Baffinland Iron Mines Corporation

MARY RIVER PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME 6
TERRESTRIAL ENVIRONMENT

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PROJECT FACT 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 - INTRODUCTION

1.1 REGIONAL TERRESTRIAL SETTING

The North Baffin Island region is located within the Northern Arctic Ecozone, as delineated in the National Ecological Framework for Canada (Ecological Stratification Working Group, 1996). The region is characterized by long dark winters and short summers, with continuous darkness from November through February and continuous daylight from May to August. The ground is covered in snow from September to June and ice persists offshore throughout most of the year. Mean temperatures range from below -30°C in winter and -1.5°C in summer. Frost-free conditions typically last from June to August though snow may occur at any time throughout the year. The climate is semi-arid with an average annual precipitation in the order of 100-200 mm. Precipitation is often in the form of snow that is present as ground cover for 10 months of the year (September to June). The eastern section of the ecozone is composed mainly of Precambrian granitoid bedrock, and tends to consist of plateaus and rocky hills. Permafrost is continuous and can extend to depths of several hundred metres. Cryosolic soils (i.e., those affected by permafrost-related processes) predominate. Ocean conditions vary from south to north. In the northern half of the ecozone, the waters are ice-fast, even through much of the summer. In the south, open water is more common in the summer, but pack ice usually persists offshore (Marshall and Schut, 1999). Cold temperatures, short growing season, high winds, shallow soils, and limited precipitation result in sparse and dwarfed vegetation. Vegetative cover consists of grasses, herbs, shrubs, and lichens, but the diversity of vegetation is relatively low. Plant growth and diversity is greater along coastal lowlands, sheltered valleys, and river banks where moisture and nutrients are more abundant. Upland areas tend to have limited vegetation as these areas are exposed to the harsher environmental conditions common in the area during most of the year.

The majority of the Project area falls within the Melville Peninsula Plateau Ecoregion. This ecoregion has a mid-Arctic climate and topography characterized by a broad, gently warped, old erosion surface. Like other ecoregions in the Project area, drier sites support sparse covering of purple saxifrage (*Saxifraga oppositifolia*), mountain avens (*Dryas integrifolia*), and willow (*Salix* spp.). Wet sites support continuous cover of grasses, and predominantly include sedges (*Carex* spp.) and cottongrass (*Eriophorum* spp.). The northern extent of the Project area includes portions of the Borden Peninsula Plateau Ecoregion and Baffin Island Uplands Ecoregion. Both reflect a high inland plateau and a broad, gently warped old erosion surface, and both ecoregions have a high-Arctic climate with sparse vegetation of moss, mixed and low-growing herbs, and shrubs in dry sites. Wet sites in the Baffin Island Uplands, because of greater precipitation, can have up to 60 % vegetation cover. Soils range from discontinuous and thin colluvial, morainal, and sandy solids to exposed bedrock. All ecoregions in the Project area have continuous permafrost with differing ice content (Marshall and Schut, 1999).

Topography varies considerably across the Project area. The shoreline of Milne Inlet in the northern part of the Project area is situated on a relatively broad, deep and flat sand beach. Milne Inlet itself is enclosed by steep fiord walls measuring 60–600 m above sea level (asl). Moving inland, the Milne Inlet Tote Road follows the Phillip’s Creek valley that starts near sea level at Milne Inlet and rises to 188 m asl at the Mine Site. The Phillip’s Creek valley is confined by hills or mountains on both sides. West of the Phillip’s Creek Valley is mountainous terrain with some occurrence of glaciers.

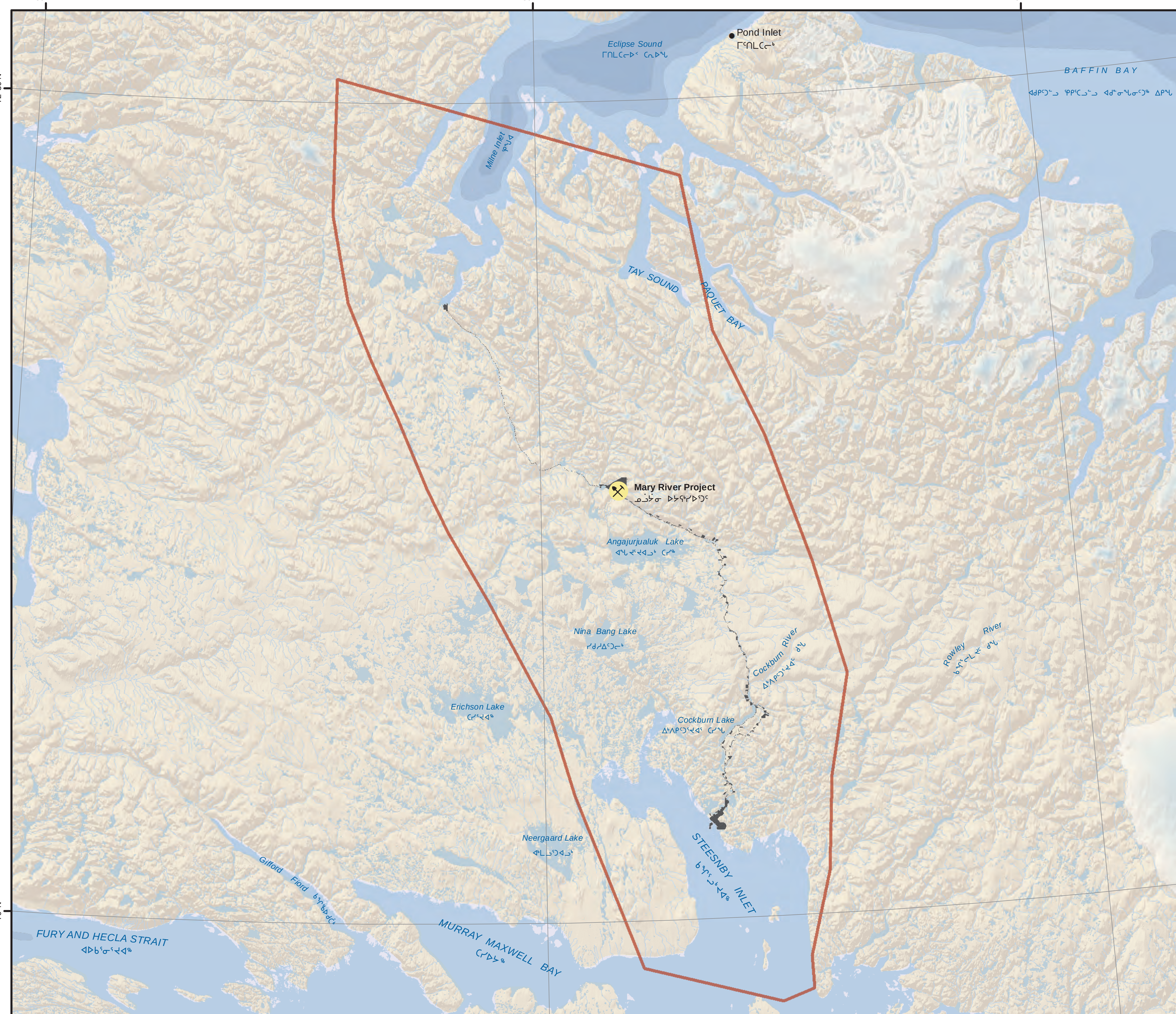
At the Mine Site, Nulujaak (Deposit No. 1) rises quickly to 679 m asl from the fairly flat and sandy outwash plain where the exploration camp is currently located. Nulujaak is a landmark for Inuit travelling on the land

and is part of a ridge trending approximately north–south. The land to the west is equally mountainous with some minor coverage of glaciers. East of Deposit No. 1 the land is somewhat rolling with several elevated plateaus formed by horizontal sedimentary deposits. South of Mary River the undulating outwash plains end near the Ravn River. South of the Ravn River the land is quite flat and poorly drained and begins to drop steeply toward the Cockburn Lake valley, which is bounded by steep cliffs that range from 360–380 m asl. The land south of Cockburn Lake to Steensby Inlet becomes flatter with mainly undulating bedrock and boulder landforms.

1.2 STUDY AREAS

A common Regional Study Area (RSA) was defined for most terrestrial environment components, as shown on Figure 6-1.1. The ecological land classification was carried out within this RSA, and was adopted for landforms, vegetation and bird VECs. The RSA extends from Milne Inlet to the north and follows an approximate 50 to 80 km wide corridor centered roughly on the Milne Inlet Tote Road, Mine Site and the proposed Railway from the Mine Site to Steensby Inlet. The RSA also encompasses the coastal areas of Steensby Inlet.

A modified RSA was identified for caribou, based on wildlife and habitat at ecologically relevant scales, to reflect regional habitat use, seasonal movement patterns, and animal movement data availability. The RSA for the caribou study varies slightly from Figure 6-1.1 and is described in Section 5 of this volume.



LEGEND

Mary River Project

Terrestrial Bird Regional Study Area

Potential Development Area

NOTES

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 5 10 20 30 40 50 Km

Baffinland Iron Mines Corporation

Mary River Project: Landforms, Vegetation and Bird Regional Study Area

EDI Environmental Dynamics Inc.

Date: 1/9/2012

FIGURE 6-1.1

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SECTION 2.0 - LANDFORMS, SOILS AND PERMAFROST

2.1 BASELINE SUMMARY

An understanding of ground conditions is essential for any project development, and is particularly important when selecting the locations of mine related facilities, including infrastructure and transportation corridors. Surface and subsurface conditions must be considered in the design of any project, and investigations were conducted at the Mary River Project sites to confirm the conditions. A key aspect of the Mary River Project is related to permafrost management; designs must address the need to minimize disturbances and preserve the integrity of the ground surface, protect the natural resources, and also protect Project infrastructure and operations.

In addition to permafrost, other aspects related to ground conditions that are addressed in this EIS include:

- Landforms and soils — identification of soil types and landforms in areas likely to be affected by Project implementation;
- Bedrock geology — focusing on rock types and structural geology;
- Geotechnical and geomechanical conditions — identification of the geotechnical properties of the soil and bedrock relating to permafrost, slope stability and bearing capacity of foundations;
- Geochemistry — characterization of waste rock, stockpile materials, borrow materials, and ultimate pit wall rocks to determine the potential of the materials to react upon exposure to atmospheric conditions; and
- Groundwater — the physical and chemical characteristics of groundwater flows and the interactions with permafrost.

The effects of the Project on landforms, soils and permafrost will be limited to the area of development. Therefore, the Local Study Area (LSA) for landforms, soils and permafrost is defined as the Potential Development Area (PDA) for the various project components. Investigations on landforms, soils and permafrost were completed within the PDA.

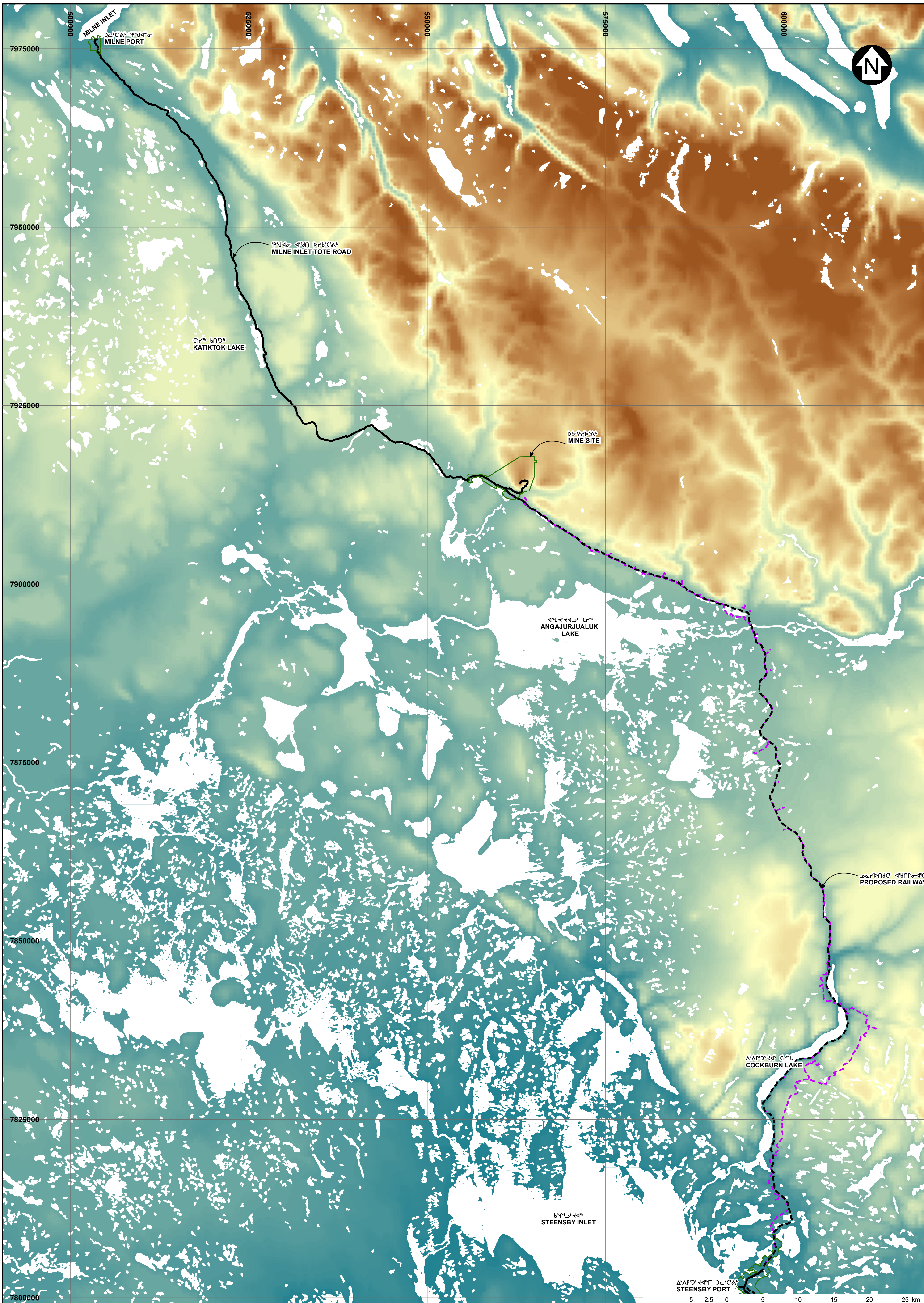
2.1.1 Landforms and Soils

2.1.1.1 Topography

The raised Canadian Shield forms a discontinuous longitudinal mountain range termed the Arctic Cordillera, part of which occurs along the northeast coast of Baffin Island. The Penny Ice Cap in the southeast and the Barnes Ice Cap in the central area are the largest icefields on Baffin Island.

