributary 1	Negative Effect on Water Quality (TSS, metals, nutrients, and Petroleum Hydrocarbons) in Camp Lake Tributary 1 and Camp Lake	• See mitigation identified in Section 3.0 (Water quality)	Level II	Level III	Level III	Level I	Level II
	Discharge of East Waste Rock, Ore Stockpile Runoff and Pit Water/Run of Mine Stockpile to the Mary River	Negative Effect on Water Quality (TSS, metals, nutrients, and Petroleum Hydrocarbons) in the Mary River	• See mitigation identified in Section 3.0 (Water quality)	Level I	Level III	Level III	Level I	Level II
	Exploration drilling Release to the Mary River	Negative Effect on Water Quality (TSS, metals, nutrients, and Petroleum Hydrocarbons) in the Mary River	• See mitigation identified in Section 3.0 (Water quality)	Level I	Level II	Level II	Level I	Level I
	Aqueous Non-Point Sources	Negative Effect on Water Quality (TSS, metals, nitrogenous compounds and Petroleum Hydrocarbons) throughout the LSA	• See mitigation identified in Section 3.0 (Water quality)	Level I	Level II	Level I	Level I	Level II

Table 7-4.15 Mine LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Effects on Arctic Char habitat	Sedimentation of habitat	Alteration in Arctic Char spawning habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level II	Level III	Level I	Level I
	Project footprints in Arctic Char habitat	Direct loss of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level II	Level III	Level I	Level I
	Water diversion: Camp Lake Tributary 1	Change in wetted area of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level III	Level III	Level I	Level II
	Water diversion: Camp Lake Tributary 2	Change in wetted area of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level III	Level III	Level I	Level II
	Effects on lower trophic level biota: Camp Lake Tributary 1	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level II	Level III	Level III	Level I	Level II
	Effects on lower trophic level biota: Camp Lake Tributary 2	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level III	Level III	Level I	Level II
	Effects on lower trophic level biota: Other Camp Lake Tributaries	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level II	Level III	Level I	Level II
	Effects on Lower Trophic Level Biota: Camp Lake	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level II	Level III	Level III	Level I	Level II
	Water diversion: Sheardown Lake Tributary 1	Change in wetted area of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level III	Level III	Level I	Level II
	Water diversion: Sheardown Lake Tributary 9	Change in wetted area of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level II	Level III	Level I	Level I

Table 7-4.15 Mine LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases (Cont'd)

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Effects on Arctic Char habitat (Cont'd)	Water diversion: Sheardown Lake Tributary 12	Change in wetted area of Arctic Char habitat	Fish Habitat Compensation Plan	Level I	Level II	Level III	Level I	Level I
	Effects on lower trophic level biota: Sheardown Lake Tributaries 1, 9, and 12	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level III	Level III	Level I	Level II
	Effects on lower trophic level biota: Other Sheardown Lake Tributaries	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level II	Level III	Level I	Level II
	Effects on Lower Trophic Level Biota: Sheardown Lake	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level II	Level III	Level III	Level I	Level II
	Effects on Lower Trophic Level Biota: Mary River	Negative effect on productive capacity of Arctic Char habitat	• See mitigation identified in Section 3.0 (Water quality)	Level I	Level III	Level III	Level I	Level II
Effects on Arctic Char Mortality	All linkages	Direct mortality of Arctic Char	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies. • Avoidance of Project footprints in Arctic Char spawning habitat.	No Residual Effects				

Table 7-4.16 Railway Alignment LSA - Freshwater Biota and Habitat Effects Assessment Summary - All Phases

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Arctic Char health and condition	Non-Point Sources due to Various Construction and Operation Activities	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See water and sediment quality assessment (Section 3.0) for detailed mitigation; • Other mitigation may include isolation of in-stream construction activities, fish salvage operations (where required), and adherence to timing windows.	Level I	Level II	Level I	Level I	Level II
	Effects of Fugitive Dust on Water Quality During Construction	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level I	Level III	Level I	Level I
Effects on Arctic Char habitat	Project Footprints in Waterbodies	Direct Habitat Loss (footprints)	• Minimize size of footprints. • Avoid Project footprints in waterbodies. • Avoid Project footprints in fish habitat. • Avoid critical Arctic Char habitat.	Level I	Level II	Level III	Level I	Level I
	Project Effects on Lower Trophic Level Biota	Change in Productive Capacity of Arctic Char Habitat	• Mitigation measures to avoid or minimize effects on water and sediment quality (see Section 3.4) • Mitigation measures to avoid or minimize Project footprints in waterbodies.	Level I	Level II	Level III	Level I	Level II
Effects on Arctic Char Mortality	All linkages	Direct mortality of Arctic Char	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies. • Avoidance of Project footprints in Arctic Char spawning habitat.	No Residual Effects				

Table 7-4.17 Steensby Port LSA - Freshwater Biota and Habitat Effects Assessment Summary – All Phases

Potential Impacts				Evaluation Criteria				
Key Issue	**Project Activity/Linkage**	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Arctic Char health and condition	Non-Point Sources due to Various Construction, Operation, and Closure Activities	Negative Effect on Water Quality (TSS, metals, nutrients, and Petroleum Hydrocarbons) throughout the LSA	• See water and sediment quality assessment (Section 3.0) for detailed mitigation; • Other mitigation may include isolation of in-stream construction activities and adherence to timing windows.	Level I	Level II	Level I	Level I	Level II
	Effects of Fugitive Dust on Water Quality During Construction	Negative Effect on Water and Sediment Quality and Arctic Char health and condition	• See mitigation identified in Section 3.0 (Water quality); • See mitigation identified in Volume 5, Section 2.0 (Air quality)	Level I	Level I	Level III	Level I	Level I
Effects on Arctic Char habitat	Water diversions	Loss of Arctic Char Habitat		Level I	Level II	Level IIII	Level I	Level I
	Effects on lower trophic level biota	Change in Productive Capacity of Arctic Char Habitat	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Minimize size of footprints. • Avoid Project footprints in waterbodies. • Avoid Project footprints in fish habitat. • Avoid critical Arctic Char habitat.	Level I	Level II	Level IIII	Level I	Level II
Effects on Arctic Char Mortality	All linkages	Direct mortality of Arctic Char	• Mitigation measures to avoid or minimize effects on water and sediment quality (see above). • Mitigation measures to avoid or minimize Project footprints and habitat alteration in waterbodies. • Avoidance of Project footprints in Arctic Char spawning habitat.	No Residual Effects				

Milne Port LSA

Residual effects of the Project on Arctic Char in the Milne Port LSA are summarized in Table 7-4.13 and descried briefly below.

Key Issue #1: Effects on Arctic Char health and condition

Potential effects on Arctic Char health and condition relate to changes in water quality, which may occur during the Construction, Operation, and Closure phases in relation to aqueous non-point sources and due to dust deposition during Construction and Operation. Most of the drainage areas in which infrastructure is located do not provide direct or indirect habitat. Exceptions include a small coastal stream (Stream M11-1) which provides low quality habitat and stream M5-1 which, while not fish-bearing, drains to the mouth of Phillips Creek, which may provide low quality habitat. Effects of dust deposition on water quality are predicted to result in low magnitude exceedances of CCME PAL guidelines due to fugitive dust during Construction. As exceedances of water quality thresholds are expected to be of low magnitude, and due to the low risk of exposure of Arctic Char to these exceedances, effects are expected to be negligible. However, to be conservative, a Low magnitude effect has been identified for this key issue.

Key Issue #2: Effects on Arctic Char habitat

Effects of the Project on Arctic Char habitat have been identified as negligible and no residual effects are expected.

Key Issue #3: Effects on direct mortality of Arctic Char

No residual effects on direct mortality of Arctic Char are expected.

Significance of Residual Effects

Effects of the Project on Arctic Char have been conservatively assumed to have a low magnitude due to the potential for infrequent, low level exceedances of CCME PAL guidelines due to non-point sources during Construction, Operation and Closure, and potential low magnitude exceedances due to fugitive dust during Construction. The Project will not have a significant effect on Arctic Char in the Milne Port LSA due to the Low magnitude and the reversible nature of effects (Table 7-4.18).

Table 7-4.18 Significance of Potential Residual Environmental Effects on Arctic Char in the Milne Port LSA

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Effects on Arctic Char health and condition	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

A high Level of Confidence was assigned to the assessment of effects on Arctic Char due to the nature of potential impacts and impact pathways, the low risk of exposure of Char and their habitat to residual effects, and the conservative approach applied.

Milne Inlet Tote Road LSA

Residual effects of the Project on Arctic Char in the Milne Inlet Tote Road LSA are summarized in Table 7-4.14 and descried briefly below.

Key Issue #1: Effects on Arctic Char health and condition

Residual effects of the Project on Arctic Char health and condition are expected to be limited to periodic exceedances of water quality thresholds, most notably for TSS, associated with aqueous non-point sources during Construction, Operation and Closure. Effects of dust deposition on water quality are predicted to result in possible low magnitude exceedances of CCME PAL guidelines due to fugitive dust during Construction.

Key Issue #2: Effects on Arctic Char habitat

No residual effects of the Project on Arctic Char habitat in the Milne Inlet Tote Road LSA were identified.

Key Issue #3: Effects on direct mortality of Arctic Char

No residual effects of the Project on direct mortality of Arctic Char in the Milne Inlet Tote Road were identified.

Significance of Residual Effects

The significance of residual effects of the Project on Arctic Char within the Milne Inlet Tote Road LSA is summarized in Table 7-4.19. Due to the Low magnitude, limited spatial extent, and the reversible nature of residual effects, no significant adverse effects are predicted.

Table 7-4.19 Significance of Potential Residual Environmental Effects on Arctic Char in the Milne Inlet Tote Road LSA

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Effects on Arctic Char health and condition	N	3	**N/A**	**N/A**

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

The Level of Confidence in the significance rating has been ranked as High. While there is uncertainty about the precise effects of the Project on water quality, a conservative approach was adopted for the water quality assessment, which increases the confidence in the predictions. Existing information characterizing

baseline conditions in the LSA is extensive and due to the low frequency and magnitude of predicted effects on water quality, the risks to aquatic biota are low.

Mine LSA

Residual effects of the Project on Arctic Char in the Mine LSA are summarized in Table 7-4.15 and described below.

Key Issue #1: Effects on Arctic Char health and condition

Residual effects of the Project on Arctic Char health and condition related to changes in water and sediment quality are expected to vary spatially within the Mine LSA in relation to locations of point sources and variability in dust deposition. The greatest effects are predicted to occur within small tributaries to Camp and Sheardown lakes in relation to dust deposition and for Camp Lake Tributary 1, due to both dust deposition and discharge from the West Waste Rock Stockpile. Water quality effects are also expected in Camp and Sheardown lakes, most notably near tributary mouths. Mary River may also experience exceedances in CCME PAL guidelines during Operation, Closure and post-Closure due dust deposition and the discharge of effluents and runoff.

The magnitude of residual effects on Arctic Char health and condition will range from Low in Mary River to Medium in tributaries to Camp and Sheardown lakes due to cumulative effects of the Project on water quality. Effects will also vary over time, with the largest effects occurring in the Operation phase during spring freshets, when dust introduction will be greatest, and during periods of effluent discharge. Effects related to runoff from the East and West Waste Rock Stockpiles and pit water release (after the pit has filled) will extend into the post-Closure period.

Effects will range from short-term to long-term duration, will be confined to the LSA, and will be reversible.

Key Issue 2: Effects on Arctic Char habitat

Potential effects on Arctic Char habitat include increased sedimentation rates, loss of habitat to Project footprints in waterbodies, water withdrawals, alterations in water levels and flows due to diversions that may reduce the amount of available habitat, and collectively, reduction of productive capacity in streams and lakes due to all of these effects pathways. Following mitigation, residual effects on Arctic Char habitat in the Mine LSA are expected to be a small to moderate reduction in the amount and productive capacity of habitat in LSA waterbodies, most notably in smaller tributaries to Camp and Sheardown lakes. Effects will be of moderate or long-term duration, limited to the LSA, and reversible.

Key Issue 3: Effects on direct mortality to Arctic Char

No residual effects on the direct mortality of Arctic Char are predicted following mitigation.

Significance of Residual Effects

Residual effects on Arctic Char in the Mine LSA will range from Low to Medium magnitude, infrequent to frequent/continuous, moderate to long-term duration, be confined to portions of the LSA, and will be reversible. Residual effects relate to changes in water quality from effluents, dust, and non-point sources with the greatest effects occurring during Construction and Operation, and alterations to or loss of Arctic Char habitat, primarily associated with water diversion and effects on productive capacity from multiple Project effect pathways.

Ultimately, due to the predicted magnitude of effects (Level I or II), the reversibility of residual effects, and the predicted spatial extent in the Mine LSA, effects are predicted to be *Not Significant* (Table 7-4.20).

Table 7-4.20 Significance of Potential Residual Environmental Effects on Arctic Char in the Mine Site LSA

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Effects on Arctic Char health and condition	N	2	N/A	N/A
Effects on Arctic Char habitat	N	2	N/A	N/A

Key
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

The Level of Confidence in the significance ratings is Medium. Existing information characterizing Arctic Char distribution, health/condition, and habitat use in the LSA is extensive, and effects were quantified through the use of modeling and/or GIS tools where possible. All predictions used a conservative approach.