Topography varies considerably across the Project's terrestrial RSA. Figure 6-2.1 shows the relief across North Baffin Island, and the topography as it relates to Project features is described below, starting in the north at Milne Inlet and extending towards Steensby Port in the south.

The PDA at Milne Port is situated on a relatively broad, deep and flat sand beach. Milne Inlet itself is closed in by steep fiord walls measuring approximately 60 to 600 m above sea level.



LEGEND:

- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONSTRUCTION ACCESS ROAD
- POTENTIAL DEVELOPMENT AREA

ELEVATION (m)

High : 1600

Low : 0

NOTES:

1. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
2. BODIES OF WATER ARE SHOWN IN WHITE.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

RELEIF MAP OF THE NORTH BAFFIN REGION

Baffinland Iron Mines Corporation

REF NO. BL_Vol6_GIS_002

FIGURE 6-2.1

REV 0

Figure ID: BL_Vol6_GIS_002 Releif Map of the North Baffin Region Figure 6-2-1.mxd

Moving inland, the Milne Inlet Tote Road follows Phillip's Creek Valley, which starts near sea level at Milne Inlet and rises to an elevation of 188 m above sea level (asl) at the Mine Site. The valley is confined by hills or mountains on both sides. To the west in particular is mountainous terrain with some occurrence of glaciers.

At the Mine Site, Deposit No. 1 (Nulujaak) rises quickly to 679 m asl from the fairly flat and sandy outwash plain at 188 m asl where the exploration camp is currently located. Nulujaak is a landmark for Inuit travelling on the land and is part of a ridge trending approximately north-south, and the land to the west is equally mountainous with some minor coverage of glaciers. East of Nulujaak the land is somewhat rolling with several elevated plateaus formed by horizontal sedimentary deposits.

Moving south from the Mine Site, the undulating outwash plains end near the Ravn River and the area to the south is quite flat and poorly drained. The land begins to drop steeply approaching the Cockburn Lake valley, which has an elevation of approximately 1.5 m on the lake and 359 m (southern) to 379 m (northern) on the adjacent cliffs. South of Cockburn Lake to Steensby Port, the land becomes more flat with mainly undulating bedrock and boulder expressions.

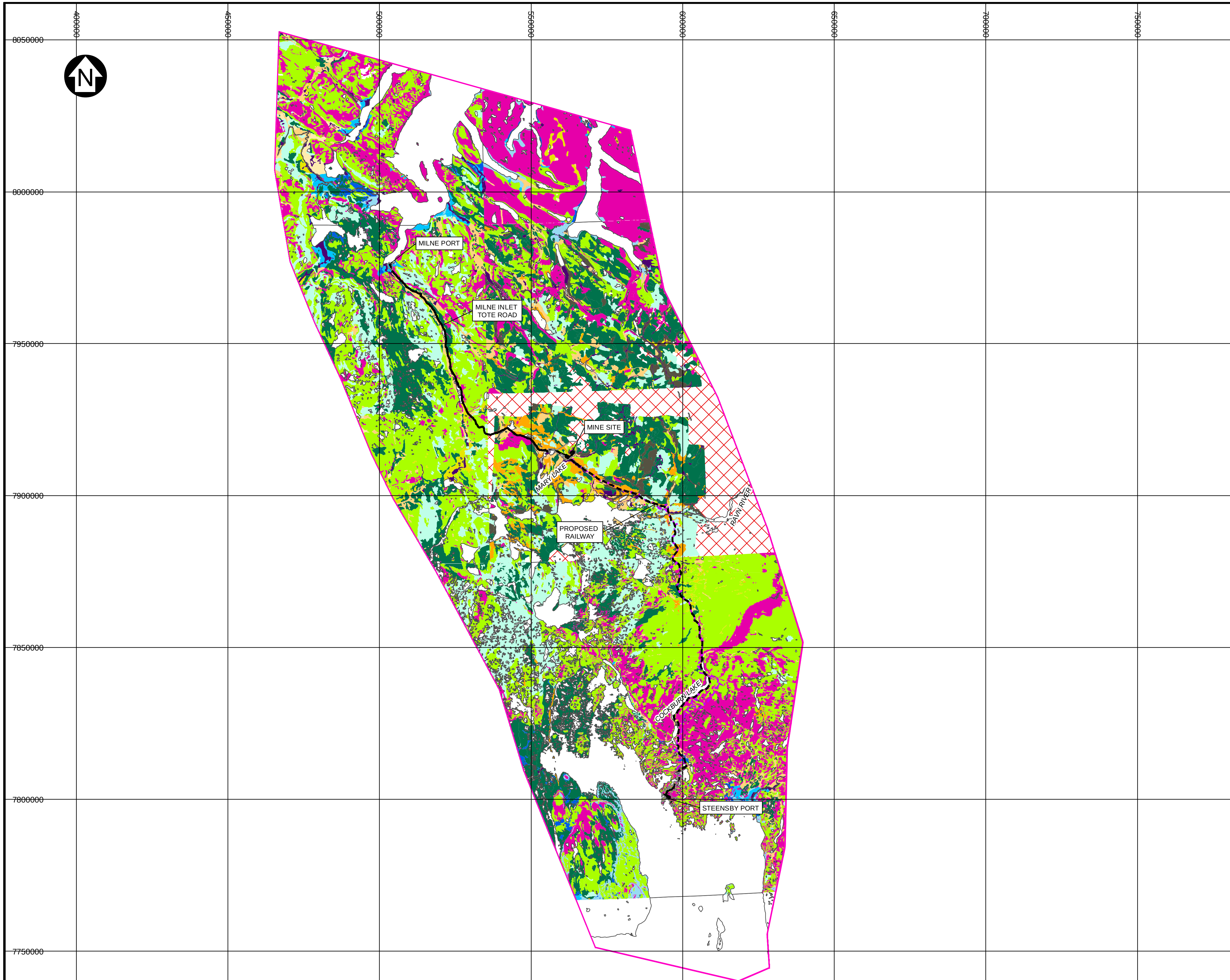
2.1.1.2 Surficial Geology

The drainage features, landforms and surface deposits of the region all attest to the widespread and relatively recent glaciation of Baffin Island. Residual snow fields and vertical ice caps still present in the mountainous regions on the eastern part of the island support this. Thick, unconsolidated deposits of glacial till that lie relatively undisturbed on the slopes and hillsides despite the lack of vegetation, further reinforces this theory.

The surficial geology of the area generally consists of locally abundant Holocene glacio-lacustrine sediments, alluvial sediments (alluvial deposits), marine and glacio-marine deltaic sediments and end moraine till, with occasional outcrops of pre-Quaternary bedrock and sedimentary rock formations (Figure 6-2.2). The Holocene glacio-lacustrine sediments are typically in the range of 1 to 10 m thick, consisting of proglacial sand and gravel outwash. The sediments commonly form braided floodplains, terraces, and fans. The early Holocene and Wisconsinan tills are mainly veneers and blankets. Till veneers are 0.5 to 2 m thick and discontinuous. Some veneer surfaces are reinforced with boulders, either due to washing by subglacial meltwater or permafrost processes, and restrict outcrop exposures. Till blankets are undulating and in the range of 2 to 10 m thick with drumlins and ribbed moraines in places.

Boulder tills are the dominant surface material, blanketing the majority of the region and restricting outcrop exposures to the high ridges, stream canyons and steep escarpments. In general, drainage in the region is poorly developed on the till plains as insufficient time has elapsed since glacial recession to allow good drainage to evolve. As a result, vast areas, particularly on the higher plateaux, are water saturated during the melt period.

Alluvial benches and kame terraces of sand and coarse gravel typically cling to the walls of the canyons and fill the stream valleys along the western flank of the precambrian mountains. These localized valley deposits are typically well drained making land travel over these areas very good within a short period of time after the snow melts.



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SURFICIAL DEPOSITS
QUATERNARY
HOLOCENE

Ca — **COLLUVIUM: block and rubble accumulations, 1-50 m thick.** Talus: active block and rubble accumulations as much as 50 m thick forming talus aprons and fans below cliffs resulting from rock falls and debris flows; commonly crossed by debris flow channels and léeves.

Ap — **FLUVIAL SEDIMENTS: alluvium; gravel and sand, 2-20 m thick.** Alluvial deposits: gravel and sand; 2-20 m thick; active braided floodplains, terraces, and fans; includes active proglacial outwash.

MARINE AND GLACIAL MARINE SEDIMENTS: gravel, sand, silt, and clay, 1-20 m thick, deposited in deltaic and beach environments during regression of the postglacial sea.

Mr — Beach sediments: gravel and sand, 1-5 m thick, forming ridges and swales.

Mt — Deltaic sediments: clay, silt, sand, and gravel, 5-20 m thick, forming coarsening upward sequences under dissected terraces.

Mv — Deepwater proglacial silt veneers: silt, clay silt, and fine sand with dropstones, 1-2 m thick.

GLACIAL LACUSTRINE SEDIMENTS: clay, silt, sand, and gravel deposited in glacier dammed lakes in deepwater, beach, and deltaic environments.

Lt — Deltaic sediments: clay, silts, sand, and gravel, 5-20 m thick, forming coarsening upward sequences under dissected terraces.

Lb — Deepwater proglacial silt: silt, clay silt, and fine sand with dropstones; veneers 1-2 m thick; blankets 2-5 m thick.

GLACIOFLUVIAL SEDIMENTS: gravel and sand, 1-10 m thick, deposited behind, at, and in front of the ice margin.

Gt — Proglacial outwash: gravel and sand, 1-10 m thick, forming braided floodplains, terraces, and fans.

Gh — Ice contact stratified drift: gravel and sand, 1-5 m thick forming eskers, and kames.

EARLY HOLOCENE AND WISCONSINAN

TILL: nonsorted stony muds, 0.5-60 m thick, deposited in subglacial and ice marginal environments; lithic composition generally reflects underlying bedrock.

Tm — End moraine: 5-60 m high, composed of or mantled by till, extensively kettled in places; large features mainly cored by debris-rich relict glacier ice.

Tv — Till veneer: 0.5-2 m thick and discontinuous; some surfaces armoured by stones due to washing by subglacial meltwater.

Tb — Till blanket: 2-10 m thick forming an undulating blanket with drumlines and ribbed (Rogen) moraines in places.

BEDROCK
PRE-QUATERNARY

R — Rock: rock of various compositions and ages (Jackson and Sangster, 1987) variously modified by glacial erosion during the Quaternary and with patchy till cover; hilly and hummocky surfaces, ice moulded in places, with lake basins in subglacially scoured regions; cliffs reslting from glacial over-steepening; in places veneered by thin till, commonly bouldery.

LEGEND:

- WATER
- POTENTIAL DISTURBANCE AREA
- SURFICIAL GEOLOGY NOT AVAILABLE
- MILNE INLET TOTE ROAD
- PROPOSED RAIL ALIGNMENT
- ACCESS ROAD

NOTES:

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2. COORDINATE GRID IS SHOWN IN UTM NAD83 ZONE 17 AND IS IN METRES.
3. BODIES OF WATER ARE SHOWN IN WHITE.

SCALE 10 5 0 10 20 30 40 50 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SURFICIAL GEOLOGY IN THE RSA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
NB102-181/30	11

FIGURE 6-2.2 REV 0

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	16JAN'12	ISSUED WITH REPORT	RAC	ASM	RAC	KDE

The following provides some more specific observations associated with the surficial geology at some of the proposed and existing project infrastructure locations/sites.

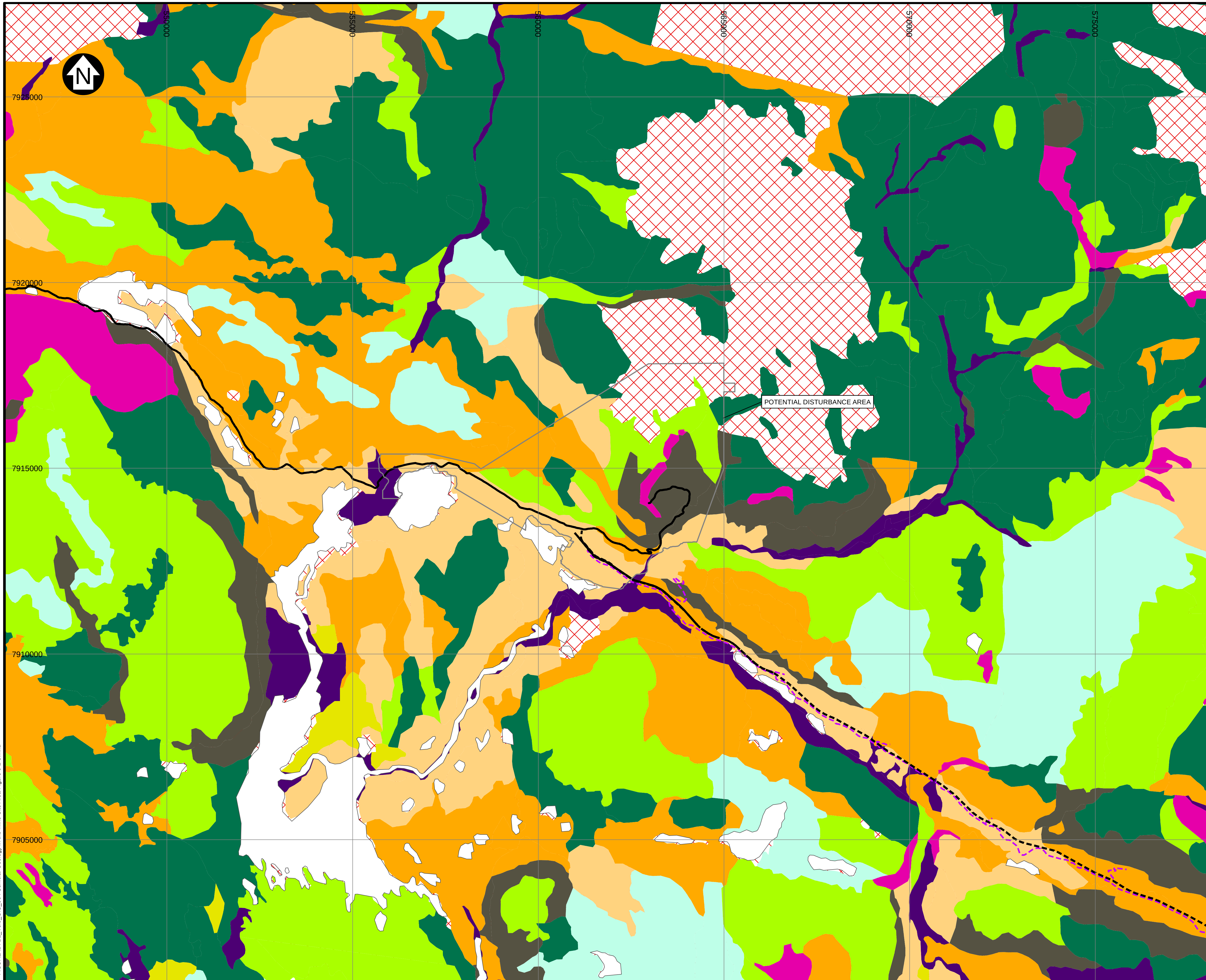
Mine Site — The Project is located in a glaciofluvial outwash deposit in what appears to be a classic U-shaped valley. There are some direct glacial deposits consisting of kames, moraines and eskers in and around the southeastern portion of Sheardown Lake. The outwash valley is essentially a relatively flat plane with very little local relief, the primary exceptions being along water bodies, esker deposits and adjacent to valley edges. Valley walls are generally steep and abrupt, often with distinct terraces. The surficial geology of the Mine Site area is shown on Figure 6-2.3.

Milne Inlet Tote Road — The Tote Road alignment generally follows a glacial valley oriented northwest-southeast to the Mine Site. The surficial deposits along this alignment include till veneer or blankets on the higher elevations with some drumlins and moraines. Glaciofluvial outwash sediments (gravel and sand) forming braided floodplains, terraces and fans or stratified glacial drift (gravel and sand) are typically found in the valley floors. Limited bedrock exposure is present along the Tote Road.

Milne Port — The dominant landforms in the Milne Inlet area are typically a result of glacial activity, marine and mechanical forms in various degrees. Glacial activity is not overly apparent on the immediate Port site but is more pronounced in the higher elevations south of the site. Marine and mechanical features are most predominant with terraces and strand (beach) lines formed by marine action which have been cut by mechanical features, some of which may be attributed to permafrost. Wind appears to have been responsible for some drifting on the finer grained soils on the lower part of the site. Recently deposited colluvium is present on many of the slopes and side hills in the area. The action of surface water has produced numerous sharp gullies along water-ways. Marine clays were also noted at some locations at the site.

Railway — The topography of the RSA is generally quite hilly, with the exception of the Ravn River area which is relatively flat. Glaciated valleys are evident along a significant portion of the alignment. The surficial geology of the RSA is also characterized by the relatively recent glacial activity of Baffin Island. Surficial geology consists of several types of deposits including glacio-lacustrine sediments, alluvial sediments (alluvial deposits), end moraine till, and till veneers and blankets. Occasional outcrops of pre-Quaternary bedrock and sedimentary rock formations are also common along the southern section of the RSA.

Steensby Port — Near surface bedrock is dominant in the Steensby Port area. Limited overburden is in the form of marine sediments and localized deposits of till. The majority of the overburden is located in depressions between the numerous bedrock outcrops and is typically overlain by a layer of vegetation and boulders.



SURFICIAL DEPOSITS

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LEGEND:

- WATER
- POTENTIAL DISTURBANCE AREA
- SURFICIAL GEOLOGY NOT AVAILABLE
- MILNE INLET TOTE ROAD
- PROPOSED RAIL ALIGNMENT
- CONSTRUCTION ACCESS ROAD

NOTES:

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2. COORDINATE GRID IS SHOWN IN UTM NAD83 ZONE 17 AND IS IN METRES.
3. BODIES OF WATER ARE SHOWN IN WHITE.

SCALE 1,000 500 0 1,000 2,000 3,000 4,000 5,000 m

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MARY RIVER PROJECT

SURFICIAL GEOLOGY IN THE MINE SITE AREA

Baffinland Iron Mines Corporation

REF. NO. BL_Vol6_GIS_004

FIGURE 6-2.3 REV 0

FIGURE ID: BL_Vol6_GIS_004 Surficial Geology in the Mine Site Area Figure 6-2-3.mxd

2.1.1.3 Surficial Soils Composition

A soils evaluation was carried out in 2007 and 2008 by an Arctic soils specialist (Veldhuis, 2010). Regionally, soil formation is controlled and limited by year-round low soil temperatures, low precipitation rates and near-surface permafrost. Soil formation occurs in the thin layer overlying the permafrost that is subject to seasonal thawing, known as the active layer. The thickness of the active layer varies substantially across the region with topography, depth to bedrock, and vegetative or water cover but is typically between 1 to 2 m thick in the Project area depending on the local soil cover. In locations where well drained, dry sand and gravels are present, thaw depth can extend to 2 to 4 m depth.

Project area soils were classified based on the Canadian System of Soil Classification (Soil Classification Working Group, 1998), and included primarily Cryosols (permanently frozen soils or soils with permafrost within 100–200 cm of soil surface) and Brunisols (soils with weak B horizon development). In general, Project-area soils all showed weakly developed horizons, with a general lack of organic material accumulation. Fine- to medium-textured soil materials were generally cryoturbated, and patterned ground phenomena related to permafrost and freeze-thaw cycling were also commonly observed throughout the RSA. Soils throughout the RSA were generally poor in nutrients (Table 6-2.1). This factor, in combination with the depressed level of pedogenic development in the area and thinness of soils where present, generally make local soils unsuitable for stockpiling for revegetation purposes (Veldhuis, 2010).

Table 6-2.1 Total Amounts of Organic Matter and Primary Nutrients in Soils in the Project Area

Parameter	Concentration Range per Horizon, %			
	B Horizon (sandy)	C Horizon (sandy)	B and C Horizons (loamy)	A Horizon
Organic Matter	0.83 (0.17 - 2.21)	0.34 (0.17 - 0.51)	2.81 (0.17 - 5.44)	13.72 (2.38 - 26.00)
Nitrogen	0.04 (0.02 - 0.08)	0.03 (0.02 - 0.04)	0.15 (0.012 - 0.36)	0.93 (0.09 - 1.14)
Phosphorous	0.03 (0.01 - 0.09)	0.07 (0.04 - 0.11)	0.04 (0.02 - 0.10)	0.06 (0.06 - 0.11)
Potassium	0.13 (0.05 - 0.36)	0.15 (0.09 - 0.25)	0.47 (0.16 - 0.69)	0.08 (0.06 - 0.11)
Sulphur	< 0.01	< 0.01	0.02 (0.01 - 0.05)	0.06 (0.01 - 0.10)

NOTE(S):
1. FROM VELDHUIS, 2010.

2.1.1.4 Permafrost

The Project is located in a zone of continuous permafrost. The active layer through the Project area typically ranges from approximately 1 to 2 m but may be greater in areas where there is loose, sandy soil at the edges of lakes or ponds and less in areas with a substantial surface layer of wet organics. Unfrozen taliks can exist within areas of continuous permafrost below lakes, under large rivers or near the coast. Taliks may exist under lakes within the terrestrial RSA, particularly larger lakes such as Mary Lake, Angajurjualak Lake and Cockburn Lake; however, this was not fully investigated because the presence of taliks under these lakes is inconsequential to the Project. No taliks have been confirmed in any of the on-land drilling completed for the project, including Steensby Inlet.

Permafrost thickness in and around the RSA is considered to be deep, typically in the 400–700 m depth range (Knight Piésold, 2010a). In 2007, a 400 m thermistor installed into Deposit No. 1 showed that the depth to permafrost is predicted to extend to 610 m at this location (Figure 6-2.4) which is well below the planned depth of mining. This is consistent with regional measurements at the former Nanisivik Mine, where permafrost was measured at depths greater than 430 m (Gartner Lee, 2003), and at drillholes located 450 km west and 450 km south of Pond Inlet, with measured permafrost depths of 500 m and 400 m, respectively (Geological Survey of Canada, 2006).

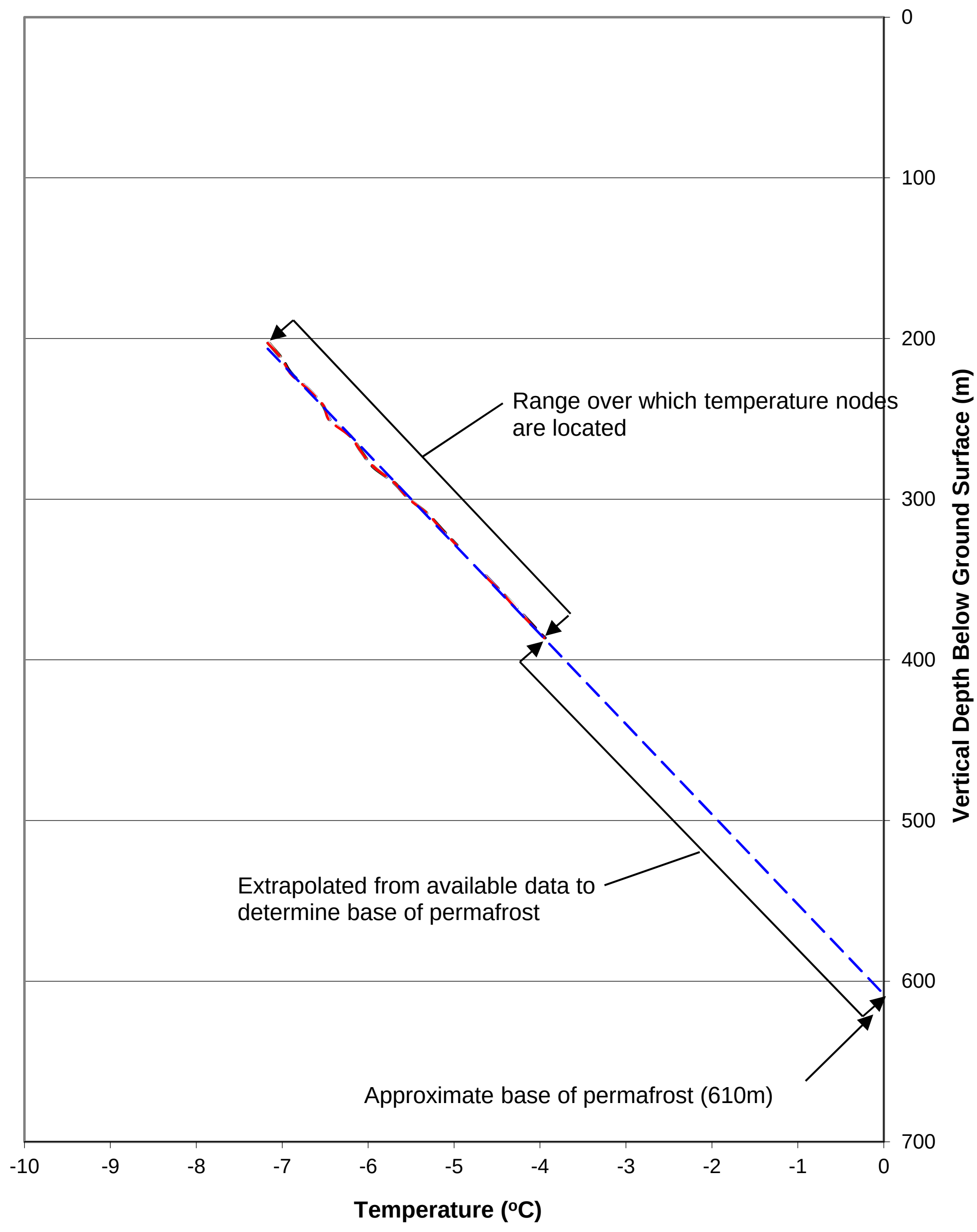
Between 2006 and 2008 more than fifty ground temperature monitoring instruments (thermistor cables) were installed and sporadically monitored to determine typical ground temperatures in the overburden soils and bedrock across the RSA. Many were installed to depths sufficient to define the typical stable temperatures in the permafrost soils below the depth of zero annual amplitude. The depth of zero annual amplitude in temperature fluctuation appears to exist at depths of between 10 and 15 m in the valleys. At that depth, the "typical" permafrost temperature is roughly -10°C.