Railway/Access Road LSA

Residual effects of the Project on Arctic Char in the Railway/Access Road LSA are summarized in Table 7-4.16.

Key Issue #1: Effects on Arctic Char health and condition

Residual effects of the Project on Arctic Char health and condition will be limited to those caused by exceedances of water quality thresholds, most notably for TSS, associated with aqueous non-point sources during Construction, Operation and Closure, and due to fugitive dust during Construction. Effects will likely be greatest during the Construction period in areas immediately adjacent to activities within or near Arctic Char habitat. Residual effects are expected to be of Low magnitude, confined to the LSA, and of moderate-term duration.

Key Issue #2: Effects on Arctic Char habitat

Construction and Operation activities in the Railway/Access Road LSA are expected to result in Low magnitude residual effects on Arctic Char habitat. Effects associated with access road stream crossings and construction camps will be short-term in duration, continuous and reversible. Effects associated with railway stream crossings and lake encroachments and effects of the Project on productive capacity will be of moderate duration, continuous and reversible.

Key Issue #3: Effects on direct mortality of Arctic Char

No residual effects related to direct mortality are predicted.

Significance of Residual Effects

The significance of residual effects of the Project on Arctic Char within the Railway/Access Road LSA is summarized in Table 7-4.21. Due to the low magnitude, limited spatial extent, and the reversible nature of the effects, no significant adverse effects are predicted.

Table 7-4.21 Significance of Potential Residual Environmental Effects on Arctic Char in the Railway/Access LSA

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Effects on Arctic Char health and condition	N	3	N/A	N/A
Effects on Arctic Char habitat	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

The Level of Confidence in the significance rating is High. While there is uncertainty relating to precise effects of the Project on water quality, a conservative approach was adopted for the assessment, which increases the confidence in the predictions. Effects on habitat were evaluated quantitatively through consideration of the area of affected habitat, the quality of the habitat, the presence and distribution of Arctic Char, and results of field surveys in potentially affected areas.

Steensby Port LSA

The predicted residual effects and significance of the Project on Arctic Char for the Steensby Port LSA are presented in Table 7-4.17 and Table 7-4.22, respectively, and summarized below.

Key Issue 1: Effects on Arctic Char health and condition

Project effects will result in a Low magnitude residual effect on Arctic Char health and condition due to changes in water quality related to aqueous non-point sources and dust. Residual effects will be short-term or moderate in duration, confined to portions of the LSA, and reversible.

Key Issue 2: Effects on Arctic Char habitat

Residual effects on habitat in the LSA, which include reduced productive capacity and habitat loss, are predicted to be of Low magnitude, reversible, of moderate duration, and confined to portions of the LSA.

Key Issue 3: Effects on direct mortality to Arctic Char

No residual effects resulting in direct mortality to Arctic Char are predicted.

Significance and Level of Confidence

Due to the low magnitude, limited spatial extent, and reversibility of residual effects, no significant adverse effects are predicted.

Table 7-4.22 Significance of Potential Residual Environmental Effects on Arctic Char in the Steensby Port LSA

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Effects on Arctic Char health and condition	N	3	N/A	N/A
Effects on Arctic Char habitat	N	3	N/A	N/A

KEY:
Significance Rating: S= Significant, N = Not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(2) Likelihood - only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

The Level of Confidence for the prediction of residual effects is High. Residual effects, significance, and overall Level of Confidence were based on results of baseline studies, which delineated the presence and distribution of Arctic Char and its habitat use in the LSA, and results of the water quality and quantity assessments. There are limited pathways of potential effects to Arctic Char in the Steensby Port LSA and residual effects are predicted to be confined to relatively localized areas. The use of a conservative approach and numerical effects thresholds provides additional confidence in the predictions.

4.5.9 Follow Up

4.5.9.1 Management and Monitoring Plans

Management plans, listed in Table 7-3.23, have been prepared for water management and the protection of water and sediment quality, thereby also providing mitigation for aquatic habitat and biota.

Table 7-4.23 Management and Monitoring Plans Applicable to Freshwater Biota and Habitat

Management Plan	Location
Air Quality and Noise Abatement Management Plan	Appendix10D-1
Emergency and Spill Response Plan	
Surface water, Aquatic Ecosystems, Fish and Fish Habitat Management Plan	Appendix 3B, Attachment 5
Wastewater Management Plan	Appendix 3B, Attachment 5
Waste Management Plan	Appendix 3B, Attachment 5
Borrow Pits and Quarry Management Plan	Appendix 3B, Attachment 6
Landfarm Design and Operation Plan	
Landfill Operating Manual	
Waste Rock Management Plan (includes contingency water treatment options for mine contact water)	Appendix 3B, Attachment 5

Table 7-4.23 Management and Monitoring Plans Applicable to Freshwater Biota and Habitat (Cont'd)

Management Plan	Location
Hazardous Materials Management Plan	
Environmental Protection Plan	
No Net Loss Management Plan	
Road Management Plan	Appendix 10D-8
Railway Management Plan	Appendix 10D-9

Detailed stormwater management plans, water balances and sediment and erosion control plans will be prepared during the detailed design phase as part of a future update to the Surface Water, Aquatic Ecosystems, Fish and Fish Habitat Management Plan. These will be important for the management of ore dust runoff at the Mine Site.

4.5.9.2 Environmental Effects Monitoring

An Environmental Effects Monitoring Framework (EEMF) is a component of Baffinland's EHS Management System (Appendix 10D-13). Within the EEMF are a series of Environmental Mitigation and Monitoring Plans (EMMPs) focused on valued ecosystem components.

Under the EEMF, EEMPs will be developed for water and sediment quality as follows:

- Monitoring of mining effluents under the MMER;
- Monitoring of sewage effluents as a condition of the Company's water licence;
- Monitoring of water quality in local drainages to confirm predictions of metals concentrations and compliance with TSS targets and metals;
- Monitoring of sediment quality in streams and lakes, the latter in accordance with guidance from Environment Canada for sampling of Arctic lakes with low deposition rates.

The MMER under the *Fisheries Act* stipulates a number of conditions under which a mine may release effluent into the environment. Mine operators are required to meet discharge limits as defined in Schedule 4 of the MMER. Further, there is a more general requirement for discharge of an effluent that is not toxic to aquatic life. Under the MMER, an Environmental Effects Monitoring (EEM) Program is to be designed, approved by Environment Canada and implemented to measure Project-related effects on fish populations, fish tissue and benthic invertebrates, thereby assessing the mitigation that was employed. Characterization of effluent quality, effluent toxicity, and receiving water quality will also be required.

Monitoring for habitat compensation site(s) - where applicable - once a decision is made regarding the Fish Habitat Compensation Plan for the Project. (See Volume 10, Appendix 10D-7 for a description of the proposed options for Fish Habitat Compensation.)

An Environmental Effects Monitoring plan (EEM) Framework, included as Appendix 10D-14, has been prepared as a starting point for the future development of an EEM Study Design. Baffinland looks forward to ongoing dialogue with Environment Canada to advance the development of the EEM.

4.5.9.3 Environmental Construction Monitoring and Followup

As described in Section 3.4.4.4, environmental monitoring will be relied on during Construction activities that have the potential to affect water and sediment quality. These construction activities tend to occur when

work is located in or around water or when surface materials are exposed. This form of monitoring helps to ensure effectiveness of mitigation measures and compliance with applicable water quality criteria. Monitoring for effects on water and sediment quality will provide the primary mechanism in monitoring for potential risks to aquatic biota. Followup during the Construction period may also include conduct of a salvage fishery, where required (e.g., stream crossing construction).

4.6 IMPACT STATEMENT

Summary of Significance

The Project will not have significant adverse residual effects on Arctic Char. The Project will cause residual effects across the five LSAs, but the effects will be confined to these areas or portions of these areas, the magnitude of residual effects is predicted to be Low or Medium, and effects are expected to be reversible.

Potential for Cumulative Effects

There is potential for cumulative effects resulting from residual effects of the Project in combination with other reasonably foreseeable activities, on the key indicator - Arctic Char. A cumulative effects assessment is presented in Volume 9, Section 1.

Prediction Confidence

There is a Moderate to High Level of Confidence in the assessment of effects on Arctic Char overall. Residual effects, significance and overall Level of Confidence for the key issues were based on results of baseline studies that delineated the presence and distribution of Arctic Char and their habitat use in the LSAs. Effects were assessed quantitatively to the extent possible and the assessment incorporated conservatism. Aquatic effects monitoring and adaptive management will be applied throughout the Project phases, which would serve to verify the impact predictions and to address uncertainty.

4.7 AUTHORS

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SECTION 5.0 - REFERENCES

1. AMEC 2012c. Interim Mine Rock ML/ARD Report, Mary River Project, January 2012.
2. AMEC. 2012a. Interim Waste Rock Stockpile Seepage Quality Model Report, Mary River Project. January 2012.
3. AMEC. 2012b. Interim Open Pit Water Quality Model Technical Memorandum, Mary River Project. January 2012.
4. Aplin, J.A. 1947. *The effects of explosives on marine life*. California Fish and Game 33: 23-30.
5. BAFFINLAND IRON MINES LICENSE 2BB-MRY0710, Nunavut Water Board.
6. Baroudy, E. and J.M. Elliott. 1994. *Tolerance of parr of Arctic char, Salvelinus alpinus, to reduced dissolved oxygen concentrations.* Journal of Fish Biology 44: 736-738.
7. Bovee, *et.al.* 1998, *Stream Habitat Analysis Using the Instream Flow Incremental Methodology: Biological Resources Discipline Information and Technology Report*. USGS/BRD-1998-0004, Viii +131 p.
8. Boward, D., P. Kazyak, S. Stranko, M. Hurd, and A.Prochaska. 1999. From the mountains to the sea: the state of Maryland's freshwater streams. U.S. Environmental Protection Agency, Office of Research and Development, EPA Report 903/R-99/023,Washington, D.C.
9. Canadian Council of Ministers of the Environment (CCME). 1999 updated to 2012. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg, MN.
10. Canadian Council of Ministers of the Environment. 1993. Guidance on the site-specific application of water quality guidelines in Canada: procedures for deriving numerical water quality objectives. Winnipeg, MN.
11. Canadian Council of Ministers of the Environment. 2003. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Winnipeg, MN.
12. Canadian Council of Ministers of the Environment. 2003. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Winnipeg, MN.
13. Canadian Council of Ministers of the Environment. 2007. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. Update 7.1. Winnipeg, Manitoba
14. Canadian Council of Ministers of the Environment. 2007. *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Winnipeg, Manitoba.
15. Canadian Council of Ministers of the Environment. 2011. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Winnipeg, MN.
16. Coker, C.M. and E.J. Hollis. 1950. *Fish mortality caused by a series of heavy explosions in Chesapeake Bay*. Journal of Wildlife Management 14: 435-444.
17. Craig, P.C. and P.J. McCart. 1975. *Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska, and the Mackenzie Delta, NWT, Canada*. Arctic and Alpine Research 7: 183-198.

18. Cronin, L.E. (Ed.). 1948. *Effects of underwater explosions on oysters, crabs and fish: a preliminary report*. Chesapeake Biological Laboratory, Publication No. 70.

19. Department of Fisheries and Oceans (DFO). 2010. *DFO protocol for winter water withdrawal from ice-covered waterbodies in the Northwest Territories and Nunavut*. June 21, 2010. 3 p.

20. Department of Fisheries and Oceans and British Columbia Ministry of Environment (BCMOE). 1989. *Fish habitat inventory and information program: stream survey field guide*. 33 p.

21. DFO (Department of Fisheries and Oceans Canada). 1986. Policy for the Management of Fish Habitat. Communications Directorate, Fisheries and Oceans Canada, Ottawa, Ont. Available at: http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/fhm-policy/index-eng.asp

22. DFO (Department of Fisheries and Oceans Canada). 1993. Land Development Guidelines for the Protection of Aquatic Habitat. Available at: http://www.dfo-mpo.gc.ca/Library/165353.pdf

23. Department of Fisheries and Oceans (DFO). 1998. Habitat Conservation and Protection Guidelines, Second Edition, developed from the Policy for the Management of Fish Habitat. Habitat Management and Environmental Science. 18 p.

24. DFO. 1995. *Freshwater intake end-of-pipe fish screen guideline*. 27 p.

25. Diavik Diamond Mines: Ammonia Management Plan, Version 2.0, http://www.mvlwb.ca/WLWB/Registry.aspx licence # W2007L2-003, title "AMP Version 2. Board Directive" Date: November 22, 2007). http://www.mvlwb.ca/WLWB/Registry/2007/W2007L2-0003/W2007L2-0003%20-%20AMP%20Version%202%20-%20Board%20Directive%20Nov01%2007%20-%20Nov27%2007.pdf)

26. Dillon Consulting (2008). *Hydraulics Design Criteria for Culverts and Bridges*. Baffinland Iron Mines Corporation, Mary River Project. Technical Memorandum. 13p.

27. Dodds, W.K., J.R. Jones, and E.B. Welch. 1998. *Suggested classification of stream trophic state: Distributions of temperate stream types by chlorophyll, total nitrogen, and phosphorus*. Water Research 32: 1455-1462.

28. Dumaresq, C. K Hedley, and R. Machebutte 2002. Overview of the Metal Mining Environment Effects monitoring program Water Quality Res J. Vol 37 No 1, 213-218).

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

30. Falk, M.R. and M.J. Lawrence. 1973. *Seismic exploration: its nature and effect on fish*. Technical Report Ser. No. CEN/T-73-9. Resource Management Branch, Fisheries Operations Directorate, Central Region, Winnipeg, Man. 5.

31. Ferguson, R.G. 1962. *The effects of underwater explosions on yellow perch (Perca flavescens)*. Canadian Fish Culturist 29: 31-39

32. Fitch, J.E. and P.H. Young. 1948. *The effects of explosives in California coastal waters*. California Fish and Game 34: 53-67.

33. Fudge, R.J.P. and R.A. Bodaly. 1984. *Post-impoundment winter sedimentation and survival of lake whitefish (Coregonus clupeaformis) eggs in Southern Indian Lake, Manitoba*. Canadian Journal of Fisheries and Aquatic Sciences 41: 118-125.

34. Gantner, N., D.C. Muir, M. Power, D. Iqaluk, J.D. Reist, J.A. Babaluk, M. Meill, H. Borg, J. Hammar, W. Michaud, B. Dempson, and K.R. Solomon. 2010. *Mercury concentrations in landlocked Arctic char (Salvelinus alpinus) from the Canadian Arctic. Part II: Influence of lake biotic and abiotic characteristics on geographic trends in 27 populations*. Environmental Toxicology and Chemistry 29: 633-643.

35. Gaspin, J.B. 1975. *Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay tests*. Technical Report NSWC/WOL/TR 75-58. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. 80 p.

36. Godard, D.R., Peters, L., Evans, R., Wautier, K., Cott, P.A., Hanna, B., and Palace, V., 2008. Development of histopathology tools to assess instantaneous pressure change-induced effects in rainbow trout (Onchorhychus myskiss) early life stages. Environmental Studies Research Funds Report #164. Winnipeg. 93p.

37. Government of Canada. 2010. Risk management strategy for mercury. October 2010. 44 p.

38. Health Canada. 2004. *Canadian Drinking Water Quality Guidelines*.

39. Health Canada. 2010. Guidelines for Canadian Drinking Water Quality. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum_guide-res_recom/index-eng.php

40. Houghton, J.P. and D.R. Munday DR. 1987. *Effects of linear explosive seismic energy releases on fish in Alaska's transition zones*. Final report. Prepared for the Alaska Oil and Gas Association by Dames and Moore, Anchorage, Alaska. 96pp + Appendices

41. Indrambarya, B. 1949. *Note on the effect of explosives on fish in Siamese coastal waters*. Thai Science Bulletin 6: 1-6.

42. Kearns, R.K. and F.C. Boyd. 1965. *The effect of a marine seismic exploration on fish populations in British Columbia coastal waters*. Canadian Fish Culturist 34: 3-26.

43. Knight Piésold Ltd. 2008. *Mary River Project, Estimated Time for Open Pit to Fill with Water (Deposit No. 1)* (Ref. No. NB08-00868). Report prepared for Baffinland Iron Mines.

44. Knight Piésold Ltd. 2011a. Baffinland Iron Mines Corporation – Mary River Project – Surface Water and Sediment Quality Baseline Report. Report Ref. No. NB102-00181/30-5, Rev.0, dated December 22, 2011.

45. Knight Piésold Ltd. 2011b. Development of Site Specific Water Quality Objectives for Application in the Final EIS Water Quality Assessment, Mary River Project. Technical Memorandum, Ref. No. NB11-00577, dated December 15, 2011.

46. Knight Piésold Ltd. 2012. Baffinland Iron Mines Corporation – Mary River Project –Baseline Hydrology Report. Report Ref. No. NB102-00181/30-7, Rev.1, dated January 4, 2012.

47. Knight Piésold. 2008. *Water Quality Baseline Report*.

48. Kroeker, K. 1986. *Steensby Inlet test fishery 1985 final report*. North/South Consultants Inc., Winnipeg, MB. 32 p.

49. Kroeker, K. 1987. *Report on the test fishery for Arctic Char, Salvelinus alpinus, in the Steensby Inlet Area, Northwest Territories, 1985-6*. North/South Consultants Inc., Winnipeg, MB. 31 p.

50. Linton, T.L., A.M. Landry Jr., J.E. Buckner Jr., and R.L. Berry R.L. 1985. *Effects upon selected marine organisms of explosives used for sound production in geophysical exploration*. The Texas Journal of Science 37: 341-353.

51. Lockhart, W.L., G.A. Stern, G. Low, M. Hendzel, G. Boila, P. Roach, M.S. Evans, B.N. Billeck, J. DeLaronde, S. Friesen, K. Kidd, S. Atkins, D.C.G. Muir, M. Stoddart, G. Stephens, S. Stephenson, S. Harbicht, N. Snowshoe, B. Grey, S. Thompson, and N. DeGraff. 2005. *A history of total mercury in edible muscle of fish from lakes in northern Canada*. Science of the Total Environment 351-352: 427-463.

52. McAnuff, L.A., M.V. van Bers, and A. Curic. 1994. *Environmental effects of marine blasting in Canadian game rivers. Proceedings of the Twentieth Annual Conference on Explosive and Blasting Techniques Jan 30-Feb 3, 1994, Austin, Texas*. International Society of Explosive Engineers.

53. McNeeley, R.N., V.P. Neimanis and L. Dwyer. 1979. *Water Quality Sourcebook - A Guide to Water Quality Parameters*. Inland Waters Directorate, Water Quality Branch, Minister of Supply and Services Canada.

54. Miller, M.C. and J.R. Stout. 1989. *Variability of macroinvertebrate community composition in an artic and subarctic stream*. Hydrobiologia 172: 111-127.

55. Muir, D., X. Wang, D. Bright, L. Lockhart, and G. Köck. 2005. *Spatial and temporal trends of mercury and other metals in landlocked char from lakes in the Canadian Arctic archipelago*. Science of the Total Environment 351-352: 464-478.

56. North South Consultants Inc. 2009. *Assessment of effects of sewage effluent discharge from the Mary River Mine Camp Site on water quality*. March 14, 2009.

57. North/South Consultants Inc (NSC). 2006. *Alberta standard watercourse crossing assessment protocol*. 17 p.

58. *Nunavut Land Claims Agreement*, Iqaluit Northwest Territories, May 25, 1993.

59. Oswood, M.W. 1989. *Community structure of benthic invertebrates in interior Alaska (USA) streams and rivers*. Hydrobiologia 172: 97-110.

60. Paterson, C.G. and W.R. Turner WR. 1968. *The effect of an underwater explosion on fish of Wentzel Lake, Alberta*. Canadian Field Naturalist 82: 219-220.

61. Peake, S.J.. 2008. Swimming performance and behaviour of fish species endemic to Newfoundland and Labrador: A literature review for the purpose of establishing design and water velocity criteria for fishways and culverts. Can. Manuscr. Rep. Fish. Aquat. Sci. 2843; v + 52p.

62. Poléo, A.B.S. and F. Bjerkely. 2000. *Effect of unstable aluminium chemistry on Arctic char (Salvelinus alpinus)*. Canadian Journal of Fisheries and Aquatic Sciences 57: 1423-1433.

63. Poléo, A.B.S., K. Østbye, S.A. Øxnevad, R.A. Andersen, E. Heibo, and L.A. Vøllestad. 1997. *Toxicity of acid aluminium-rich water to seven freshwater fish species: a comparative laboratory study*. Environmental Pollution 96: 129-139.

64. Read, C.J. 2004. *An assessment of the Arctic char population of Tugaat River, Nunavut*. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2699. 35 pp.

65. Roguski, E.A. and T.H. Nagata. 1970. *Observations on the lethal effect of under ice detonations on fish*. Alaska Department of Fish and Game Information Leaflet 139: 30 p.

66. Saffran, K. A. and D.O. Trew. 1996. *Sensitivity of Alberta Lakes to Acidifying Deposition. An Update of Maps with Emphasis on 109 Northern Lakes*. Water Management Division. Alberta Environmental Protection.

67. Sakaguchi, S., Fukuhara, O., Umeyawa, S., Fujiya, M., Ogawa, T. 1976. The influence of underwater explosion on fish. Bulletin of the Nansei Regional Fisheries Research Laboratory. Japan. 9:33-56.

68. Stewart, D.B. and G. MacDonald. 1981. *An aquatic resource survey of Devon, Cornwallis, Somerset and northern Baffin islands, District of Franklin, Northwest Territories, 1980*. Environmental Studies No. 20, Northern Environmental Protection Branch, Department of Indian Affairs and Northern Development, Ottawa. 84 p.

69. Sverdrup, A., E. Kjellsby, P.G. Kruger, R. Gloysand, F.R. Knudson, P.S. Enger, G. Serck-Hanssen, and K.B. Helle. 1994. *Effects of experimental seismic shock on vasoactivity of arteries, integrity of the vascular endothelium and on primary stress hormone of the Atlantic salmon*. Journal of Experimental Fish Biology 45: 973-995.

70. Teleki, G.C. and A.J. Chamberlain. 1978. *Acute effects of underwater construction blasting on fishes in Long Point Bay, Lake Erie*. Journal of the Fisheries Research Board of Canada 35: 1191-1198.

71. Thomson, J.A. 1958. *Biological effects of the Ripple Rock explosion*. Progress Reports of the Pacific Coast Stations Fisheries Research Board of Canada 111: 3-8.

72. US Environmental Protection Agency. 2006. *National Recommended Water Quality Criteria*. Office of Water, Office of Science and Technology. Washington, D.C. EPA-822-R-01-001, April 2001.

73. Wheatley, B. 1984. *Methylmercury in Canada: Exposure of Indian and Inuit Residents to methylmercury in the Canadian Environment*. Health and Welfare Canada, Ottawa, Ont., 164 p.

74. Wiley, M.L., J.B. Gaspin, and J.F. Goertner. 1981. *Effects of underwater explosions on fish with a dynamical model to predict fishkill*. Ocean Science and Engineering 6: 223-284.

75. Wright, D.G. 1982. *A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories*. Canadian Technical Report of Fisheries and Aquatic Sciences 1052: v + 16 p.

76. Wright, D.G. and G.E. Hopky. 1998. *Guidelines for the use of explosives in or near Canadian fisheries waters. Canadian Technical Report of Fisheries and Aquatic Sciences* 2107: iv + 34 p.

77. Wyatt, L.H., A.L. Baker, and D.L. Berlinsky. 2010. Effects of sedimentation and periphyton communities on embryonic rainbow smelt, Osmerus mordax. Aquat. Sci. 72: 361-369.

78. Yelverton, J.T., D.R. Richmond, W. Hicks, K. Sanders, and E.R. Fletcher. 1975. *The relationship between fish size and their response to underwater blast*. Defense Nuclear Agency, Dep. Defense, Wahington, D.C. Topical Rep. DNA 3677 T: 42pp.

Websites

1. Canadian Food Inspection Agency: http://www.inspection.gc.ca/english/fssa/fispoi/man/samnem/app3e.shtml; last accessed August 11, 2010
2. Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011. www.cosewic.gc.ca <http://www.cosewic.gc.ca/>
3. Species at Risk Act. 2011. http://www.sararegistry.gc.ca/

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SECTION 6.0 - DEFINITIONS AND ABBREVIATIONS

6.1 DEFINITIONS

100-Year Flood	A flood with a return period of 100 years. A 100-year flood does not refer to a flood that occurs necessarily once every 100 years, but to a flood with a 1 percent chance of being equalled or exceeded in any given year.
24-Hour Precipitation	The amount of precipitation falling within a specified 24-hour period.
2-Year Flood Benchmark	A flood with a return period of 2 years see 100-year flood.
Abundance	The total number of individuals, or the total amount of a resource (i.e. food, water, habitat) present in an area, population, or community. 'Absolute abundance' refers to the exact number present and 'relative abundance' refers to the relative number in one area compared to another area and is usually a less accurate estimate (i.e. an index of high, medium, low).
Acid Base Accounting	The acid-base accounting procedure measures the acid and alkaline producing potential of soil and rock in order to determine if, after disturbance, the waste material will produce acid and subsequently, leach metals.
Acid Deposition	A comprehensive term for the various ways acidic compounds precipitate from the atmosphere and deposit onto surface. It can include a) wet deposition by means of acid rain, fog and snow; and b) dry deposition of acid particles (aerosols)
Acid Rock Drainage	The generation of sulphuric acid when sulphide compounds in rock become exposed to oxygen and water.
Acidic	Any substance with a pH below 7.
Active Layer	Layer of ice, soil and rock which is subject to seasonal freezing and thawing above the true permafrost. In the region of Baffin Island in which the Project is located, the active layer is typically from 1 to 3 m thick.
Acute Toxicity	Mortality that is produced in test animals by contaminated water or sediment within a short period of exposure, usually 24 to 96 hours.
Adaptive Management	A management approach that continually updates and improves policies and practices by learning from previously employed policies and practices and/or from the result of research and monitoring.