In general, permafrost greatly increases ground stability at depth but at surface it can affect the rates of soil erosion through the formation of ice wedges and patterned ground, pingos and palsas, massive ground ice, solifluction, etc. Changes to the thermal regime resulting from surface disturbance or climate warming can lead to thawing of the permafrost causing the formation of thermokarst topography and mass wasting. Thaw instabilities or soil weakening can also occur either naturally as part of the annual cycle within the active layer or as a result of increased thaw due to change. A more detailed description of issues associated with ice-rich and thaw sensitive soils in relation to project components and proposed design measures to offset these issues is provided in Section 2.3. Additional detail related to the potential implications of climate change on the permafrost and recommended design measures is provided in Volume 9, Section 2.2.

2.1.1.5 Unique and Valuable Landforms

The surficial landforms and deposits in the RSA are evidence of the recent, widespread glaciation on Baffin Island. The surficial deposits include thick, undisturbed and unconsolidated deposits of till on slopes and hillsides, glacio-lacustrine sediments associated with historic lakes or coastal regions, glaciofluvial and alluvial deposits along waterways in valley bottoms, marine and glacio-marine deltaic sediments and lateral or end moraine till deposits. These surficial landforms are not particularly unique in themselves; however, subsequent periglacial processes (including the presence of and development of ground ice, and soil and rock weathering, mass movement and erosion) continue to be the dominant forces shaping the landscape of the region. These processes result in ground ice accumulation, frost heaving, sorting of materials within the upper soil matrix, fracturing of the upper bedrock profile and the development of patterned ground (tundra polygons), drumlins, pingos and thermokarst lakes.

Fragile landscapes in the RSA are generally associated with frost/thaw sensitive till blankets and the presence of massive ground ice within glaciofluvial deposits. Pingos are one such phenomenon. No pingos were identified during the geotechnical investigations. A number of significant polygons and areas of high potential for ground ice content are present along the tote road alignment and in the vicinity of the Mine Site.



Notes:

1. DATA READINGS FROM AUGUST 25 - SEPTEMBER 25, 2007.

2. THERMISTOR READINGS WERE RECORDED BETWEEN DEPTH OF APPROXIMATELY 200 M AND 400 M BELOW THE GROUND SURFACE. TEMPERATURES ARE INTERPOLATED TO 610 M BELOW GROUND SURFACE.

BAFFINLAND IRON MINES CORPORATION	
MARY RIVER PROJECT	
DEEP THERMISTOR TEMPERATURE RESULTS	
Baffinland Iron Mines Corporation	REF NO. **BL_Vol6_EXL_001**
	FIGURE 6-2.4 REV. 0

2.1.2 Bedrock Geology

The following sub-sections summarize the baseline information available on bedrock geology in the Project area, based on field geological exploration programs conducted by Baffinland geologists from 2004 to 2008 and summarized by Aker Kvaerner (2008).

2.1.2.1 Regional Bedrock Geology

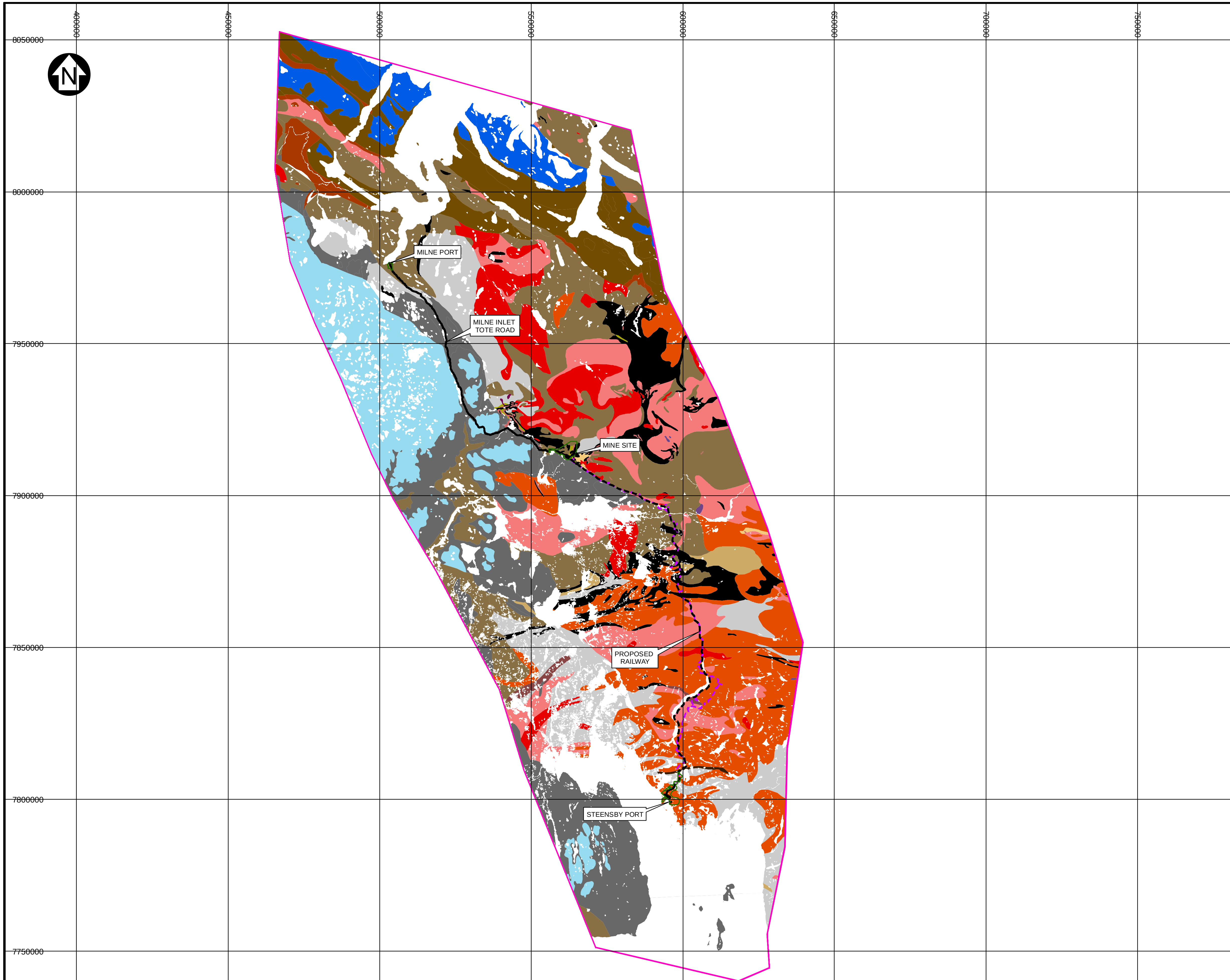
The North Baffin Island region and Mary River area lie within the Committee Belt, a granite-greenstone terrane mixed with rift basin sediments and volcanic rocks. The belt lies within the Churchill Province, extending from Baker Lake to Greenland, and is divided into five main assemblages: the Archean, the Mary River Group, the Piling Group, the Bylot Supergroup, and the Turner Cliffs-Ship Formation (Aker Kvaerner, 2008).

The Mary River iron deposits are located within the Mary River Group, an assemblage of Late-Archean (2.76 to 2.72 Ga) metasedimentary to metavolcanic rocks that have been folded and preserved in greenstone belts (Aker Kvaerner, 2008). The Mary River Group greenstone belts are present as fragmented remnants stretching from Bylot Island south to Eqe Bay (Figure 6-2.5), with a maximum thickness of 4,000 m. Primary sequences within the Group consist of a lower series of metavolcanic rocks and an upper series of turbidite pelitic-greywacke; the stratigraphic position of iron formation, quartzite, conglomerate, minor marble, and volcanic breccia units within the belts, which varies across the region. The Mary River Group is part of the regional Committee Belt, an Archean-aged (2.9 to 2.5 Ga) assemblage of granite-greenstone terranes, granitic migmatites gneissic granitic intrusions, and clastic and carbonate sedimentary units reworked during the Paleo-Proterozoic (2.5 to 1.6 Ga).

2.1.2.2 Iron Ore Deposit Geology

Iron formations occur in varying thicknesses discontinuously within the Mary River Group metasedimentary units but are typically not present in economically extractable thicknesses or configurations except in the Mine Site area. The high-grade iron ore at Deposits No. 1, 2, 3 and 4 were discovered in 1962, and these initial hematite-magnetite mineralized zones were mapped within extensive belts of banded iron formation in the area over the next three years. Deposit No. 5 was discovered and surface mapped in 2009. The deposits are characterized by zones of massive layered to brecciated hematite to magnetite, variably intermixed with banded oxide to silicate facies iron formation. As typified at Deposit No. 1, the high-grade iron formations are interlayered with thin bands of chlorite-actinolite schist, staurolite-garnet-mica schist, amphibolite, and banded iron formation across their strike width, with the entire assemblage up to 400 m thick.

The Mary River iron deposits are considered to belong to an Algoma-type iron formation (Aker Kvaerner, 2008) formed in a volcanic ark setting in an extensional or rift basin during the Archean. Algoma-type deposits are typically characterized by a lower series of volcanics followed by banded iron formation and/or interlayered to pure iron oxides of variable and potentially substantial thickness, in turn overlain by volcanics and volcaniclastic sediments (Gross, 1996).



BEDROCK LEGEND:

ORDOVICIAN

OSba	**Brodeur Group** Ballarge Formation: Member B- limestone and dolomite; light gret, buff, brown, microcrystalline; minor breccia. Member A- dark gret, shaly carbonate rocks.

CAMBRO-ORDOVICIAN

COad	**Admiralty Group** Turner Cliffs-Ship Point Formation: microcrystalline to very finely crystalline dolomite commonly silty or sandy; very fine-to coarse-grained quartzose and dolomitic and calcareous sandstone.
COga	**Admiralty Group** Gallery Formation: arkose to orthoquartzite, conglomerate beds and lenses, minor dolomitic sandstone, ferruginous zones, hematite iron ore clasts abundant locally.

NEOHELIKIAN

NBsc	**Bylot SuperGroup** Society Cliff Formation: dolomite; microcrystalline to very finely recrystalized; minor limestone, dark shale, pink arkosic sandstone.
Nbab	**Bylot SuperGroup** Arctic Bay Formation: Upper Member: shale, mudstone, very finely crystalline dolomite. Lower Member: shale siltstone; minor mudstone, sandstone; slump structures, crossbedding, mudcrack, ripple marks.
Nbas	**Bylot SuperGroup** Adams Sound Formation: Orthoquartzite, quartzose sandstone, white to dark grey, buff, brown, pink. Shale, siltstone, granule to cobble conglometate locally at base; dessication cracks, ripple marks and cross bedding common.

APHEBIAN

APgr	Massive granite-grandodiorite, chiefly pink qwuartz monzonite; fine-to coarse-grained and pegmatitic; abundant aplite and pegmatitic dykes, syenitic dykes.
APck	Charnockite to monzocharnockite; massive and finely foliated to medium banded; medium- to coarse-grained.
APgp	Porphyritic quartz monzonite-granodiorite; minor granite, syenite-syenodiorite; locally granulated.
Apgp	Porphyroblastic migmatite; commonly of granodioritic composition.
APmg	Chiefly banded migmatite; white to light grey granitoid bands alternate with grey to black mafic bands; derived in part from Mary River Group.
PPbl	**Piling Group** Chiefly quartz-mica-feldspar paragneiss (metagreywacke, metasiltstone) and garnetiferous gneiss; minor alumino-silicate-bearing schists, lit-par-lit gneiss, amphibolite and mafic pyroxene gneiss.

ARCHEAN AND/OR APHEBIAN

AMu	**Mary River Group** Ms-metasediments; chiefly mica-quartz-feldspar schists and gneisses; Ma-acid metavolcanics; chiefly of quartz latite composition; Mn-meta-anorthosite, metagabbroic anorthosite; Mb-Basic metavolcanic rocks.
AMam	**Mary River Group** Metagabbro: chiefly amphibolite, fine-to medium-grained.
AMum	**Mary River Group** Ultrabasic rocks; peridotite, serpentinite, actinolite rock.
AMif	**Mary River Group** Metamorphosed iron-formation; mainly oxide facies, abundant silicate facies; iron-ore (magnetite-hematite rock).
AMqz	**Mary River Group** Upper member: quartzite; fne-to coarse-grained; Lower Member: mic-quartz-feldspar schist and paragneiss; rodded quartz paragneiss.
Agr	Foliated quartz monzonite-granodiorite, local granite.
Aam	Metagabbro: amphibolite pods, dykes, sills, fine-to medium-grained.
APmu	Undifferentiated gneisses, mixed rocks; chiefly undivided Pmg, Pmp, Agr, Amn.

ARCHEAN

Amn	Fluidal nebulitic granodiorite migmatite; minor quartz monzonite-graodiorite; lenses and boundined bands of amphibolite; metasedimentary and granitoid rocks are common.

LEGEND:

- WATER
- POTENTIAL DISTURBANCE AREA
- SURFICIAL GEOLOGY NOT AVAILABLE
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- CONSTRUCTION ACCESS ROAD

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83 ZONE 17 AND IS IN METRES.
3. BODIES OF WATER ARE SHOWN IN WHITE.