Adaptive Management Plans	A systematic, rigorous approach for deliberately learning from management actions with the intent to improve subsequent management policy or practice.
Additive Effects	Effects that can be added to estimate the total net effect of several different activities. Additive effects occur at the same time in the same place.
Aerosol	Particles of solid or liquid matter that can remain suspended in air from a few minutes to many months depending on the particle size and weight.
Aggradation	To fill and raise the level of (the bed of a stream) by deposition of sediment , or, the process by which the upper surface of permafrost may be raised within an embankment fill.
Aggregate	Crushed rock from quarries as well as sand and gravel from borrow sources.
Aggregate Sites	Quarries and borrow sources.
Air	So called "pure" air is a mixture of gases containing about 78 percent nitrogen; 21 percent oxygen; less than 1 percent of carbon dioxide, argon, and other gases; and varying amounts of water vapour.
Air Pollutants	Amounts of foreign and/or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, and/or materials.
Air Quality Dispersion Model	A mathematical relationship between emissions and downwind air quality which simulates on a computer the plume rise, transport, dispersion, and transformation of compounds emitted into the air e.g. ISC3, AERMOD and CALPUFF.
Air Quality Modelling	To predict the potential fate and transport of Project-related air emissions at Milne Port (including ore haulage traffic), the Mine Site and Steensby Port (including railway operations).
Air Shed	A geographical area that shares the same air because of similar topography, meteorology, and climate. Air shed boundaries are often defined along political boundary lines.
Albedo	The fraction of light hitting an object that is reflected by that object or surface.
Alevin	Newly hatched, incompletely developed fish, still in nest or inactive on bottom, living off stored yolk.
Alkalinity	The amount of alkaline or base in a solution; often expressed in terms of pH.

Alluvial	Unconsolidated accumulation of stream-deposited sediments, including sand, silt, clay or gravels.
Ambient	Background conditions independent of specific activities; the qualities of the environment, especially with respect to physical factors such as temperature.
Amphidromous Fish	Fish that breed and over winter in freshwater but migrate out to the coastal waters for several months each summer to feed.
Amphipods	Small shrimp-like crustaceans (e.g., sand fleas). Many live or burrow in sediment, feed on algae and detritus, and are food for larger marine animals. Amphipods are commonly used in laboratory bioassays to test the toxicity of sediments.
Anadromous	A salmonid fish that move up rivers from the sea to spawn.
ANFO	Acronym for ammonium nitrate and fuel oil, a mixture used as a blasting agent in mines.
Anthropogenic	Caused by human activity.
Aquifer	A permeable material through which groundwater moves.
Area sources	An emission source associated with a surface or geographic area. This can include sources such as tailings ponds and storage piles.
Atmosphere	The gaseous mass or envelope of air surrounding the Earth. From ground-level up, the atmosphere is further subdivided into the troposphere, stratosphere, mesosphere, and the thermosphere.
Backfill	Unclassified soil, till, overburden or rock used to fill in an opening or depression.
Backwater	Water held back by a dam.
Baseline	Environmental settings in the Project area as they exist naturally or pre development, against which changes in the environment from a project can be assessed.
Baseline study/survey	A study/survey designed to establish baseline conditions against which the effects of a project can be compared.
Bathymetry	Measurement of the elevations of the sea bed, with respect to the top of the water.
Bedload	The material in movement along a stream bottom.
Bedrock	The more or less solid, undisturbed rock in place either at the ground surface or beneath surface deposits of gravel, sand or soil.

Benthic	Referring to organisms living in or on the sediments of aquatic/marine habitats.
Benthos/Benthic invertebrate	Animals without spines that live at the bottom of a body of water.
Best Practice Methods	A technique, method, process, or activity which conventional wisdom regards as most effective at delivering a particular outcome.
Bioaccumulation	The accumulation of contaminants in increasing concentrations in organisms higher up the food chain.
Bioavailable	The ease with which a material (i.e., a chemical) in the surrounding environment can be taken up by organisms. The environment may include water, sediment, suspended particles, and food items.
Biodiversity	The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are apart; this includes diversity within species, between species and of ecosystems.
Biomass	The mass of living matter present in a specific location or species.
Biophysical	All living organisms and the natural physical environment that sustains them (terrestrial, aquatic and atmospheric)
Biophysical assessment	Analysis of expected environmental effects on the physical and biological components of the environment; for example, air quality, aquatics, and wildlife on land and in water.
Biotite	A common phyllosilicate mineral within the mica group, more generally referred to as the dark mica series.
Bioturbation	The movement and relocation of bottom sediments by the activities of bottom-dwelling organisms.
Bivalve	A type of Mollusca with a hinged shell.
Bladder Tank Farm	Fabric fuel tanks situated in lined containment that are highly portable and can be constructed and filled very quickly.
Borehole	A hole drilled in rock, generally to be used for blasting purposes.
Borrow	Earth material (sand, gravel) taken from one location (such as a borrow pit) to be used for fill at another location (e.g., embankment material obtained from a pit when there is insufficient excavated material nearby to form the embankment).

Borrow Pit	Excavated areas used to provide low quality fill for construction activities such as roadbed building and landscaping. Fill of the type is usually removed from a nearby borrow pit and then compacted on the site as a base for other construction (DIAND, 1999)
Borrow Source	Source of sand and gravel.
Boulder	Rounded or subrounded particles greater than 256 mm in size.
Brackish	Slightly salty water (generally defined as having TDS of 1,000 to 10,000 mg/L).
Buffer Area	An area of undisturbed natural vegetation maintained between watercourses (and other sensitive areas) and activities such as right-of-way clearing and grubbing.
Bulk Sample	A large ore sample extracted as a test for the purpose of demonstrating the quality of an ore and/or the economic viability of mining the ore.
Camp	An archaeological site containing structural remains of habitation features and/or cultural materials suggestive of a variety of activities.
Catchment	A drainage basin.
Certainty	The level of confidence in the knowledge or analysis that supports the prediction, in particular with respect to limitations in overall understanding of the ecosystem, and limitations in the ability to foresee future events or conditions.
Channel Regime	Relationships among channel cross-section, gradient, discharge and sediment
Chironomids	True files, belonging to the midge family, Chironomidae.
Chiton	A member of the Mollusca phylum, related to snails, slugs and limpets. Chitons are invertebrates that resemble limpets.
Chronic Effects	Adverse effects on growth or reproduction of an organism due to long term exposure to sublethal contaminant concentrations.
Chronic Test	A bioassay (toxicity test) that examines sublethal (e.g., larval development) as well as lethal effects.
Chronic Toxicity	Toxicity marked by a long duration that produces an adverse effect on organisms. The end result of chronic toxicity can be death although the usual effects are sublethal (e.g., inhibiting reproduction or growth). These effects are reflected by changes in the productivity and population structure of the community.

Civil Works	Includes foundation preparations; earthworks and soil exchange; general site preparation and construction of temporary facilities; pre-stripping and removal of overburden in preparation for ore extraction; surveying; construction of roads, airstrips, the railway, bridges, tunnels, ports and buildings; drainage management including construction of ditches and ponds; and ore extraction at a rate of up to 3 Mt/a in the open pit
Cladocera	A group of small crustaceans called water fleas, which includes Daphnia.
Clay	Fine textured inorganic material less than 0.004 mm diameter.
Climate Change	Any long-term change in statistics of weather over periods of time that range from decades to millions of years. It can express itself as a change in the mean weather conditions, the probability of extreme conditions, or in any other part of the statistical distribution of weather. Climate change may occur in a specific region, or across the whole Earth. Climate change includes Global Warming.
Closure and Post-Closure Phase	Considered the period required for decommissioning and/or removing Project infrastructure.
Closure Plan	The plan incorporates progressive rehabilitation during the course of the Project to limit the work required after cessation of operations and to limit the environmental effects during the Project life. It addresses temporary and long-term closure as well as final cessation of operations. The main objective is to return the Project affected and viable sites (mine site, Milne Port and Steensby Port) to "wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and human activities"
Cobalt	A brittle hard silvery-white element that is a ferromagnetic metal: occurs principally in cobaltite and smaltite and is widely used in alloys.
Cobble	Bed or bank material between 64 and 256 mm diameter.
Colluvium	Surface soils and rocks that are loosened and transported down slopes by weathering and erosional processes.
Combined Effects	The sum of direct and indirect effects.
Combustible Wastes	Waste which can be incinerated.
Combustion	The act or instance of burning some type of fuel such as gasoline. Combustion is typically the process that powers automobile engines and power plant generators.

Community (ecological)	An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.
Concentrate	A processed material that contains higher concentrations of an element than were in the original ore.
Concentration	A measure of how much of a substance is in air, water or living tissue.
Concentrator	An industrial plant that removes rock from an ore, leaving a concentrate of the valuable minerals or metals. Further processing is required to recover the pure metal.
Conformance	Ensuring that all applicable Nunavut and Canadian laws, regulatory requirements, agreements, permits and licences are followed
Constraint mapping	A technique using GIS tools to identify areas suitable for an activity (e.g. placement of project infrastructure), base on identifying (and avoiding) areas of ecological sensitivity or certain terrain features.
Construction Phase	Defined by the length of the construction phase of the railway.
Consultation	Information exchange.
Consumers	The totality of animal organisms in a habitat, so-called because they feed on the organic matter already formed (e.g., the primary consumers on plant biomass, the secondary consumers on animal matter).
Contact Water	Water that comes into contact with the waste rock.
Contaminant	A substance that is not naturally present in the environment or is present in unnatural concentrations or amounts which can, in sufficient concentrations, adversely alter the environment.
Contaminated Sediment	Sediment that contains measurable levels of contaminants.
Continental Climate	A climate which is not moderated by proximity to a large water body, characterized by hot summers and cold winters.
Contingency Plan	A program intended to address malfunctions, accidents or unplanned events that may occur in connection with the Undertaking.
Continuous Emission Monitor (CEM)	A type of air emission monitoring installed to operate continuously inside of a smokestack or other emission source.
Continuous permafrost	A region has continuous permafrost if all land is covered by permafrost at some depth.

Copepod	Subclass of Class Crustacea of the Phylum Cnidaria. Important component of zooplankton. Takes in energy from phytoplankton and synthesizes it into food for fish, birds and mammals.
Copper	A malleable ductile reddish metallic element occurring as the free metal, copper glance, and copper pyrites that is used as an electrical and thermal conductor and in such alloys as brass and bronze.
COSEWIC	Committee on the Status of Endangered Wildlife in Canada is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada.
Critical Levels	The concentration of pollutants in the atmosphere above which direct adverse effects on receptors such as plants and ecosystems may occur according to present knowledge. Critical levels relate to direct effects on plant physiology, growth and vitality and are expressed as atmospheric concentrations or cumulative exposures over a given period of time.
Critical Load	A quantitative estimate of an exposure in the form of deposition for one or more pollutants, below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge. Critical loads relate to ecosystem structure and functioning and are expressed as annual depositions of mass or acidity. Typically, critical loads relate to the potential effects over periods of decades.
Crown Land	Land owned by the Federal Government, administered by Indian and Northern Affairs Canada within Nunavut.
Crustacean	One of a class (Crustacea) of arthropods that breathe through gills or branchiae and have a body commonly covered by a hard shell or crust (e.g., barnacles, crabs, shrimp and lobsters).
Cryoturbation	Movement of surficial materials by heaving and/or churning as a result of frost action.
Cumulative Environmental Effects	Cumulative effects occur when impacts on the natural and social environments take place so frequently in time or so densely in space that the effects of the individual events cannot be assimilated; or when the impacts of one activity combine with those of another in a synergistic manner. The additive effects of an Undertaking in combination with other undertakings or activities that have been or will be carried out.
Cut and Fill Operations	The process during earthworks construction of cutting or excavating high ground to fill lower ground, to make a level surface. Used to construct roads and laydown areas.

Dam Crest	The uppermost horizontal surface of a dam embankment.
Decant Water	Water that exceeds the amount that can be contained in a pond or basin: this excess water is usually pumped to another location and treated if required, before being discharged into the environment
Decline	A tunnel developed from surface at a shallow angle which interconnects underground levels at different elevations.
Decommissioning	The closing of a mine.
Dedicated Tank Cars	Rail cars used to transport diesel and Jet A fuels.
Definition Phase	Inclusive of all exploration and research programs, as well as the bulk sampling program carried out in 2007 and 2008.
Definitive Feasibility Study	See feasibility study. Definitive refers to the estimated level of accuracy of cost estimates - generally accepted to be +/- 15%.
Delta	An area at the mouth of a river where sediments accumulate in a broad plain that is usually exposed during low tide.
Demobilize Equipment	Remove equipment from a work area (for this Project from Baffin Island) and return back to the equipment owner's home.
Deposit	Any collection of earth material accumulated through the activities of water, wind, ice, or other agents.
Deposition	The sinking of material out of the water column or air and onto the bottom of the water body or land.
Detritivore	An organism that eats detritus.
Detritus	Unconsolidated material composed of both inorganic and dead and decaying organic material.
Development	Work carried out to access a mineral deposit and make ore extraction possible.
Development Proposal	Proposal to initiate the regulatory review of a project based on currently defined iron ore reserves.
Diabase	Fine-grained, intrusive, mafic rock, typically occurring in dykes.
Diadromous Fish	Fish that travel between salt and freshwater.
Diatoms	A major group of algae, and one of the most common types of phytoplankton. Generally unicellular, with some forming chains or simple colonies.
Diffusion Barrier	A layer of material such as sand or organic matter placed on top of submerged tailings to reduce the movement of metals from the tailings to the water level.

Direct Effects	Refers to changes in the VC that result from direct interactions between Project activities and the environment.
Direct Habitat Loss	The physical loss of habitat due to the Project footprint. Compare to Indirect Habitat Loss.
Direction and Nature (of an Effect)	The ultimate long-term trend of an environmental effect - positive, neutral or negative.
Discharge	The volume of water that passes a given location within a given period of time.
Dispersion	The gradual decrease in concentration of material with increasing distance from a source of emission. Dispersion is enhances by turbulence in the surrounding environment, and can be limited by deposition.
Dissolved Organic Carbon (DOC)	A measure of the amount of organic matter dissolved in a liquid; in terms of sediments, DOC typically refers to the organic carbon content of the interstitial water.
Dissolved Oxygen	The concentration of oxygen dissolved in the water, expressed in mg/L or as percent saturation, where saturation is the maximum amount of oxygen that can be dissolved in water at a given altitude and temperature, usually 10 mg/L.
Distribution	The boundaries or ranges within which individuals of a particular species are found.
Distribution (of an Effect)	The boundaries or ranges within which effects are found.
Disturbance	A Project related process that influences the behaviour, abundance, or distribution of individuals and/or populations.
Diversion facilities	Diversion facilities typically redirect water away from a construction site and return it to the natural channel.
Drainage basin	Watershed; area of land contributing runoff to a specified point.
Drawdown	The release of water from a reservoir for power generation, flood control, irrigation or other water management activity.
Dredgeate	Fill material originating from dredging.
Drift	A horizontal passage in a mine that follows a mineral vein.
Duration	The period over which an effect will occur.
Dust	Airborne particulate matter ranging in diameter from 10 to 50 microns. Dust can be emitted into air from anthropogenic sources and natural sources.
Dust Suppressants	Suppressants sprayed on the road to limit dust raised by vehicle traffic.

Dyke	A long and relatively thin body of igneous rock that, while in the molten state, intruded into cracks in older sedimentary rocks.
Dystric	An acidic soil, found mainly on coarse materials on acidic bedrock.
Echinoderms	Includes organisms from the phylum Echinodermata (e.g., sea urchins, sand dollars, sea cucumbers, starfish). These marine organisms are characterized by having radial symmetry, an exoskeleton with external spines and a water-vascular system.
Ecology	The study of the interactions between organisms and their environment.
Ecosystem	A dynamic complex of plant, animal, and microorganism communities and their abiotic environment interacting as a functional unit, usually within the certain set of boundaries (i.e. a coastal ecosystem, or a wetland ecosystem).
Ecosystem Approach	A holistic, interdisciplinary method of studying a system that seeks to integrate biophysical and socioeconomic factors with input from a variety of sources.
Ecosystem Integrity	The overall health of an ecosystem.
Ecosystemic	Relating to the complex of a natural community of living organisms and its environment functioning as an ecological unit in nature.
Ecozone	An area where organisms and their physical environment endure as a system.
Effects Assessment	An assessment of the environmental and socio-economic effects of a project, using accepted methodologies.
Effects Management measure	A measure used to help manage different environmental outcomes of a project, to prevent or limit negative effects or enhance positive ones.
Effluent	Liquid discharged as waste flow resulting from sudden rain or melting snow.
Emission Factor	The relationship between the amount of an emission produced and the amount of raw material processed, moved, burned, etc. By using the emission factor of a pollutant and specific data regarding quantities of materials used by a given source, it is possible to compute emissions for the source. This approach is used in preparing an emissions inventory.
Emission Inventory	An estimate of the amount of pollutants emitted into the atmosphere for mobile, stationary, area-wide and natural sources over a specific period of time such as a day or a year.

Emission/Effluent Rate	The rate at which a source releases contaminants into air/water.
Endangered	Any species, subspecies or geographically separate population The State of Canada's Environment 1997,<http://ww1.sid.ncr.doe.ca > of wildlife or plants that were formerly native to Canada, but which no longer exists anywhere (extinct) or no longer existing in Canada but occurring elsewhere (extirpated).
Endangered Species	A wildlife species that is facing imminent extirpation or extinction.
Engineered Landfill	A place to bury garbage and waste which has been designed to incorporate liners and other features to prevent the release of contaminants into the surrounding soil and groundwater.
Entrainment	The occasions when a large amount of water having particular properties (e.g. temperature and salinity) is trapped or carried within an even larger mass of water that has different properties.
Environmental Assessment	A planning process to predict the environmental effects of a proposed development before it is carried out.
Environmental Compliance Monitoring	Activities that are undertaken in order to ensure compliance with regulations, acts, permits and guidelines, the Environmental Management Plan, environmental protection plans, internal standards, or environmental policies. Monitoring also includes activities undertaken to ensure compliance with the terms or conditions of commitments or project agreements, such as the Impact and Benefit Agreements. Monitoring are activities undertaken by the proponent in order to demonstrate that the project operates within specific limits of environmental performance.
Environmental Components	Human, atmospheric, terrestrial, freshwater, and marine.
Environmental Effect	A positive or negative change in the biophysical and/or socioeconomic environment caused by or directly related to a proposed activity.
Environmental Effects Monitoring	The primary tool for achieving the goals of the Follow-up Program. An Environmental Effects Monitoring program includes the regular measurement of environmental variables in order to detect changes that are directly or indirectly attributable to the Project.
Environmental Impact Statement	A statement of an evaluation of the predicted environmental and socio-economic effects of a proposed undertaking or project.

Environmental Protection Plan	A plan that outlines project-specific environmental protection measures.
Environmental receptors	Living and non-living components of the environment that can absorb pollutants.
Environmental Sensitivity	Refers to areas of heightened sensitivity that will be identified where applicable in relation to the Project (i.e., areas sensitive to spills; caribou calving areas).
Ephemeral	Non-permanent.
Epibenthos	Animals that live on the surface of or above the sea floor.
Erosion	The breaking down and subsequent removal of either rock or surface material by wind, rain, wave action, freezing and thawing, and other processes.
Esker	A long winding ridge of sand and gravel, unrelated to the surrounding landscape. These ridges are formed as streambeds in or under glaciers, and are left as the glacier retreats.
Euphotic Zone	A zone near the water surface into which sufficient light penetrates for photosynthesis to take place.
Eutric	Soil with a B horizon with a pH of 5.5 or more.
Eutrophic	Nutrient-rich waters with high primary productivity.
evapotranspiration	The combined process of evaporation and of transpiration through vegetation.
Exceedance	A measured level of a substance, usually a pollutant, higher than the established standards.
Exfiltration	Refers to a loss of liquid from a system as the result of percolation or absorption into the surrounding soil.
Exotic	A species that has been moved beyond their natural range as a result of human activity.
Exploration	The act of searching a terrain for the purpose of discovering resources.
Exposure	The reaction between a chemical or physical agent and a living organism.
Extent (of an Effect)	The geographic area over which the interaction will occur.
Extent of Calving	The aggregate extent of all known annual calving grounds used during the peak of calving and the following 3 weeks.
Extralimital	Outside the normal range of a species or population.

Fast Ice	Stationary and thick sea ice that is present in the deep winter as coastal surface waters freeze with reduced winter air and water temperatures. It attaches to the shoreline.
Feasibility study	A technical analysis of the basic geology, operations, environmental considerations and economics of constructing and operating a mine.
Fecundity	Potential ability of an organism to produce eggs or young.
Federal Claims	Mining claims registered with the Federal Government Mining Recorders Office at Indian and Northern Affairs Canada.
Ferrous	Containing iron.
Filter Feeder	An aquatic animal that feeds on particles or small organisms strained out of the water. Includes most of the stationary feeders, such as clams, oysters, barnacles and sponges.
Final Closure	This occurs when the ore deposit is exhausted and requirements of the Mine Closure and Reclamation Plan have been completed.
Fine Ore	A smaller sized ore product, pea sized.
Fines	The fine-grained particles in stream banks and substrate.
First, Second and Third Order Streams	A first order stream is the main freshwater channel directly connected to salt water. A second order stream is the main channel of a tributary (from the confluence with the main channel). A third order stream is a branch of the main channel of a tributary.
Fish	Includes (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals (Fisheries Act, 2009)
Fish Entrainment	To pull or draw fish into water intake structures.
Fish Habitat	Spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. (Fisheries Act, 2009)
Flat	Tidal flats are formed in sediments which may be mudflats (accretional) or sand and gravel flats (erosional). Slopes are usually <5°.

Flotation	A common process in the concentration of minerals. When the various mineral particles have been ground sufficiently to allow separation from one to another and the gangue material, they are pumped in suspension to flotation cells. With the addition of certain chemicals and the passage of air through the suspension, the different mineral particles can be made to attach themselves selectively to the air bubbles to form a froth which is then skimmed from the remaining bulk of the suspension.
Flow	(a) The movement of a stream of water and/or other mobile substances from place to place. (b) The volume of water passing a given point per unit of time.
Flushing Rate	The rate at which the water in a water body is replaced by new water, determined by the rate of water inflow and outflow.
Fluvial	Produced by the action of a stream or river (e.g. sand and gravel deposits).
Follow-up Program	An on-going process to verify the accuracy if the environmental assessment of the undertaking and determine the effectiveness of migration measures. If either of these two steps identify unforeseen adverse impacts, then the existing mitigation measures should be adjusted or, if necessary, new mitigation or compensation measures should be developed.
Footprint	Area encompassing all physical project activities (e.g. dam, construction camp, access roads, and associated quarries and borrow areas).
Fork Length	Length of fish from snout to centre of fork in tail.
Fossil Fuels	Fuels such as coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.
Freeboard	The space or distance between the waterline and the top of an impoundment.
Frequency (of an Effect)	The number of times during a project or a project phase that an interaction or environmental effect can be expected to occur.
Freshet	A rapid temporary rise in stream discharge and level caused by heavy rains or rapid melting of snow and ice.
Fry	The young of fish.
Fuel Farm	A bulk fuel storage facility, consisting of multiple steel tanks within a lined containment area.
Fuel Tanker Cars	Rail cars used to transport fuel.

Fugitive Dust	Dust particles that are introduced into the air through certain activities such as soil cultivation, or vehicles operating on open fields or dirt roadways. A subset of fugitive emissions.
Fugitive Emissions	A source associated with an area rather than a distinct point of emission is known as a fugitive source. In addition, a fugitive emission source can be described as a source whose emission stream is not under the control of the facility between the point in which the contaminant is created (source) and the point where it is released into the natural environment (emission point).
Fyke net	A type of fishing net used in shallow nearshore waters. The basic fyke net design has two rectangular conduit frames, 5 steel hoops, two throats, and a 50 pound lead line.
Generator	An engine that uses oil, gasoline or diesel to produce electrical power.
Geochemistry	The study of Earth in terms of the earth and the physical and chemical processes responsible for it.
Geographic extent	Refers to the geographic location where the impact is predicted to occur; a local geographic extent is assigned if the impact is restricted to the LSA; a regional geographic extent is assigned if the effects extends beyond the LSA and into some part of the RSA; an extraregional geographic extent is assigned if the effect extents beyond the RSA.
Geographical Extent	Identifies whether the effect will be experienced in the smaller communities, in Iqaluit, or in both these areas.
Geology	The study of the rocks that compose the Earth.
Geomembrane Liner	A containment lining material with a very low permeability, installed within dams.
Geomorphology	The surficial features of the earth, their classification, description, origin, and relation of landforms to the underlying geologic structure.
Gillnets	Most common commercial fishing net that has floats along the top and weights on the bottom. It is named so because large fish that swim through the netting get caught by the gills when they try to back out.
Glacial Drift	Sedimentary material, consisting of clay and boulders that has been transported by glaciers.
Glacial Erratic	A piece of rock transported some distance from its original outcrop, carried by a glacier.