SCALE 10 5 0 10 20 30 40 50 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BEDROCK GEOLOGY IN THE RSA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
NB102-181/30	11

FIGURE	REV
FIGURE 6-2.5	0

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	16JAN'12	ISSUED WITH REPORT	RAC	ASM	RAC	KDE

SAVED: I:\1\02\00181\30\A\GIS\Figs\B118_r0.mxd; Jan 16, 2012 2:45 PM; amoore

2.1.2.3 Deposit No. 1 Mineralization

Deposit No. 1 is the largest of the five iron deposits defined to date in the Mary River area, with a total strike length of 3,800 m (Aker Kvaerner, 2008). Based on magnetic surveys, the deposit may extend a further 550 m to the south and 750 m to the north of the main outcrop along Nuluujaak. The deposits are localized within the nose and along the limbs of a northeast-plunging syncline. Economic mineralization consists of a high-grade iron oxide formation containing hematite (Fe_2O_3), magnetite (Fe_3O_4), and specularite (a form of hematite) denoted the "lower zone" and interlayered iron (magnetite) formation and schists (the "middle" and "upper" zones). In Deposit No. 1, the lower zone forms a tabular body ranging from 105 to 150 m thick, bounded by a chlorite-amphibole schist hanging wall and a predominantly quartz-feldspar-biotite gneiss footwall.

Drill core samples revealed the presence of visible sulphides (including paite and parhotite) in selected samples, primarily occurring in disseminated form, or as small vein-like occurrences within some of the deposit rocks. Sulphide oxidation is the primary mechanism for formation of acidic drainage in mine wastes, thus sulphide presence in the Mary River waste rock, borrow, and stockpile materials is of interest. Within the deposit, sulphides are thought to be predominately associated with magnetite-rich oxides (Aker Kvaerner, 2008) although it is not known whether the sulphide occurrence is lithologically controlled. The extent and total distribution of the sulphides is not known but they appear discontinuous. Recent drill core observations suggest that the majority of the recovered material has zero to trace amounts of visible sulphides.

2.1.2.4 Palaeontology

Baffinland retained Dr. Natalia Rybczynski of the Canadian Museum of Nature to conduct a desktop review of potential palaeontological resources (inclusive of palaeobotanical resources) in the region (Appendix 6A). Rybczynski (2008) identified potentially fossiliferous lithologic units outcropping near the Project area that include Paleozoic carbonates of the Gallery and Turner Cliffs Formations (Cambrian to Ordovician), Ship Point Formation (Ordovician) and Baillarge Formation (Ordovician to Silurian). These units have a total combined thickness on the order of 1 km in the northern Baffin Island area, and are shown on Figure 6-2.5. Fossils known to be present in these units in the Admiralty Inlet region (west of the Mary River Project area) include invertebrate fossils such as shells and sponge-like organisms. In the Project area, these units are typically covered by recent glacial and fluvial sediments along both sides of the Milne Inlet Tote Road beginning around km 22 from Milne Inlet for the next approximately 60 km, at which point they occur on the southwestern side of the Milne Inlet Tote Road all the way to the Mine Site, and continue to occur along the southwestern side of the Railway alignment for the first approximately 30 km south of the Mine Site. As the surficial geology map shows (Figure 6-2.2), surface exposures of these bedrock units are uncommon.

2.1.2.5 Petrology

Two petrographic studies have been completed on suites of rock samples from Deposit No. 1, mainly to characterize specific, non-representative portions of the ore body and associated interleaved schist, to investigate specific zones with elevated amounts of substances that are considered undesirable in iron ore used for making steel. Baffinland is currently supporting an MSc thesis that will (in part) expand the petrographic and probe work to other portions of Deposit No. 1 and look at more of the associated host lithologies.

2.1.2.6 Regional Seismicity

Regional bedrock structures include a northwest-trending fault set system and the Central Borden Fault, a crustal-scale structure which extends more than 200 km northwest from Angajurjualak Lake to Milne Inlet. This forms the southern boundary of the Mary River iron deposits. These fault systems typically show very large displacements both vertically and horizontally.

The majority of recorded earthquakes in the Baffin Island region are concentrated along the east and northeast coastline and within the northwestern area of Baffin Bay. Most of these events are small earthquakes with magnitudes of less than 5.0. However, some moderate to large earthquakes have been recorded in this region, the largest being a Magnitude 7.3 earthquake in 1933, located over 150 km off shore in Baffin Bay. This is the largest earthquake to be recorded north of the Arctic Circle.

A seismic review was performed in support of the Railway embankment design (Knight Piésold, 2008b) using information from the seismic hazard database of Natural Resources Canada. Information obtained included determination of seismic coefficients and horizontal Peak Ground Acceleration (PGA) value. PGA values for a range of earthquake return periods ranging from 100 years to 2,500 years are summarized in Table 6-2.2.

Table 6-2.2 Preliminary Seismic Parameters for the Project Area

Return Period (Years)	Probability of Exceedance[1] (%)	Mine Site Peak Ground Acceleration (g)[2]	Steensby Port Peak Ground Acceleration (g)[2]
100	39	0.051	0.033
475	10	0.114	0.067
1000	5	0.163	0.089
2500	2	0.246	0.120

NOTE(S):
1. PROBABILITY OF EXCEEDANCE CALCULATED FOR A DESIGN LIFE OF 50 YEARS.
2. PEAK GROUND ACCELERATIONS ARE FOR "VERY DENSE SOIL AND SOFT ROCK" (SITE CLASS C), AS DEFINED BY THE NATIONAL BUILDING CODE OF CANADA.

In accordance with the National Building Code of Canada, the maximum considered earthquake ground motion has been defined as the ground motion with a 2 % probability of exceedance in 50 years (return period of 2,500 years). Based on the findings of the seismicity assessment, an appropriate design earthquake for foundations and structures at the mine site area is the 1 in 2,500 year earthquake, with an estimated maximum bedrock acceleration of approximately 0.25g. At the Steensby Port site the estimated maximum bedrock acceleration for the design earthquake is approximately 0.12g. The peak ground acceleration for the Steensby Inlet port site is significantly lower due to a rapid decrease in the apparent seismic hazard along the western side of Baffin Island. Potential earthquakes of these magnitudes will be incorporated into facility engineering designs, in compliance with National Building Code of Canada regulations.

2.1.3 Geotechnical and Geomechanical Conditions

Geotechnical (soil mechanics) and geomechanical (rock mechanics) investigations were conducted from 2006 to 2008 to evaluate the soil, bedrock and permafrost conditions at locations where project infrastructure will be situated at the Mine Site, Railway and port facilities. Additional field investigations were carried out in 2011 to complement subsurface data from the previous investigation programs.

Air photo interpretation (API) studies were completed by Knight Piésold Ltd. and EBA Engineering Consultants Ltd. (EBA) in 2008. The interpretations were completed for the mine site area, rail alignment

(including the Ravn River alternative alignments) and Steensby Inlet Port Site (Knight Piésold, 2008d - 2008g). The objectives of the API were to:

- Map the surficial deposits along in areas of project infrastructure;
- Identify and map hazardous permafrost-related geomorphic processes and landforms and recent slides; and
- Aid in the scoping of ongoing site investigation programs.

Black and white aerial photographs taken at a scale of 1:30,000 in 2005 were used in this study. The air photos were examined with a stereoscope. The mapping incorporated the delineation of surficial geology units, relief features and hazardous permafrost-related geomorphic landforms and recent landslides in the vicinity of the Railway alignment. The base maps included the ortho-rectified images and the 5 m contours from the LIDAR survey. To supplement these results, the entire Railway alignment was walked by foot in July-August 2007 and observations of ground conditions were recorded and used to update the air photo interpretation.

In addition to the API, the methods that have been used for the Project include the following:

- Site reconnaissance and surface mapping for all areas;
- Geotechnical drilling using diamond drilling techniques;
- Excavation of shallow test pits by hand and mini-excavator;
- Collection of soil and bedrock samples for on-site and laboratory testing;
- Installation and monitoring of thermistors;
- Oriented core drilling for rock mass classification; and
- Geophysical surveys.

The drilling, thermistor installations and test pitting completed between 2006 and 2011 by Project area are summarized as follows:

<u>Milne Port (including once-proposed docks, stockpile areas, airstrip, roads)</u>

- Geotechnical Drilling: 39 holes

<u>Milne Inlet Tote Road (including once proposed road alignment, rock quarries and borrow sources)</u>

- Test Pits: 22 locations

<u>Mine Site (including open pit, general plant infrastructure and waste rock stockpile)</u>

- Geotechnical Drilling: 146 holes
- Geomechanical Drilling (open pit): 15 holes
- Thermistor Installations: 14 thermistors
- Test Pits: 19 locations

<u>Railway Alignment (including foundations, bridges, rock cuts and tunnels)</u>

- Geotechnical Drilling: 669 holes
- Geomechanical Drilling (tunnels): 8 holes
- Thermistor Installations: 52 thermistors
- Test Pits: 284 locations

Steensby Port Site Area (including on-shore infrastructure and docks)

- Geotechnical Drilling (off-shore): 110 holes
- Geotechnical Drilling (on-shore): 98 holes
- Thermistor Installations: 3 thermistors
- Test Pits: 11 locations

Borrow and Quarry Sources

- Geotechnical Drilling: 64 holes
- Test Pits: 19 locations

The results of the geotechnical investigations were summarized in a series of reports completed between 2006 and 2010 by Knight Piesold and AMEC(Knight Piésold, 2006, 2007a, 2007b, 2008a, 2008b, 2008c, 2008g, 2008h, 2010a, 2010b, 2010f; AMEC 2010a and 2010b), and by Thurber/Hatch in 2011.

The results were used for development of design recommendations and approaches for the project infrastructure. Recommendations related to foundation design, rail routing and embankment/bridge design, waste rock storage design, and slope design for the open pit and other excavations have been provided and incorporated into the design development of the various Project components.

2.1.3.1 Geotechnical Overview

The geotechnical conditions associated with the Project areas are summarized as follows:

Milne Port

The Milne Port area consists of a series of variably dipping, dissected terraces sloping towards the waters of Milne Inlet. The surficial deposits are marine and glacial marine sediments, ranging from coarse beach sediments (gravel and sand) to finer deltaic sediments (clay, silt, sand and gravel) to even finer deep water periglacial silt veneers (silt, clay and fine sand). The soils in the area are often covered by a thin layer of organics at the ground surface. The soils were noted to typically be frozen below 2 m depth and contain ice lenses (AMEC, 2010a, Thurber, 2011a). Offshore drilling encountered loose to compact silty sand underlain by sand containing varying amount of gravel and cobbles (Thurber, 2011b)

Milne Inlet Tote Road

The Milne Inlet tote road generally follows a glacial valley oriented northwest-southeast to the Mine Site. The surficial deposits along this alignment were reviewed in 2006 (Knight Piésold, 2006), in 2009 (EBA, 2009) and most recently in 2010 (AMEC, 2010b) and generally include the following materials:

- Till deposits: veneer (up to 2 m thick) or blanket (up to 10 m thick) with drumlins and moraines (in places);
- Glaciofluvial sediments: outwash gravel and sand forming braided floodplains, terraces and fans or stratified glacial drift (gravel and sand);
- Limited bedrock exposure: especially nearer to the Mine Site/Deposit No. 1 area; and
- Mary River flows across the glacial valley to the southeast of the Mine Site, and several thaw lakes and thermokarst depressions are located along the valley floor.

Mine Site

The results of recent investigations completed for the mine site areas were summarized in a series of factual reports (Knight Piésold, 2007a, 2008b, 2010b, Thurber 2011a,). Deposit No. 1 is located along the top and margins of a bedrock hill on the north side of the valley, while the waste rock piles will be located along the west-facing and east-facing side slopes of the hill. Bedrock is exposed at the apex of the deposit with talus present on the upper slopes. The mid slopes on the east side of the deposit comprise up to 50 m (vertical depth) of glacial till, tapering out to near surface bedrock at the base of the slope. The till on the north and west side of deposit is shallower, in the 10 to 15 m range. The till around Deposit No. 1 is typically dominated by boulders, cobbles, gravel and trace to some organics and a moderately thick, wet organic layer is present over the majority of this upper area. The overburden materials are considered to be very ice-rich based on site investigations, observations from bulk sample road construction and general understanding of the deposit.

Other Project-related infrastructure in the Mine Site area will be located on areas of glaciofluvial terrace along the valley floor directly south and southwest of Deposit No. 1. In addition to the glaciofluvial deposits, there appears to be some direct glacial deposition in and around the south-eastern portion of Sheardown Lake. Overburden depths over the majority of the valley floor are typically noted to be in the 10 to 20 m thickness ranges. Based on the investigations and surficial features in and around these deposits, evidence of ice-rich areas and localized massive ice bodies are present, particularly in the vicinity of the existing airstrip areas. A thin organic layer is present in some areas, over the till, in depressions and at the base of some slopes.

Underlying the glaciofluvial materials southwest of the deposit in the valley floor is weak, unconsolidated sandstone; gneissic bedrock to the south, west and north of Deposit No. 1; and amphibolite schists to the east. Often, the upper horizon of the bedrock is highly fractured and often contains ice lenses and/or infilling in the joints.

Railway Alignment

The following points provide a summary of the geotechnical conditions along the Railway alignment, based on studies and investigations completed to date (Knight Piésold, 2007b, 2008c, 2010f, Thurber, 2011a, 2011c, 2011d). Descriptions are provided according to kilometre posts (kp) that demark the length of the Railway alignment.