Glacial Landform	Landscape features that were originally formed by glacial action (i.e., eskers, kames, drumlins).
Glaciofluvial Deposits	Unconsolidated rock material deposited by meltwater streams flowing from glaciers.
Global Warming	An increase in the temperature of the Earth's troposphere. Global warming has occurred in the past as a result of natural influences, but the term is most often used to refer to the warming predicted by computer models to occur as a result of increased emissions of greenhouse gases.
Gossan	The rust-coloured capping or staining of a mineral deposit, generally formed by the oxidation or alteration of iron sulphides.
Gradient	The general slope of the land or the rate at which a physical or chemical measurement changes with distance.
Granodiorite	A type of intrusive igneous rock.
Granite	A coarse-grained (intrusive) igneous rock consisting of quartz, feldspar and mica.
Gravel	A mixture of pebbles and cobbles which also may include some interstitial sand; article size between 2 and 64 mm diameter.
Green tonne	A weight measurement of timber when freshly felled, usually before any natural or artificial drying has begun.
Greenhouse Effect	The warming effect of the Earth's atmosphere. Light energy from the sun which passes through the Earth's atmosphere is absorbed by the Earth's surface and reradiated into the atmosphere as heat energy. The heat energy is then trapped by the atmosphere, creating a situation similar to that which occurs in a car with its windows rolled up. A number of scientists believe that significant emissions of carbon dioxide and other gases into the atmosphere may increase the greenhouse effect and contribute to global warming.
Greenhouse Gases (GHGs)	Greenhouse gases are gases in the atmosphere that trap energy from the sun. Naturally occurring GHGs include water vapour, ozone, carbon dioxide (CO2), methane (CH4), and nitrous oxide (N20) (EC, 2008)
Ground Truthed	Data confirmed by field observations.
Groundwater	Underground water that has come mainly from the seepage of surface water and is held in the soil and in rocks.
Habitat	The place where a type of animal or plant lives and its surroundings, both living and nonliving; includes the availability of food and shelter.

Halocline	In oceanography, an abrupt change in water salinity in relation to depth.
Hardness	Water hardness is measured by the total amount of dissolved calcium salts, magnesium salts, iron, and aluminum. "Soft" water contains less than 17.1 mg/L of these compounds and elements while "very hard" water contains over 180 mg/L (Strauss 1995).
Harvest	The reduction of wildlife into possession, and includes hunting, trapping, fishing, as defined in the Fisheries Act, netting, egging, picking, collecting, gathering, spearing, killing, capturing or taking by any means (GC and TFN, 1993).
Haul Road	A road built to carry haulage trucks and other mobile equipment in and out of an open pit mine or quarry.
Hazardous Materials	Explosives or chemicals
Hazardous Substance	A substance that poses a potential threat to the environment and/or human health and safety if improperly used, handled, stored, transported or disposed.
Head Waters	A) The source and upper reaches of a stream; also the upper reaches of a reservoir. B) The water upstream from a structure or a point on a stream. C) The small streams that come together to form a river. Also may be thought of as any and all parts of a river basin except the mainstream river and main tributaries.
Heterogeneous Habitat	Non-uniform or varied habitat.
Holistic	An interrelated system perspective.
Humic	Soils developed in wet meadows and forest wetlands. Relating to, involving, containing, or typical of humus.
Humus	Soils located at or near the surface, formed from organic residues, either separate from of intermixed with, mineral material. A dark-brown organic component. Humus improves the water-retaining properties of soil, adds nutrients and makes it more workable.
Hydraulic Conductivity	Describes the ease with which water can move through soil pore spaces or rock fractures; and relates the amount of water that will flow through a unit cross-sectional area of aquifer under a unit gradient of hydraulic head.
Hydraulic Gradient	The change in groundwater pressures over a certain distance.
Hydraulic Head	A measure of the energy of groundwater per unit weight. Hydraulic head represents the pressure exerted by a fluid and is the sum of gauge pressure and elevation.

Hydrocarbon Contaminated Materials	Soil, water, ice, and snow contaminated by accidental oil spills.
Hydrocarbons	Any organic chemical compounds that consist entirely of carbon and hydrocarbon (e.g. gasoline and oil)
Hydrogeology	The study of the movement and characteristics of water contained within and between rocks under the Earth's surface.
Hydrograph	A graph showing discharge versus time.
Hydrology	The science that deals with water, its properties, distribution and circulation on or below the earth's surface.
Hydrometric Station	A definite location on a watercourse at which stream discharge measurements are obtained.
Hydrostatic	Relating to the pressure or equilibrium of fluids.
Ice Rich Soils	Soil with high ice content.
Ice-Free Season	The summer to early fall period when sea ice is at its minimum.
Igloolingmiut	Residents of Igloolik.
Igneous	A rock formed by the solidification of magma.
Impact and Benefit Agreements	Contractual agreements under negotiation between the Proponent and Aboriginal groups. The intent of these agreements is to make it possible to develop the Project in a way that respects Aboriginal rights and culture, provides socioeconomic benefits to nearby Aboriginal communities and addresses negative environmental, economic, and social impacts.
Impact Significance	Based on comparing the predicted state of the environment with and without the Project, and expressing a judgment as to the importance of the changes identified.
Impoundment	The collection of water by a reservoir or dam.
In situ	A description for something that is in its original location of confined to its site of origin.
Incineration	The main disposal method for combustible non-hazardous wastes generated on-site using an appropriately designed variable flow dual chamber incinerator, and ashes from the incineration process will be placed in closed drums and buried within a designated area of the landfill. It diverts putrescible waste from the landfill and thus prevents problems associated with odours which attract wildlife.

Indicator	Variables related to the biology of Valued Ecosystem Components that can be used to monitor the predicted adverse environmental effects of Project activities.
Indirect Effects	Refers to effects on the environment that are not a direct result of the Project.
Indirect Habitat Loss	The loss of habitat due to indirect alterations rather than direct physical alterations, that cause the habitat to no longer be suitable for use by individuals (loss of habitat functionality). Often caused by factors such as sensory disturbance. Compare to Direct Habitat Loss.
Inert	Not readily reactive with other elements.
Infaunal	Living within sediment.
Inferred Resources	Resources that have not been sufficiently investigated to warrant their inclusion in proven reserves used for economic evaluation of ore bodies.
Information	Flow from the company to stakeholder.
Innu Traditional Knowledge	The knowledge accumulated by the Innu through generations of living in close contact with nature.
Interaction	Relating key Project activities with valued components and key indicators.
Interstitial Water	The water within wet sediment that surrounds the sediment particles. The amount of interstitial water in sediment is calculated and expressed as the percentage ratio of the weight of water in the sediment to the weight of the wet sediment. Also referred to as pore water.
Intrusion	An igneous rock formed from the movement of magma from within the earth's crust into spaces in the overlying strata.
Inuit	Aboriginal peoples of northern Ontario Canada and Greenland.
Inuit Owned Lands	Means a) those lands that vest in the DIO [Designated Inuit Organization] as Inuit Owned Lands pursuant to Section 19.3.1 [of the NLCA], and b) any lands that are vested in, acquired by or re-acquired by the DIO as Inuit Owned Lands from time to time pursuant to the [NLCA], so long as they maintain such status pursuant to the [NLCA] (GC and TFN, 1993).
Inuit Qaujimajatuqangit (IQ)	Inuit traditional knowledge gained by individuals who have extensive experience in a geographic location and from personal observations rather than through scientific methods.

Inuit Qaujimaningit	(a) Inuit traditional knowledge and variations of Inuit Traditional Knowledge; (b) Inuit epistemology relating to: Inuit Societal values (including the legal obligations set out in the NLCA regarding Inuit Participation, Inuit employment and training, etc.); and Inuit knowledge (both contemporary and traditional).
Inuit-Owned Land	Land identified in the Nunavut Land Claims Agreement (NLCA) as being held by a designated Inuit Organisation. May include ownership of surface rights only or both surface and sub-surface (i.e. mineral) rights.
Inuktitut	Dominant language in Nunavut.
Inundation	The filling of a reservoir
Inversion	An abnormal condition in which the layer of air next to the Earth's surface is cooler than an overlaying layer.
Invertebrates	Collective term for all animals without a backbone or spinal column, such as insects, worms, clams and crustaceans.
In-Water Blasting	Specialized blasting under water.
Issues Scoping	The process of focusing an environmental assessment on a concise list of those components of the biophysical and socio-economic environment that are valued (socially, economically, culturally or scientifically) and of interest when considering the potential environmental effects of a project.
Kajjuqtikkut Workshop	A five-day workshop held in Arctic Bay on March 10-14, 2008, attended by members of the five Inuit Knowledge Study working groups. The key themes of transportation (marine and rail), caribou, marine mammals, and socio-economic issues were discussed and minutes recorded.
Key Indicator (KI)	A VEC might have a have a KI, which focuses the assessment to a finer level of the environment; in the case of the terrestrial environment, the finer level is often a species; in the socio-economic environment, it is often a component, such as employment.
Key Issues	Interactions that are of substantial public interest and/or of potentially high environmental importance or consequence and, consequently require rigorous investigation and analysis in the EIS.
Key Project components	Includes Milne Port, Milne Inlet Tote Road, Mine Site, Railway and Steensby Port facilities.

Labrador Inuit Land Claim Agreement	Designates Labrador Inuit Lands that are under the jurisdiction of Nunatsiavut Government. A larger area, known as Labrador Inuit Settlement Area (LISA) includes land and water areas extending into Lake Melville.
Lacustrine	Pertaining to, or living in, lakes or ponds.
Landfarming	Facility for the remediation of hydrocarbon contaminated soil, water, ice, and snow. The landfarms will be bermed and lined and consist of multiple cells to handle waste generated from several events separately. Soil remediation will occur through volatilization and natural biological processes and once hydrocarbon levels meet the applicable Nunavut remediation standards, the soil will be transferred to the landfill.
Landfast Ice	Sea ice that is anchored to the shore or ocean bottom.
Landfill	Used to dispose of only inert solid waste and ashes from the incinerator. Contents will remain permanently frozen and isolated.
Laydown Area	The place where equipment, supplies, and material are put before building begins.
LC_{50}	The median lethal concentration; the concentration of material in water to which test organisms are exposed that is estimated to be lethal to 50% of the test organisms after 96 hours.
Leaching	The process by which a liquid (e.g. water) passes through a substance, picking up some of the material and carrying it to other places. Leaching can occur underground in soil and rock, or above ground through piles of material.
Level of Confidence	Related to limitations in the overall understanding of the ecosystem and limitations in accurately foreseeing future events or conditions.
Likelihood	A parameter is assigned both a probability dimension as well as a level of certainty, to qualify significance rankings relative to the likelihood that the predicted effects will actually occur.
Limnology	Limnology is the study of the structural and functional interrelationships of organisms of inland waters as they are affected by their dynamic physical, chemical and biotic environments.
Linkage diagrams	A diagram that is used to depict cause and effect pathways.
Listed Species	Species listed by the federal or territorial government as being at some level of risk, such as extirpated or extinct, endangered, threatened, or of special concern.

Lithic	Anything related to stone.
Lithology	The physical characteristics of a rock, including colour, composition and texture.
Littoral	The shallow waters near the shore. Usually it is the region of a lake from the highest water level to the depth at which photosynthesis ceases.
Local Study Area	The study area that describes areas within and directly adjacent to the Project footprint, and that may be subject to direct and indirect effects. See Regional Study Area.
Long-Term Closure	The state of inactivity resulting from economic considerations or a reduction in ore reserves for a period greater than one year.
Lowest Observed Effect Concentration (LOEC)	The lowest concentration of a material used in a toxicity test that has a statistically significant adverse effect on the exposed population of test organisms as compared with the control or reference material.
Macroinvertebrate	The larvae of animals, such as insects and snails that occur underwater and form the basis of the freshwater food chain.
Macrophyte	A macroscopic photosynthetic organism growing submerged, floating, or emergent in the water.
Magazine	A building that stores explosives.
Magnitude (of an Effect)	The amount or degree of change in a measurable parameter or variable relative to existing conditions (the exposed population).
Management Plan	A document that sets goals and objectives for maintaining sustainable population levels of one or more species that are particularly sensitive to environmental factors, but which are not in danger of becoming extinct.
Management Required	Active intervention is required to bring the effect to an acceptable level.
Marine	Refers to oceans and seas as opposed to freshwater.
Mary River Project Components	The main project development areas including Milne Port, Milne Inlet Tote Road, Mine Site, Railway and Steensby Port.
Maximum Point of Impingement	A location in the environment where the centreline of a contaminant plume first impacts the terrain or a receptor.
Mean	The sum of the values of the variable divided by the number of values.
Mean Annual Discharge	The mean annual flow of a river.
Mean Annual Flow	The mean annual flow of a river.

Meander	A winding course, curves or bends as in a river.
Measurable Parameters	Clearly defined aspects of an indicator (VEC/VSEC) that can be quantified and compared against a baseline value or condition; has an associated performance level or standard that can establish an effect magnitude or indicate compliance with formal standards.
Median	The middle value in a population distribution, above and below which lie an equal number of individual values; midpoint.
Method Detection Limit (MDL)	The smallest concentration of an analyte in a given matrix determined by a given method that has a 99% confidence that this value is not zero.
Microclimate	The weather variations in a very local area; the atmospheric conditions affecting an individual or small group of organisms, especially when they differ from the climate of the rest of the community.
Microhabitat	The smallest part of the environment that supports a distinct flora and fauna, such as a fallen log in a forest.
Mineral	An inorganic, homogeneous substance that occurs naturally in the earth. It has a definite chemical makeup and usually appears in crystal or grain form. It may or may not have economic value.
Mitigation	The elimination, reduction or control of the adverse environmental effects of the Undertaking, including restitution through replacement, restoration, rehabilitation, compensation or any other means [MOU].
Mitigation Measures	Management actions or strategies applied to minimize or eliminate negative environmental effects. They are also used to reduce or eliminate the potential residual effects of the Project and are identified in each of the effects assessments, along with potential residual effects of the Project.
Monitoring	Systems that will be put into place to document the adequacy of each mitigating action in reducing impacts to insignificant levels.
Moraine	An accumulation of material (typically sand, gravel or rock) that has been transported by ice (commonly glaciers).
Morphometry	Measurement of the shape or form of a feature.
Mysid	A member of the shrimp family often referred to as opossum shrimps.