- kp-0 to kp-26: This portion of the alignment primarily comprises glacial-alluvial sand and gravel, with some minor pockets of glacial till present along the slope of the escarpment to the northeast. Throughout the area, frost wedges, upward soil displacements and evidence of some thermokarst ponds (subsidence due to melting ice) can be observed, indicating that the alluvial materials contain considerable amounts of ground ice. Of the One-hundred-and-thirty (130) drillholes and sixty-two (62) test pits completed relatively along this section of the main rail alignment, many encountered evidence of high ice content, and some massive ice lenses were observed within the glacial-alluvial terraces, often starting within 3 to 3.5 m of the ground surface. The sand and gravel soil typically contains cobbles and boulders. Bedrock encountered to approximately kp-24 consist of sedimentary rock (sandstone), and changing into granitic bedrock after kp-24.
- kp-26 to kp-42 (original alignment): This segment, once investigated, was abandoned in favour for an alternate alignment between kp-26 and kp-46.5. It is dominated by a relatively deep cover of finer grained glacial till. The area is generally low lying and flat, with relatively poor drainage characteristics. Much of the area is blanketed by a thin layer of organic material, and boulders are often present at surface. There are some localized eskers in the vicinity of kp-28.5 and kp-30, in addition to some localized mounds of glacial-alluvial or alluvial materials overlying the till. No significant bedrock outcrops were observed along this section of the route. Evidence of high ice content was encountered in many of the 41 drillholes and 36 test pits completed along this section of the main rail alignment, and

some massive ice lenses were observed within the glacial-alluvial terraces, often starting within 3 m of the ground surface. The drillholes confirmed that the overburden is relatively deep, averaging 15 to 16 m depth; the shallowest overburden depth encountered was less than 1 m and the deepest more than 28 m. Hummocky ground with numerous mounds, undulations and depressions exist along this segment, specifically between kp-32 and kp-37. Drilling confirmed that this hummocky terrain often has a core of massive ice or ice rich soil, which is often very close to the ground surface.

- kp-26 to kp-34 : This section follows the toe of a steep slope with surficial evidence of slope instability. Solifluction lobes and debris flows were noted along portions of this segment. There is a significant organic cover over the area and ice-rich materials, including large bodies of ice/ice and soil, were confirmed at a number of locations. Boreholes drilled up to approximately kp-31 is typically less than 10m depth and mostly encountered no bedrock. Boreholes drilled between kp-31 and kp-34 encountered granitic bedrock. The overburden materials generally consist of very ice rich silty sand and gravel with many cobbles and boulders (glacial till). Significant finer materials were noted in many of the drillholes and near surface in the test pits completed in this area. The materials vary greatly both spatially and with depth. Twenty (20) drillholes and sixteen (16) test pits were completed along this segment.
- kp-34 to kp-39 : This section generally consists of active alluvial fans with apparent seasonal lateral changes in the location and direction of the channels. There is limited organic cover. Ice rich materials were confirmed in a number of the drillholes, with large bodies of ice/ice and soil between kp-37 and kp-39. Overburden materials vary in, with the deepest overburden encountered in the 10 to 20 m depth range between kp-36 and kp-38. The majority of this section had overburden depths in the range of 3 to 8 m. The overburden materials generally consist of ice rich sand and gravel with many cobbles and boulders (glacial outwash material). Twenty-six (26) drillholes and thirteen (13) test pits were completed along this segment, including drillholes in the vicinity of a proposed bridge site near kp-37.5 (Ravn River).
- kp-39 to kp-41 : This section is covered with a deposit of glacial moraine. There is evidence of thermokarst and polygonal patterned ground throughout the area, typical of ice rich glacial deposits. There is a very thin organic cover over portions of this area. Ice rich materials were confirmed in some of the drillholes with large bodies of ice/ice and soil encountered adjacent to the alignment at kp-40; however, it is suspected that the majority of this area contains very ice rich soils. Overburden materials range in depth from 4 m to 10 m and generally consist of ice rich, silty sand and gravel with many cobbles and boulders (moraine) overlying granitic bedrock. Five (5) drillholes and eight (8) test pits were completed along this segment.
- kp-41 to kp-46.5 (preferred re-alignment): This portion of the alternate rail alignment is generally dominated by relatively stable gently sloping terrain with little evidence of thermokarst and only few areas of poorly defined polygonal patterned ground. There is a moderately thick layer of organic cover over the majority of this area. It is suspected that the majority of this segment contains ice poor soils. Many areas are poorly drained with wet ground conditions at surface. Overburden materials are relatively thin, with bedrock typically encountered within the upper 2 to 3 m from surface. The limited overburden materials generally range from silty sand and gravel (till) to gravel outwash materials, often stratified in nature. Eleven drillholes and sixteen test pits were completed along this segment.
- kp-41 to kp-51: This segment of the alignment generally has a thin veneer of finer grained glacial till over highly fractured granitoid gneiss. The initial 6 km is generally dominated by relatively stable, gentle

sloping terrain, often blanketed with a thin layer of moist to wet organics. It is suspected that the majority of this segment contains ice poor soils, with many areas are poorly drained with wet grounds at surface. Highly fractured bedrock outcrops were noted, becoming more predominant beyond kp-47. Thirty-nine (39) drillholes and twenty-four (24) test pits were completed), including drillholes of a proposed bridge site near kp-46. Most of the deepest overburden encountered was less than 8 m. While most drillholes were completed in areas where overburden soils were suspected to be thickest, the average overburden depth encountered was in the range of 2 to 4 m. Ice rich soils that may be frost/thaw sensitive should be expected due to the presence of finer grained soils and a wet till layer between kp-41 to kp-42 and kp-44 to kp-45.

- kp-51 to kp-70: This segment is dominated by Felsenmeer-type terrain with frost shattered and heaved bedrock and angular boulders present at surface, indicative of ice rich, fine grained till over weathered bedrock. Approximately half of this section consists of wetter, low lying areas with a thick organic layer at surface. Overburden depths are relatively shallow,; there is evidence of ice rich soils near surface in the majority of the holes. Ranging from less than 2 m to just over 20 m of overburden, the average depth of overburden was 6 to 7 m and generally consisted of a matrix of ice rich boulders, cobbles, sand and gravel, often with a thin to significant layer of moist to wet organics at surface. Ice or ice rich soil was noted within 1 to 2 m of the ground surface in many drillholes. Forty-six (46) drillholes and Twenty-four (24) test pits were completed along this segment.
- kp-70 to kp-78: This section is generally dominated by a surficial veneer of glacial till with some wetter organic covered areas and numerous bedrock outcrops. Overburden depths are relatively shallow; however deeper deposits were encountered up to 22 m deep in vicinity of kp-75. Some evidence of ice rich soils near surface was encountered in many of the holes. Thirty (30) drillholes and two (2) test pits were completed over this segment of the alignment.
- kp-78 to kp-116.5: The initial portion of this segment is dominated by exposed high quality granitoid gneiss up to the Cockburn Lake bridge crossing (kp-95 to kp-97) where alluvial type material is prevalent in the valley bottom. South of the bridge location, exposed bedrock dominates the general conditions and geology of the area; however, overburden thickness increases significantly in some areas with intermittent glaciofluvial deposits, colluvial aprons, talus slopes and till blankets along and near the alignment. Evidence of solifluction activity was noted between kp-97.5 and kp-99. One-hundred-and-fifty-two (152) drillholes, including nineteen (19) at Cockburn Lake bridge crossing (in vicinity of kp-95.5 and twenty-five (25) test pits were completed over this segment. Two proposed tunnels are also located within this segment, near kp-102.5 and kp-109.
- kp-116.5 to kp-126: This portion of the alignment skirts along the base of the bedrock escarpment on the east side of Cockburn Lake. A significant portion of the segment is dominated by alluvial terraces at the base of the exposed bedrock, adjacent to Cockburn Lake. Talus slopes are also present between kp-19.5 and kp-22.5. Evidence of thermokarst development within the alluvial terraces indicates the presence of ice rich materials, massive ice bodies or possible buried glacial ice. The depth of overburden along the majority of this portion becomes significantly deeper with overburden commonly greater than 15 or 20 m. Fifty (50) drillholes, and twenty-one (21) test pits were completed over this segment.
- kp-126 to kp-132.5: The area is generally dominated by low lying glacial-alluvial deposits, glacial till and low lying wet areas typically blanketed with a surficial layer of wet organics. Ice was commonly observed directly below the organics layer, often less than 0.3 m from the ground surface. The

overburden deposits along this segment are typically deep and are anticipated to be slightly ice rich based on the polygonal patterning identified at surface. Thirteen (13) drillholes and six (6) test pits were completed over this segment.

- kp-132.5 to Steensby Port: The section of alignment is generally undulating and dominated by exposed bedrock. Small deposits of glacial till and glacial-alluvial materials, often with a thin layer of wet organics at the surface, are present in the low drainage areas between the exposed bedrock and on some of the natural slopes adjacent to small lakes and waterways. Saline permafrost may be an issue further south. Field readings taken indicated that salinity was less than 3 ppt in most cases and was between 1 and 3 ppt in less than ten cases. Forty-six (46) drillholes and nine (9) test pits were completed over this segment, including two proposed bridge crossings at approximately kp-137 and kp-141.

Steensby Port

In general, the area was found to be primarily either exposed bedrock hills or bedrock very close to surface. Lower depressions between the hills generally have a moderate layer of wet organics at surface and drainage is poor. These lower areas have a range of materials present from colluvial/alluvial type deposits to till, with significant fines present. In areas where overburden was present, this generally comprised of a thin layer of organics, underlain by moist gravely sand with some silt with some higher ice content and ice-rich materials noted. Some clay and silt materials were encountered toward the southwest side of the site. Overburden depths greater than 13.5 m were encountered; however, typically the depth of overburden ranges from 4 to 8 m in these lower areas. The underlying granitoid gneiss bedrock is generally of moderate to good quality across the footprint of the proposed rail maintenance shop.

2.1.3.2 Geomechanical Overview

Mine Site

The results of investigations completed to study the rock associated with the open pit was previously summarized in the investigation and design recommendations report for the open pit (Knight Piésold, 2010a). At the Mine Site, specifically in the area of the proposed open pit, a number of different rock masses were identified and investigated and subsequently divided into geomechanical domains for design purposes. The domains were defined along lithological boundaries and three main geomechanical domains were identified:

- Hangingwall Rocks consisting primarily of Tuffs, Amphibolites and Schists.
- Ore Body consisting primarily of High Grade Magnetite, High Grade Hematite and Mixed Ore.
- Footwall Rocks consisting primarily of a Gneissic rock mass that locally grades to Schist.

Although there are some strong local variations, each domain generally has discontinuities from three main joint-set families and will often appear blocky when exposed on the pit walls. In some cases the minor joint-set orientations will be widely spaced and in other cases a wide range of orientations will be present at the same location and local ravelling failures will be likely. In all cases, the dominant discontinuity can be expected to be parallel to the local dip of the Ore Body and its orientation will change depending on position relative to the Deposit No. 1 syncline.

Unconfined Compressive Strength (UCS) results from the field and laboratory testing suggest medium to strong intact strengths of 30 to 85 MPa for each domain. Rock mass qualities as suggested by the Rock Mass Rating (RMR89) system, vary widely but are generally in the fair to good range. The exception to this is within the Fold Axis (the point where the North and South Limbs join) where all rock mass qualities were poor to fair. The diamond drilling program encountered a relatively large number of shears and faults, which can be characterized as sheared, broken or rubble zones. These regions also have reduced rock mass qualities and were more frequently encountered in the hangingwall and the Ore Body domains. While some of these are likely to locally affect bench integrity and could even affect overall wall stability at some locations, investigations from nearby drillholes suggest that a substantial proportion of these may not cross-cut lithology or be particularly persistent.

Potential Quarry Sites

The results of investigations completed for the quarry sites were recently summarized in the site investigation report for the Railway (Knight Piésold, 2010f). Additional field investigation on the proposed quarry sites were completed in 2011 (Hatch, 2011a).Potential borrow source/quarry locations were given an overall site suitability rating from poor to good, based on a combination of estimated size, haul distance to right-of-way, material suitability and constructability. Further work will be completed on these potential material sources as the project advances through the more detailed design phases.

In terms of the ballast testing, the results of the AMEC laboratory testing on the saw-cut suggested that only one of the eleven samples passed the Los Angeles Abrasion test, seven met the requirements for the Mill Abrasion test, and all tests failed to meet the limits specified for shape factor. Failed tests might be contributed to the limited amount of samples and the use of cored samples available for the make-up of the specimens prepared for the testing. More samples were collected in 2011 and additional physical and geochemical tests are currently being initiated.

Rock Cuts along the Railway

The results of investigations completed at the location of rock cuts along the Railway alignment are summarized in the site investigation report for the Railway (Knight Piésold, 2010f). Surface reconnaissance was undertaken for the smaller rail cuts (<15 m height) and core samples were taken from nearby geotechnical drillholes for the purpose of geochemical testing. Ore detailed site investigations for the rail cuts (i.e., >15 m height) were completed based on the height of the expected cut, the idea being that stability concerns and the information needed to support design decisions will increase with cut height. The data collected will eventually need to be analysed and supplemented with additional information in order to provide recommendations on achievable bench geometries. As it stands now, the strategy discussed with Canarail involves providing blanket recommendations for all smaller cuts with specific designs for the larger cuts and for any ones with recognized slope stability challenges. The primary areas of focus for the cuts along the alignment included:

- Cut kp-122+750 (Turntable Corner): the proposed cut at chainage 122+750 is approximately 200-250 m in length and has a maximum cut height approaching 30 m.
- Cut kp-132+750 (Saddle): the approximate size of the cut at 132+750 is 200 m in length with a maximum cut height approaching 20 m.
- Cut kp-133+450 (BAL1): the cut located at 133+450 is also the site of the favoured ballast material borrow source (BAL1). If selected as the ballast quarry, this cut would be increased in size to meet the ballast needs for the entire rail line. In its current configuration, this cut is greater than 40 m in height and is 200 to 300 m in length.

- Cut kp-138+470 (BAL2): the approximate size of CUT138+470 is 400 m in length and with a maximum height approaching 30 m. This cut is also being considered as a potential ballast source (BAL2). While BAL1 remains the favoured source, if BAL2 is selected, then the cut will be enlarged.