Natural Variation	Measurable change in an environmental indicator or variable (i.e. number of individuals in a population, or number of species in a community) that occurs from natural processes such as population cycles, and are not a result of human induced disturbance(s).
Negotiation	Face-to-face discussions with the intent of reaching agreement.
Nickel	A malleable ductile silvery-white metallic element that is strong and corrosion-resistant, occurring principally in pentlandite and niccolite, and used in alloys.
Nitrate	A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and that can have harmful effects on humans and animals.
Nitric Oxide (NO)	Precursor of ozone, NO2, and nitrate; nitric oxide is usually emitted from combustion processes. Nitric oxide is converted to nitrogen dioxide (NO2) in the atmosphere, and becomes involved in the photochemical processes and/or particulate formation.
Nitrite	A chemical compound produced when ammonia in wastewater is oxidized by bacterial or chemical reactions and ultimately becomes nitrate.
No Observed Effect Concentration (NOEC)	The highest concentration of a material used in a toxicity test that has no statistically significant adverse effect on the exposed population of test organisms as compared with the control.
Non-Acid Generating (NAG)	Classification of excavated rock, assessed based on various tests and sulphur content, as having negligible potential for acidic drainage and associated metals leaching.
Non-Contact ("Clean") Water	Water that does not comes into contact with the waste rock.
Non-Reversible	Effect will not be reversed.
Not Detectable	Below the limit of detection of specified method of analysis.
Nunavummiut	The indigenous inhabitants of Nunavut.
Nursery Habitat	Areas used by developing embryos and young of the year occurring at a depth below average ice thickness.
Oligotrophic	Nutrient-deficient waters with low primary productivity.
Open Pit Mine	A mine working or excavation open to the surface, used to recover mineral reserves near surface.
Operation Phase	Open pit mining of iron ore in Deposit No. 1 and the related processing and transportation of the iron ore.

Ore	Mineralized rock which can be mined and processed at a profit.
Organic	A substance derived from animal or plant matter.
Osmoregulation	Physiological activity within an organism that serves to maintain the internal salt and fluid balance within a narrow acceptable range.
Otoliths	A calcified structure used as part of the balance system in bony fish. The mineral structure changes over time and annual banding can be seen in the otolith allowing scientists to estimate the age of the fish.
Outwash	Coarse soil material, mainly sand and gravel, removed or "washed out" from a glacier by melt-water streams and deposited near the ice.
Outwash terrace	A flat or gently sloping landform of glacial debris variably sorted by meltwater.
Overall Significance (of an Effect)	Derived from the experience and professional judgment of the environmental practitioners who prepared the assessment, considering the rankings of the contributing attributes of significance.
Overburden	Soil, till or rock that is located over areas proposed for development as open pit mines or quarries. Overburden must be removed prior to mining.
Ovoid	The main orebody at Voisey's Bay.
Oxidation	Chemical attachment of free oxygen to other elements and compounds. Also a type of chemical weathering.
Packaged Explosives	Explosives that are packaged to be ready to use after detonators are applied.
Particulate Matter (PM)	Any material, except pure water, that exists in the solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, windblown dust particles to fine particle combustion products.
Pathway	A conduit.
Pebbles	A rounded or subrounded rock fragment, generally rounded by abrasion, larger than a granule and smaller than a cobble; it has a diameter in the range of 4 to 64 mm, or a size between that of a pea and tennis ball.
Pelagic	Used to describe those animals or plants living in the mass of the water column in a lake, ocean or sea (as opposed to those living on or near the bottom).

Periphyton	Very small plants that live attached to a surface in freshwater but do not move around.
Permafrost	Ground (rock and/or soil) remaining at or below 0°C continuously for at least 2 years.
Permeability	The ability of a rock or earth to transmit water.
Persistent Organic Pollutants	Chemical substances that persist in the environment, bio-accumulate and cause adverse effects to human health and the environment.
pH	A measure of the acidity or baseness of a liquid. The measurement range is from 0, for the most acidic, to 14, for the most base. Lemon juice is 2.4, blood is 7, and lye is about 13 on the scale (Strauss 1995).
Phreatic	Relating to groundwater occurring below the water table.
Physical Environment	Includes climate, air, noise, water, waste rock characterization, soils, and the physical aspects of archaeology.
Phytoplankton	Small floating plant life in aquatic ecosystems, predominantly microscopic.
Piezometer	A instrument for measuring pressure head, ranging from simple standpipe to devices using electrical or pneumatic transducers, and typically installed within boreholes or during construction of major geotechnical structures such as dams.
Pit Dewatering	Removal of water from an open pit that might result from groundwater inflows or precipitation.
Pit Lake Quality Modelling	To predict the long-term quality and ecological risk posed by the post-closure pit configuration.
Plume	A visible or measurable discharge of a substance from a given point of origin. Plumes may occur in water or air.
Point Sources	Specific points of origin where pollutants are emitted into the atmosphere or natural environment.
Polishing and Waste Stabilization Pond	Place for sludge disposal and discharge of treated effluent.
Polychaete	Any aquatic annelid worm of the Class Polychaeta, having numerous bristles on the fleshy lobes of each body segment.
Polycyclic Aromatic Hydrocarbons (PAHs)	Organic compounds which include only carbon and hydrogen with a fused ring structure containing at least two benzene (six-sided) rings. PAHs may also contain additional fused rings that are not six sided. The combustion of organic substances is a common source of atmospheric PAHs.

Post-Closure Monitoring Program	Program to ensure the reclamation measures remain effective and continue to provide a high level of protection for the public and the environment.
Post-Decommissioning	The time after which an operation has closed and equipment and facilities have been removed from the site.
Post-project Audit	An evaluation occurring after a development which assesses the environmental and social impacts of a project and the mitigation measures applied to them.
Potential Development Areas	A boundary established to encompass a Project component, where future development is expected to occur.
Potential Effects	Refers to potential changes in the VC that result from interactions between Project activities and the environment.
Potentially Acid Generating (PAG)	Classification of excavated rock, assessed based on various tests and sulphur content, as having significant potential for acidic drainage and associated metals leaching.
Precautionary Principle	Where there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to prevent environmental degradation
Pre-Commissioning Activities	Activities which will be carried out prior to mine commissioning (start-up).
Prestripping	The removal of uneconomic materials to facilitate mining of orebodies.
Primary Production	The amount of organic matter produced by photosynthesis within a defined ecosystem.
Probability	The likelihood that an interaction and a consequent effect will, in fact occur.
Probable Maximum Flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur.
Probable Maximum Precipitation (PMP)	Highest precipitation considered to be physically possible under known climatic conditions.
Productivity	In general, the increase of biomass concentration per unit of time.
Project Footprint	Areas of direct disturbance and habitat loss due to Project facilities, roads and other infrastructure.
Proponent	The organization, company, or department planning to undertake a proposal.

Pyrite	A common yellow mineral with a brilliant metallic lustre; the most widespread and abundant of all the sulphide minerals.
Qualitative Analysis	A non-numerical estimation of the magnitude of an effect.
Quality Assurance (QA)	The total integrated program for assuring the reliability of monitoring and measurement data. A system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements.
Quality Control (QC)	The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process. Included are standardization, calibration, replicates, and control and check samples suitable for statistical estimates of confidence of the data.
Quantitative Analysis	Use of numbers to estimate the magnitude of an effect.
Quarry	An open or surface working usually developed for the extraction of building stones, aggregate, limestone and other industrial minerals.
Rating Curve	A drawn curve showing the relation between gage height and discharge of a stream at a given gauging station.
Reagent	A reagent is a substance used in a chemical reaction to bring about a chemical change.
Rearing Habitat	Areas used by sub-adult fish other than young of the year for foraging and refuge occurring at all water depths.
Reasonably Foreseeable Future Development	Projects or activities that are currently under regulatory review or that will be submitted for regulatory review in the near future, as determined by the existence of a proposed project, letter of intent, or any regulatory application filed with an authorizing agency
Receiving Stream	A stream into which another empties.
Receptor	A theoretical location used for modeling purposes at which the model calculates a given contaminant concentration.
Recharge Area	A region receiving water, defined by downwards moving flow.
Reclaim Water Barge	A small boat used to take water from a sedimentation pond or tailings pond and reuse the water elsewhere in the mine operations.
Reclamation	The restoration of a site after mining or exploration activity is complete. In addition to removing buildings and other infrastructure, reclamation often involves contouring the land, tree-planting, and converting the open pit into a pond.

Redox Conditions	A measure of electron activity of an environment (i.e., sediments); high redox conditions mean oxygen-rich environments, low redox conditions mean oxygen-poor environments.
Reference Sediment	A field-collected or a laboratory-generated sample of sediment relatively free of contaminants (i.e., "clean" sediment) representing the test (contaminated) sediment in all possible characteristics. Test organisms should be able to survive in reference sediment with little if any adverse effects. Used in bioassays to determine the response of the test organism to similar sediment in the relative absence of the contaminant (s) of concern.
Refugia	An area that has escaped ecological changes occurring elsewhere, and so provides a suitable habitat for relict species.
Regional Study Area	The study area that describes the Project's regional context that may be subject to indirect effects as well as areas that could function as control areas beyond the range of Project impacts.
Relative abundance	An estimate of the number of individuals within an area relative to the number of individuals within a larger area.
Renewable Resources	Natural resources that can be replenished as long as they are not exploited in excess or destroyed (e.g. wildlife, plants, fish).
Reproductive Sink	Areas where reproductive attempts are high but reproductive success is low which can contribute to a population's overall decline.
Reserves	The part of the reserve base which could be economically extracted or produced.
Residual Effects	Effects that remain in a system or population after all mitigation attempts have been made to try to minimize impacts.
Return Period	An annual maximum even has a return period (or recurrence interval) of T years if its magnitude is equalled or exceeded once, on the average, every T years. The reciprocal of T is the exceedance probability of the event, which is the probability that the event is equalled or exceeded in any one year.
Reversibility	The likelihood that a VEC/VSEC or Indicator will recover from an environmental effect, including consideration of active management techniques. Reversibility is considered for biological VECs at the population level. Therefore, although an effect like mortality is irreversible, the effect at the population level might be reversible.

Riffle	Shallow areas in a stream or river section characterized by increased habitat heterogeneity, sediment size, stream velocity, and sometimes oxygen content.
Rip Rap	A loose assemblage of large and durable broken stones, used for protection against erosion.
Riparian	Inhabiting or situated on the bank of a river.
Rotary Dumper	3 cars are turned upside down simultaneously to empty the ore into unloading bins, without any requirement to uncouple the cars from the rest of the train.
Royalties	Usage-based payments made by one party and another for ongoing use of an asset.
Runoff	The water that flows along the surface into water bodies, rather than being absorbed by soil.
Runoff coefficient	The ratio of runoff to precipitation or snowmelt.
Run-of-Mine	This term applies to mined ore prior to it undergoing crushing or any other form of processing and treatment.
Salinity	Refers to the concentration of dissolved salts present in a quantity of water.
Sand	Particles with size between 0.0626 to 2 mm diameter.
Schedule 1	Under Canada's Species at Risk Act (SARA), is the official list of species that have been designated by COSEWIC as being extirpated (extinct in Canada), endangered, threatened, or of special concern and are officially protected by SARA regulations.
Schedule 2	Under Canada's Species at Risk Act (SARA), species that have been previously designated as being extirpated (extinct in Canada), endangered, threatened, or of special concern, but have yet to be re-evaluated by COSEWIC under new SARA criteria and are not currently protected by SARA regulations. Once these species have been re assessed, they may be considered for inclusion in Schedule 1.
Schedule 3	Under Canada's Species at Risk Act (SARA), species that have been previously designated as being of special concern, but have yet to be re-evaluated by COSEWIC under new SARA criteria and are not officially protected by SARA regulations. Once these species have been re assessed, they may be considered for inclusion in Schedule 1.
Scoping	A process used to determine the scope of issues to be addressed.