Railway Tunnels

Investigations (surface mapping and geomechanical drilling) were conducted for the North and South tunnels. The rock type encountered in each drillhole, at either tunnel, was variations on the gneissic material found throughout this area. Stereonets for the North and South tunnel orientation data were presented in the site investigation report (Knight Piésold, 2010f).

Geotechnical site investigations were completed to support the rail tunnel design and the specific objectives of the investigations were to determine the rock mass characteristics along the path of the tunnel and to recognize any particular ground control challenges that might be encountered during excavation. The completed investigations involved site reconnaissance, surface geomechanical mapping and four oriented and triple-tubed drillholes. All drill core was logged, photographed and samples were taken for ARD testing, unconfined compressive strength (UCS) and basic friction testing.

The rock type encountered at both tunnels was variations on the gneissic material found throughout the area. Available data and results from the investigations are presented below.

North Tunnel

Due to the available bedrock exposures, only spot mapping was undertaken in the vicinity of the North Tunnel alignment. Ten locations were mapped in the northern area and a number of measurements were made over a large area in the region of the South Portal. This latter mapping region was at a lower elevation than the mapping carried out to the north and was primarily along an exposed rock face.

Three of the oriented geomechanical drillholes for the tunnels were located along the North Tunnel with the objective of collecting rock mass information as well as supplying a thermistor location (discussed below). From the three drillholes, a total of 19 UCS, 9 ARD and 6 Basic Friction (BF) samples were taken.

Three additional drillholes were completed in 2011 (Thurber, 2011a), and a number of UCS tests were completed by point load tests of selected core samples. Three rock samples, one from each boreholes were subjected to direct shear tests, performed at Queen’s University, Kingston, ON.

South Tunnel

The majority of the South Tunnel area is exposed bedrock, of which three zones of surface mapping have been completed (made up of 6 individual traverses). The three zones are spread across the top of the tunnel area. One oriented geomechanical drillhole was completed along the South Tunnel. An additional drillhole from an earlier geotechnical investigation program was also located in the South Tunnel area. Both holes were logged for geomechanical properties and a total of 5 UCS, 3 ARD and 3 BF samples were taken.

Due to the similar rock type and quality, the strength test results for both tunnels were combined together. These results were provided in the site investigation summary report (Knight Piésold, 2010f).

One additional drillhole was completed in 2011 (Thurber, 2011a), and a number of UCS tests were completed by point load tests of selected core samples. One rock sample was subjected to direct shear tests performed at Queen’s University, Kingston, ON.

2.1.4 Geochemistry

Geochemical assessments of the potential for metal leaching and acid rock drainage (ML/ARD) have been completed for the Mine Site and for prospective quarry and borrow sites along the Railway alignment and existing Milne Inlet tote road. A summary of the work completed is provided in the following sections. Mine Site

AMEC (2010c) has evaluated existing geochemical studies and completed additional sampling of rock materials from drill core that are expected to be representative of the waste rock produced during mining. Geochemical characterization of rock materials from this and previous studies has been completed using industry-standard ML/ARD assessment techniques. In addition, AMEC has evaluated drainage and runoff data from existing stock piles to assess the potential mine drainage quality at the site during mine operations and closure. A full report on these studies is provided in Appendix 6B-1 and summarized below.

A total of 277 drill core waste rock samples (including an additional 180 samples from current studies) were submitted for Acid-base Accounting (ABA) testing. Results of this testing has determined that approximately 86 % of the waste rock samples are unlikely to generate acidic drainage in the future. The remainder of the samples were classified as potentially acid generating (PAG) materials.

Drainage quality expected at the site, based on monitoring of existing ore stock piles, is expected to be circum-neutral to mildly acidic (pH 5.5 to 6) with generally low metal concentrations.

The current mine plan includes encapsulation of the PAG rock within the core of the waste rock pile. Based on the proportion of PAG samples and the findings of the ML/ARD characterization study, this proposed approach appears to be a viable method for minimizing any ML/ARD effects on the environment. Additional geochemical studies, including further kinetic testing, are continuing to evaluate and refine this option. Additional testing is planned to better understand the kinetics of potential acid leaching behaviour and further refine the expected drainage quality and metal leaching behaviour from materials at the site.

2.1.4.1 Milne Inlet Tote Road

A screening level ML/ARD assessment has been completed for a number of proposed quarries and borrow pits along Milne Inlet Tote Road. Full details of this investigation (AMEC, 2010d) are provided in Appendix 6B-2 and summarized below.

At the time the Milne Inlet Tote Road was being considered for upgrading, drill core and unconsolidated surficial materials were collected from potential quarry and borrow pit locations along the route during a geotechnical investigation and aggregate sourcing program. Selected samples from that program were submitted for geochemical analyses. The objective of sample selection for ML/ARD characterization was to collect samples representative of the geochemical variation of the different soil and rock types expected to be used as borrow and quarry material for the Milne Inlet Tote Road upgrade.

The geology along the route includes both relatively flat lying Paleozoic sedimentary rocks and more structurally complex Precambrian rocks. Potential quarry sites sampled for this study include granitic gneiss and schist along the Precambrian portion of the route and carbonate rich sedimentary rocks in the Paleozoic section. Borrow materials sampled include sand and silty sand with variable quantities of gravel, cobbles and boulders.

Sulphide content of all samples was low (maximum of 0.04 % total sulphur), and all Paleozoic rock samples analyzed were carbonate rich (mostly limestone or dolomite). Borrow materials were also carbonate rich; only a single sample was carbonate deficient with a correspondingly low neutralization potential. The

Precambrian rocks consistently exhibited a low neutralization potential with little evidence of carbonates. Diligence through adequate levels of sampling and monitoring during extraction operations will be necessary to ensure that the low concentrations of sulphide observed in this study are confirmed elsewhere, particularly for any materials identified as having low neutralization potentials.

Based on this screening level ML/ARD assessment, the once proposed quarries and borrow pits along the Tote Road route appear to have a low potential for ML/ARD and are expected to be suitable as quarry or borrow sources. Individual quarry and borrow sites will be subjected to additional site specific ML/ARD characterization at a sampling density sufficient to address potential geological variability. Collection and analysis of material from future drilling or excavation programs related to quarry and borrow pit development is planned.

2.1.4.2 Railway

A screening level ML/ARD assessment has been completed by AMEC for a number of rock materials expected to be representative of future quarries along the Railway alignment. As for the above described Milne Inlet Tote Road route, the Railway alignment follows both Paleozoic sedimentary and Precambrian metamorphic and intrusive rocks. This ML/ARD assessment used selected samples of targeted Paleozoic rock (sandstone), and Precambrian rocks (felsic intrusive and metamorphic gneiss) sampled by Knight Piésold in 2008. Full details of this investigation (AMEC, 2010e) are provided in Appendix 6B-3 and summarized below.

The three rock-types investigated along the Railway alignment appear to have a low potential for ML/ARD and should be suitable as quarry sources. However, due to the screening level nature of this assessment, individual quarry sites should be subjected to additional site specific ML/ARD characterization. The relatively low NP in most of the rocks analyzed suggests that the presence of low contents of sulphide could result in ML/ARD conditions. Adequate levels of sampling will be necessary to ensure that even low concentrations of sulphide are identified.

In addition, two samples of gneiss were identified that are potentially acid generating. This result and the expected heterogeneity of this unit suggest a greater level of characterization of gneiss may be warranted. Further integration of regional geological information with site specific data may aid in further assessment in the complex Precambrian terrane. If quarry material is required in the vicinity of the potentially acid generating gneissic rocks near the North End of Cockburn Lake, an investigation sufficient to understand the distribution of these more sulphide rich materials and their ML/ARD characteristics will be conducted.

Additional physical and geochemical testing from selected cored samples from the proposed quarry sites drilled in the 2011 drilling program had been initiated and currently in progress (Hatch, 2011a)

2.1.5 Groundwater/Hydrogeology

Groundwater flow in the LSA consists of seepage through unconsolidated materials within the active layer, which typically ranges from 1 to 2 m (up to 3 m) below surface. This groundwater reports to local surface drainages and lakes.

As described in Section 2.1.1.4, the Project is located in a zone of continuous permafrost, which extends to a projected 610 m below ground surface at Deposit No. 1. As such, no groundwater flow is anticipated to exist below the active layer. This conclusion is supported by observations at other mine sites in northern latitudes, including the Polaris[1] and Nanisivik underground mines, as well as the EKATI™ mine where open pits in moderately faulted granite did not generate groundwater until the pits extended below the limit of permafrost at around 350 to 400 m depth below ground surface (Kevin Jones, pers. comm.).

Based on these empirical examples, the Deposit No. 1 open pit is not expected to develop significant groundwater inflow below the active layer. This is further supported by the fact that the open pit will be developed in relatively high quality bedrock, with minimal faulting. In addition, the area has generally colder mean temperatures, is topographically higher, and has a deeper permafrost zone than the previously cited examples. In addition, site geologists have reported that ground ice is present in fractures in the rock.

2.2 ISSUES SCOPING

Issue scoping completed by the Project team for the landforms, permafrost and soil VEC included:

- literature review of previously completed geotechnical and permafrost studies within and immediately surrounding the study area;
- Company and consultant mining and geotechnical experience;
- Baffinland experience carrying out the bulk sample program in 2007 and 2008;
- review of applicable legislation, policies, and guidelines;
- Mary River Project team scoping meeting held in November 2007;
- geotechnical and geomechanical investigations conducted for the Project in 2006 through 2008;
- soils investigations carried out in 2007 and 2008; and
- NIRB scoping sessions in April 2009, its scoping report, and EIS guidelines.

These scoping activities identified sensitive landforms as a key indicator for assessment within the landforms, soils and permafrost VEC, based on the scoping process and the criteria presented in Volume 2, Section 3. Thaw sensitive soils and massive ice deposits common to permafrost regions including the Project area, are the most common sensitive landforms in the RSA. These areas are typically identified through the existence of patterned or hummocky ground, thermokarst areas, areas of mass wasting, solifluction slopes, etc.

2.3 SENSITIVE LANDFORMS

Sensitive landforms, defined as landforms which are sensitive to disturbance, is a key indicator for the landforms, soils and permafrost VEC. The most common sensitive landforms in the RSA are thaw sensitive soils and massive ice deposits which are common to permafrost regions.

2.3.1 Assessment Methods

Geotechnical investigations have been conducted across the PDA but in most cases not at a scale that can identify sensitive landforms at the scale that they occur. Some broad mapping of sensitive landforms was completed for the Railway. Therefore, a qualitative assessment of the effects of the Project is used to assess the significance of residual effects.

Thaw-sensitive soils 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 borderline ice rich can be thaw

[1] The Polaris mine encountered problems with groundwater coming into the mine causing temporary closure of the mine. However, the water was due to thawing of permafrost in ice-rich rock (shale) due to the ventilation system, rather than natural groundwater inflow. The ventilation system was subsequently renovated and there were no additional problems with underground water accumulations in the mine as it was extended to a total depth of approximately 450 metres. The mine was not extended deeper due to incompetence of the shale, rather than groundwater inflow problems. (K. Jones, pers. comm.)

sensitive if they are fine-grained (i.e., have a low enough permeability). The two main issues with thaw sensitive soils are thaw settlement and thaw weakening.

Thaw settlement is due to loss of ice volume upon melting. Melting may occur when the thermal regime of permafrost soils is disrupted or changes. Thaw settlement is a process that occurs naturally, as evidenced by thermokarst topography within the terrestrial RSA, which consists of irregular pits and depressions formed by the melting of massive ground ice. Ground disturbance activities such as excavation/cuts, fills, and changes to drainage patterns can change the thermal regime and induce thaw settlement. Therefore, road and Railway construction, development of borrow areas for aggregate, and the clearing of project development areas have the potential to affect sensitive landforms.

Thaw weakening is due to inability to dissipate excess pore pressure upon melting of the soil and soil loses strength. This weakening occurs more often with soils that are fine grained and are saturated. These soils cannot support the weight of vehicles and equipment, and if excess weight is applied to these soils, severe rutting and erosion may occur.

2.3.1.1 Potential Sensitive Landforms

For the Project, effects to sensitive landforms are primarily related to changing the thermal regime of permafrost. High ice content soils and thaw sensitive soils are the primary issues which lead to areas with potential for slope/ground instability. Areas of solifluction, active thermokarst, and previous/ongoing ground movements (slides) result from changes to thermal regimes and have been identified in the Project area as part of the geotechnical investigations conducted to date.

Potential issues that have been identified relating to sensitive landforms for specific areas of the Project are summarized below.

Milne Port

- Potential for ice-rich permafrost and ground ice;
- Potential for saline permafrost (i.e., high salt content pore ice); and
- Thaw sensitive ground.

Milne Inlet Tote Road

- Potential for shallow ice-rich soils and ground ice; and
- Thaw sensitive ground (Thaw Weakening/Liquefiable Soils).

Mine Site

- Thermokarst terrain in the air strip area;
- Random subsurface massive ice deposits;
- Ice-rich soil and rock;
- Solifluction features on the slopes near to and adjacent to Deposit No. 1; and
- Active thermal erosion adjacent to the toe of the deposit.

Railway Alignment

- Debris flows carried by significant runoff events in creek and rivers crossings along the alignment;
- Recent thaw flows along and crossing the alignment;
- Thermal erosion features on slopes including solifluction lobes and recent debris flows at various locations along the alignment;
- Areas of massive ground ice and ice-rich soils;
- Active fluvial deposition/fans at various locations along the alignment;

- Potential ground ice-cored hummocks;
- Thermokarst lakes identified locally along the alignment;
- Polygon patterned ground at various locations;
- Talus slopes along the northernmost section of the alignment and throughout the Cockburn Lake area;
- Rock falls as a potential hazard, primarily along Cockburn Lake where the rail alignment passes through terrain where the track or embankment could be affected by rock fall material from the adjacent cliffs; and
- Thaw sensitive ground.