Scoping Sessions	Public meetings where all relevant issues and concerns related to a proposed project or activity are identified.
Scrubber	An air pollution control device that uses high-energy liquid spray to remove aerosol and gaseous pollutants from an air stream. The gases are removed either by absorption or chemical reaction.
Secchi depths	A measurement of the turbidity of surface water. The depth at which a Secchi Disk can no longer be seen.
Sediment	Material, such as sand or mud, suspended in or settling to the bottom of a liquid. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities, such as forest or agricultural practices, or construction activities. Some contaminants tend to collect on and adhere to sediment particles.
Sedimentation	Sinking to the bottom of suspended matter carried in water.
Sedimentation Pond	A pond where water from mine and mill operations is put so that impurities (dirt and grit) can sink to the bottom of the pond.
Seismicity	The phenomenon of earth movements, in extreme cases in the form of earthquakes, and their geographic distribution.
Sequence Batch Reactor	A fill-and-draw activated sludge system for wastewater treatment. Wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged.
Sessile	An organism that moves very little (e.g., mussels).
Shareholders	One who owns shares of stock in a corporation.
Significance Evaluation	An evaluation of the "significance" of environmental effects.
Significant	Significance is a consideration of the context of the project and the intensity of adverse effects, by giving particular regard to the following: (a) the environmental sensitivity of the geographic area likely to be affected by the project; (b) the historical, cultural and archaeological significance of the geographic area likely to be affected by the project; (c) the extent of the effects of the project, including the geographical area that will be affected, the size of the affected human populations, and the size of the affected wildlife populations and related habitat; (d) the extent of the effects of the project on other regional human populations and wildlife populations, including the extent of the effects on Inuit Harvesting activities; (e) the magnitude and complexity of adverse effects; (f) the probability of adverse effects occurring;

	(g) the frequency and duration of adverse effects; (h) the reversibility or irreversibility of adverse effects given past, present and future relevant events; and (j) any other factors NIRB considers relevant to assessing significance (NIRB, 2007).
Silt	Muddy deposits of fine sediment usually found on the bottom of lakes.
Snow water equivalent (SWE)	The depth of water that would result if the snow depth at a given location melted.
Spatial Boundaries	The anticipated zone of influence of project effects.
Spawn	To produce or deposit eggs.
Spawning Habitat	Areas used by fish for the specific act of spawning, occurring at a depth below average ice thickness.
Speciation	The set of all concentration values for the various chemical compounds present in a system.
Species at Risk	Species at Risk includes a) those species listed on Schedule 1 of the Species at Risk Act (SARA), b) species assessed as "at risk" by the committee on the Status of Endangered Wildlife in Canada (COSEWIC), and c) species with territorial, regional, or local "at risk" status.
Species Diversity	A relative index describing the number of species found in an area and their relative abundance. Compare to Species Richness.
Species of Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats, and/or a species for which very little information is available.
Species Richness	The number of unique or different species in a community of individuals.
Spontaneously Reversible	Effect reverses with no intervention within an acceptable time frame.
Stage	Water level in terms of height above a given datum.
Staging	The tendency for migrating birds (particularly waterfowl) to congregate in areas where food is abundant in order to replenish energy lost during migration.
Stakeholder Engagement	Activities that engage stakeholders in the project, or in the review of the project.

Stakeholders	The Inuit communities proximate to the Project sites the public, local and regional Inuit organizations, the Government of Nunavut, and federal agencies with a mandate relevant to the Project.
Standard Deviation	A measure of the variation of a set of data in terms of amounts by which the values deviate from their mean.
Steady-State	The condition of a system when some or all of the quantities describing it do not change over time.
Stream flow	The water discharge that occurs in a natural channel at a given place and time, whether or not affected by diversion or regulation.
Stream gauge	Device to measure streamflow.
Subaqueous	Occurring, appearing, formed or used underwater.
Subarctic	Areas with discontinuous permafrost, including taiga or boreal zones.
Subjects of Note	Interactions are those that are less likely to be of notable environmental importance or consequence.
Sublethal	Concentration levels below that which will kill fish, but may affect other life stages.
Substation	A small pumping station that re-pumps water that is moving over a large distance.
Substrate	The base on which an organism lives.
Sulfur Oxides	Pungent, colourless gases formed primarily by the combustion of sulfur-containing fossil fuels, especially coal and oil. Considered major air pollutants, sulfur oxides may impact human health and damage vegetation.
Sump	A pit or reservoir serving as a drain or receptacle for liquids.
Supernatant	The liquid in the tailings or other polishing ponds after precipitation of insoluble solids, and sedimentation of suspended solids.
Surface Runoff	That part of the runoff that travels over the ground surface to the nearest stream without passing beneath the surface.
Surge Pond	A pond for temporary storage of overflow water.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Synergistic	Acting together.

Synergistic Effects	Effects that occur from different activities but the effects combine to cause a completely new effect or an effect that is larger (or smelter) then if the bold effect were added (see additive effects). Synergistic effects do not always occur when more than one activity happens.
Taxa	Plural of taxon or taxonomic unit. A grouping of organisms.
Temporal Boundaries	The period analyzed within which the Project or Project activities interact with environmental or socioeconomic components.
Temporary Closure	The planned shutdown of a mine site for a period of less than one year.
Temporary Infrastructure	Infrastructure constructed or positioned at Project sites needed only for the construction phase will be removed once construction is complete.
Thaw Sensitive Ground	They are typically "ice rich" or at least contain a small amount of ice. Depending on the grain size and subsequently the permeability of a soil, even soils that are just borderline ice rich can be thaw sensitive if they are fine grained in nature (i.e. have a low enough permeability).
Thermal stability	The degree to which something, such as permafrost, has the capacity to remain at the same temperature over time.
Thermocline	Temperature gradient or layer of water where temperature changes rapidly with depth.
Thermoregulate	The ability of a mammal to regulate its body temperature.
Threatened Species	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Threshold	Specified limits of acceptable change to measurable parameters, beyond which adaptive management is implemented. See Indicator and Adaptive Management.
Threshold Concentrations	The concentration of a chemical or other material below which no adverse effect occurs or is expected to occur.
Timing	The Project Phase within which the environmental effect will occur.
Total Dissolved Solids (TDS)	A measure of the combined content of inorganic ionized constituents in a liquid.
Total Organic Carbon (TOC)	A measure of the total amount of organic matter present in a sample. The sum of all carbon of organic origin in a sediment sample. The amount of organic carbon in sediment; usually expressed in % dry weight of sediment.

Total Suspended Particulate	The total quantity of suspended matter in a solution.
Total Suspended Solids (TSS)	The organic and inorganic material left on a standard glass fibre filter (0.45 micrometers) after a water sample is filtered through it.
Toxic Substance	A poisonous substance.
Toxicity	The inherent potential or capacity of a material to cause adverse effects (lethal or sublethal) in a living organism. Toxic effects are a result of concentration and exposure time, and are modified by variables such as temperature, chemical form and availability.
Toxicity Test	The means by which the toxicity of a chemical or other test material is determined. A toxicity test is used to measure the degree of response produced by exposure to a specific level of stimulus (or concentration of chemical).
Transboundary Impacts	Any impact, not exclusively of global nature. Within an area under the jurisdiction of a Party caused by a proposed activity, the physical origin of which is situated wholly or in part within the area under the jurisdiction of another Party (UN, 1991).
Transect	Surveyed area along a line flown during aerial surveys.
Transmission Line	A device designed for the transmission of electric power. Transmission lines are either overhead, where conductors are suspended from structures, or are composed of buried or submarine cables.
Transportation Corridor	The general routing for an area containing a road (winter or permanent), a pipeline, transmission line or any combination of the three, within Nunavut but outside community boundaries (NPC, 2000). In the current context, routings or tracts utilized for regular marine shipping activities are also considered to be transportation corridors.
Treatment Facility/Plant	A place where water is partially cleaned before it is sent into the environment.
Trophic Levels	Functional classification of organisms in an ecosystem according to feeding relationships.
Turbidity	A measure of the extent to which light passing through water is reduced due to suspended materials.
Undercatch	That portion of the precipitation that is missed by a precipitation gauge due to wind, evaporation etc.

Ungulate	A wide taxonomic group of hoofed mammals (e.g. caribou and muskoxen).
Units	See Measurement Units.
Upwelling	The process which water rises from a lower to a higher depth, usually as a result of divergence and offshore currents. It influences climate by bringing colder water to the surface. The upwelled water, besides being cooler, is richer in (plant) nutrients.
Value	The value attached to the affected VEC or VSEC by those who identified them. An environmental or socio-economic component was identified as "valued" and was addressed in the EIS if it was found to have a high value to communities.
Valued Components (VCs)	VCs identify key species or topics to focus the effects assessment. NIRB (2007) distinguishes between valued ecosystem components (VECs) as the VCs of the biophysical environment, and "valued socio-economic components" (VSECs) relating to the human, economic, and spiritual environment.
Valued Ecosystem Component (VECs)	Environmental attributes or components perceived to be locally important based on local ecological, social, cultural, and/or economic reasons.
Valued Socio-Economic Components (VSECs)	Those aspects of the socio-economic environment considered to be of vital importance to a particular region or community, including components relating to the local economy, health, demographics, traditional way of life, cultural well-being, social life, archaeological resources, existing services and infrastructure, and community and local government organizations (NIRB, 2007)
Volatile Organic Compounds (VOCs)	Carbon-containing compounds that evaporate into the air (with few exceptions). VOCs contribute to the formation of smog and/or may themselves be toxic. VOCs often have odour, and some examples include gasoline, alcohol, and the solvents used in paints.
Volume Source	An emission source associated with a volume rather than a surface or a point. These can include fugitive emissions from a building.
Vulnerable	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Waste Management Handling Facilities	A central depot where waste generated across the site will be managed, properly processed, packaged, labelled, inventoried, secured (e.g., on pallets) and stored for sealift or reuse on site.
Waste Rock	Barren rock or rock too low in mineral content to be mined or processed economically.
Water Column	The mass of water that lies between the surface and seabed or lakebed. The depth of the water column can range from a few metres for lake to thousands of kilometres, for oceans.
Water Crossing	An area used for the purpose of crossing a water body. Water crossings may consist of naturally occurring areas, or installed structures such as pipelines, bridges, culverts, or roads, etc.
Water Quality Modelling	To estimate the quality of water that contacts and runs off waste rock and ore stockpiles.
Watershed	See Drainage basin. Area of land contributing runoff to a specified point.
Wayside Detectors	Safety systems to monitor passing trains for defects, such as hot bearings/wheels and dragging equipment along the Railway.
Wetland	Marsh area periodically inundated and containing a unique assemblage of salt-tolerant plants.
Wetted Width	The width of the wetted stream at the time of the survey. Also referred to as low flow channel.
Working Groups	The working groups have provided valuable insights into community and cultural values, priorities, fears, and hopes, and helped researchers prepare culturally sensitive and appropriate research methodologies and plans. Additionally, the presence of working groups facilitates information flow between the company and the communities.
Zone of Influence	The geographic area where species behaviour and/or abundance may be influenced by Project activities.

6.2 ABBREVIATIONS

AFDW ..... Ash free dry weight
ANFO ..... Ammonium Nitrate Fuel Oil
ARD ..... Acid Rock Drainage
BCMOE ..... British Columbia Ministry of the Environment
BMP ..... best management practices
BOD ..... Biological oxygen demand
CALA ..... Canadian Association for Laboratory Accreditation Inc.
CCME ..... Canadian Council of Ministers of the Environment
CDWQ ..... Canadian Drinking Water Quality Guidelines
CFIA ..... Canadian Food Inspection Agency
CPUE ..... Catch-per-unit-effort
CSP ..... Corrugated steel pipe
CSPP ..... Corrugated structural plate pipes
DFO ..... Fisheries and Oceans Canada
DO ..... dissolved oxygen
EEM ..... Environmental Effects Monitoring
EEMP ..... Environmental Effects Monitoring Program
EIS ..... Environmental Impact Statement
EMMP ..... Environmental Mitigation and Monitoring Plans
EPS ..... Environmental Protection Service
GIS ..... Geographic Information System
HADD ..... habitat alteration, disruption, or destruction
IQ ..... Inuit Qaujimajatuqangit
ISQG ..... Interim Sediment Quality Guidelines
KPL ..... Knight Piésold Ltd.
LEL ..... Lower Effects Level
LSA ..... Local Study Area
MAD ..... mean annual discharge
MAUR ..... mean annual unit runoff
ML ..... Metal Leaching
MMER ..... Metal Mining Effluent Regulation
MOE ..... BC Ministry of Environment
NLCA ..... Nunavut Land Claims Agreement
NPS ..... Non-point Source
NSC ..... North/South Consultants Inc.
NWB ..... Nunavut Water Board
OS ..... Operational Statement
PAL ..... Protection of Aquatic Life
PEL ..... Probable Effects Limit
Project ..... The Mary River Project
QA/QC ..... Quality assurance/quality control
RBC ..... rotating biological contactors
ROM ..... Run-of-Mine
RSA ..... Regional Study Area

SEL.....Severe Effects Level
SWM.....stormwater management
SWMP.....Stormwater Management Plan
TKN.....Total Kjeldahl Nitrogen
TOC.....Total Organic Carbon
TP.....total phosphorus
TSP.....total suspended particulates
TSS.....total suspended solids
US EPA.....United States Environmental Protection Agency
VEC.....Valued Ecosystem Component
WSC.....Water Survey of Canada
WWTP.....Waste Water Treatment Plant
YOY.....Young-of-the-year
ZOI.....zone of influence