Steensby Port

- Potential for thermokarst development in ice-rich organic soils along road alignment; and
- Potential for saline permafrost (i.e., high salt content pore ice).

These areas and issues will be further investigated as the Project advances through the ongoing design and ultimately construction phases.

2.3.2 Potential Effects and Proposed Mitigation

Generally, the following Project activities have the potential to affect sensitive landforms, where they occur:

- Fills over the existing ground which can change drainage patterns and consequently disrupt the thermal regime;
- Earth-moving: excavation, drilling, grading, trenching, backfilling;
- Ore and freight dock: piling, blasting, dredging, extraction, drilling;
- Aggregate sources/ borrow sites (permanent): drilling, blasting, extraction, hauling;
- Fuel storage and distribution (permanent): construction of bermed facility, operation of trucks;
- Waste management: garbage and sewage waste facilities, including incinerator use;
- Water use and management: water supply intake, pumphouse, pipeline, ditching, ponding, berms, and snow management and stockpiling;
- Ore stockpiles and transport;
- Construction of roads and railway: land clearing, blasting, grading, water body crossings;
- Power generation and distribution: installation of surface structures, land clearing; and
- Closure activities including dismantling and removal of infrastructure, demolition, drainage restoration, excavation and backfilling/plugging, waste management, and ground restoration, open pit closure, waste rock storage facility restoration, revegetation.

Table 6-2.3 discusses sensitive landforms that have been mapped within the PDA, along with the potential Project activities that could affect them adversely.

Avoidance of sensitive landforms and potential hazard areas is the first mitigation measure that has been used in the planning of the project to date. Not all areas of concern can be avoided. The following sub-sections provide an overview of the site specific potential effects and the proposed mitigation measures to be used in development of the Project.

Table 6-2.3 Activities That May Destabilize/Degrade Thaw Sensitive Landforms

Location	Activity	Sensitive Landforms	Project Phase
Milne Port	Ground clearing for additional facilities, including laydown areas	Ice rich permafrost Saline permafrost Thaw sensitive ground	Construction, lasting into post-closure
Milne Inlet Tote Road	Maintenance construction	Ice rich Permafrost Thaw sensitive ground	Construction, lasting into post-closure

Table 6-2.3 Activities That May Destabilize/Degrade Thaw Sensitive Landforms (Cont'd)

Location	Activity	Sensitive Landforms	Project Phase
Mine Site	Ground clearing for additional facilities, including accommodations and support buildings, access roads, and laydown areas, upgrading the existing airstrip, foundation preparation for waste rock disposal areas, open pit development , machine and equipment pads	Ice rich permafrost Thaw sensitive ground	Construction, lasting into post-closure
Railway	Construction of Railway and a construction access road along the rail alignment, development of quarries and borrow areas along the rail alignment	• Ice rich permafrost • Thaw sensitive ground	Construction, lasting into post-closure
Steensby Port	Ground clearing for additional facilities, including laydown or work areas, concrete batch plant, bulk fuel storage areas, access roads, and temporary personnel accommodations; construction of a temporary port site; development of the airstrip; and construction of access roads and Railway construction camps	• Ice rich permafrost • Saline permafrost • Thaw sensitive ground	Construction, lasting into post-closure

Mine Site

A number of sensitive landforms were identified in the vicinity of the Mine Site. The majority of these were associated with high ground ice contents or massive ice deposits identified during interpretation of air

photos and site reconnaissance (patterned ground) and subsequently verified in some areas through site investigations (drilling). Particular areas of concerns are outlined as follows:

- Deep, ice-rich till deposits associated with open pit perimeter and waste dump locations;
- Solifluction slopes near mid-slopes of deposit and base on slopes near valley floor;
- massive ice bodies and ice-rich glaciofluvial areas in valley floor where majority of surface infrastructure will be located; and
- Ice cores moraines along slopes and in valley floor.

The mine site will consist of the following infrastructure that may interact with sensitive landforms:

- Open pit overburden slopes;
- Waste dumps;
- Haul roads;
- Stockpiles, rail loading infrastructure and spurs;
- Tank farms, power plants, various building infrastructure; and
- Solid waste disposal site (landfill).

The following provides a general summary of the specific design measures being incorporated for the various Mine Site infrastructure.

Open Pit Overburden Slopes

The majority of the open pit slope design work focused on the bedrock. However, the overburden located on the east edge of the proposed pit was previously identified as an area for concern due to depth and suspected high ice contents and geotechnical drilling was completed to assess the conditions in this area. In general, the overburden was found to be shallower toward the north and was primarily glacial till ranging in depth from 46 m toward the south, and underlain by highly-fractured hematite ore, to 9 m, toward the north, and underlain by approximately 20 m of highly-fractured gneiss, followed by more competent gneissic bedrock.

The area investigated for the east pit slope overburden was generally dominated by a thin layer of organic material mixed with boulders, cobbles and flat rocks of various origins. The area was observed to be quite wet over most of the summer and demonstrated numerous features indicative of solifluction slope movements. The materials are anticipated to be ice rich to depth.

A preliminary stability review was completed for a typical overburden slope configuration (based on anticipated foundation conditions) to determine the factor-of-safety (FOS) against slope failure (Knight Piésold Ltd., 2008b). Protection of the cut slopes against thaw will be one of the most important aspects of the slope design, based on the assumption that the overburden will be ice rich in areas. Typically, thermal protection is accomplished through the application of thermal layer (i.e., sand and gravel or rockfill) placed against the slope. The recommended approach for the Mary River overburden slopes would involve a minimum 10 to 15 m setback from the edge of the bedrock slope and cutting to a maximum 2.25H:1 V with 10 m wide benches every 20 m in elevation, thus creating an effective slope of approximately 2.5H:1 V. This configuration would be stable, provided that adequate thermal protection is used and the natural soils in the slope remain frozen.

Excavation of the final slopes is best carried out in the winter, at which time the slope should be lined with a minimum 1 to 2 m thick layer of either sand and gravel or rock fill (i.e., waste rock). If sand and gravel is used, it should be covered with a 0.5 m thick layer of fine rock fill for erosion protection.

Proper runoff collection and diversions systems will need to be established to control runoff from the slopes and prevent erosion (and/or ponding of water on benches) from affecting the modified thermal regime. Collection ditches constructed along the benches should route flows to a central collection areas for sedimentation and removal via pumps. Ongoing monitoring of the slopes should be carried out during operations and regular maintenance should be expected.

Overburden and Waste Rock Dumps

The current mine plan sees the production of Non Acid Generating Waste Rock (NAG), Potentially Acid Generating Waste Rock (PAG) and waste overburden. The waste overburden is expected to be ice rich in nature and will be subject to thaw weakening and the production of significant quantities of sediment laden seepage. The current design has all three of these waste materials disposed of within the same dump area thereby enabling progressive encapsulation of the PAG and overburden within the chemically and physically stable NAG waste rock. This will minimize the generation of acid from the PAG waste rock and prevent/control the release of sediments from ice rich Overburden waste materials.

As a general rule, an initial layer of NAG waste will be placed over previously uncovered ground surface only during the winter months or when the active layer is fully frozen. This layer will act as a thermal barrier over the short term prior to placement of waste materials during warmer months and protecting the frozen ground surface from thaw during operations. Covering of unfrozen ground with waste rock would lock in heat, thus changing the thermal conditions of the ground and possibly thawing ice rich soils and reducing the stability of the dump foundations. Construction of the initial thermal barrier will also be completed such as to minimize water management requirements on thaw sensitive ground upslope of the work front. Only good quality, durable NAG waste rock should be used for this initial thermal layer. Other considerations/measures that will be made include:

- Disturbance of the natural ground surface will be minimized prior to placement of the thermal barrier. Existing organics and topsoil should remain frozen and in place to aid in protection of the thermal regime beneath the waste dump footprint. Only existing surface ice and snow should be removed from the footprint during the winter prior to placement of waste rock.
- Ultimately, an adequate layer of NAG material will be placed over and around the PAG and Overburden to provide a thermal barrier from thaw. The thickness of the encapsulating barrier will be adequate to prevent thaw even under the potential effects of climate change (i.e., increasing active layer).
- Depending on the site specific conditions encountered at the perimeter of dump footprint, a stability buttress (extension of thermal barrier) may be required at the toe in some locations to prevent minor localized stability issues due to thaw. The need for these buttresses will be reviewed following more detailed investigations as well as during operations of the dumps.
- Management of surface runoff will be an important component of the waste dump construction/operation. Minimizing erosion and/or the effect of flowing or standing water on the thermal regime within the waste dump foundation soils and in close proximity to the toes will be critical.
- Ongoing monitoring of the slopes will be required during operations. With the presence of ice rich foundations soils, creep settlement is expected to occur within the underlying foundations, leading to the development of cracks within the dump and at the dump surface. Any cracks that develop will be monitored and repaired as required to minimize inflow of surface water and subsequent ice wedge formation within the dumps.

The measures summarized above were previously outlined in a technical memo (Knight Piésold, 2010c). Additional drilling program and slope stability analyses for the waste rock dump were carried out in 2011 (Hatch, 2011b). Final details of the permafrost protection measures for the waste dumps will be designed for potential effects of climate changes either through use of conservative assumptions, or upon completion of detailed thermal modeling based on world recognized global warming scenarios as proposed by the Arctic Climate Impact Assessment 2005 (Arctic Council and International Arctic Science Committee, 2005).

General Mine Site Infrastructure

The Mine Site is located in an area of continuous permafrost conditions and therefore the foundation designs must consider its effect. Except for the buildings and facilities located part way up the access road to the open pit, the facilities are located in the Mary River Valley, where foundation conditions are typically ice-rich permafrost and competent thaw stable bedrock is not found within reasonable depth. The facilities located above the valley (e.g., truck shop, primary crusher, screener, etc.) have been sited in areas where they can be founded on competent bedrock. The foundations for all the facilities located in the valley must be designed in a way that permafrost is not thermally affected because for the most part they are located where the depth to competent bedrock precludes them from being founded on bedrock. All facilities in the area have been sited based on available geotechnical information (including air photo interpretation) as best as possible to avoid areas of potential geo-hazards or instabilities.

Specific details of the foundation types recommended to provide stable foundations and protect the underlying permafrost from degradation due to changes in the thermal regime from construction or climate change are outlined as follows:

Foundations on Bedrock — Where possible, buildings/structures will be founded on competent bedrock. To the maximum extent possible, infrastructure locations have been optimized to take advantage of this type of foundation.

Pile Foundations —Pile foundations can be either adfreeze or rock socketed, depending on the depth to bedrock. Adfreeze pile foundations are designed on the basis of allowable deformation from which the allowable stress is back-calculated using a creep deformation formulation appropriate for the ground temperature, porewater salinity and ice content conditions that exist at the location. Grouted rock socketed piles are an effective foundation alternative where the depth to bedrock is too great to utilize footings on rock but it is not so deep that excessive pile lengths would be required. Steel pipes are often used for grouted piles.

Granular Pads and Engineered Fills — The mine site facilities will typically be surrounded by, or constructed on, a pad of granular fill material. Pads can generally be constructed in a similar manner to the access and haul roads on site. The minimum thickness of pad to provide thermal protection to the underlying permafrost overburden soils and rock is estimated to be 1.5 m for pads that are subjected to only ambient temperatures. Similar granular materials will also be required to construct engineered fill for foundations and slabs. In both cases, it is anticipated that these materials will be produced from waste rock from mining operations or from quarried rock obtained from a suitable source of competent rock in the vicinity of the mine site. Where engineered fills are required to support slabs or foundations, the fill materials must be placed in a controlled manner and compacted to ensure adequate density and thereby adequate support for the structure. Chilled, Insulated Gravel Pads - In some cases, such as vehicle maintenance buildings where at grade access for heavy vehicles is required, it will not be possible to provide an air space below the building to prevent heat from the building from thawing the underlying permafrost. In these situations a chilled and insulated compacted gravel pad will be constructed below the building. Heat from the building will be prevented from thawing the permafrost below the gravel pad through the use of thermosyphons or air ventilation ducts.

A summary of some specific effects and mitigation measures associated with sensitive landforms around the mine site areas are summarized on Table 6-2.4.

Railway Alignment

Previous investigations consisted of air photo interpretations, geophysical surveys, conducting various surficial observations, geotechnical and geomechanical drilling, digging of test pits at drillhole locations, collection of representative samples for index testing and characterization, collection of overburden and rock samples for geochemical testing, installation of thermistor strings, and recording of data from thermistor strings installed during the 2006, 2007 and 2008 site investigation programs (Knight Piésold, 2007a, 2008b, 2010b, Thurber, 2011a, 2011b, Hatch, 2011a).

The entire railway corridor is underlain by permafrost, except below large bodies of water. The depth to bedrock ranges from surface to depths of over 60 meters. The overburden consists primarily of silty sands and gravels with cobbles and boulders. The overburden generally contains less than 5 percent excess ice, although excess ice and thick ice deposits, ranging up to 20 metres in thickness were encountered in many boreholes, particularly between the Mary River Mine Site and Cockburn Lakes (kp-84).

Although ground conditions are quite variable within the RSA, areas of massive ice, ice rich soils and thaw sensitive ground conditions have been noted based on air photo interpretation (surface features), geotechnical drilling and geophysical surveys. Although dominated by ice rich soils, the permafrost documented along the RSA is generally found to be colder with low salinity. While these factors are desirable, the potential for thermal degradation and settlement problems remain, especially when factoring in the potential effects of climate change. Other environmental problems related to thermal degradation such as erosion, siltation and the formation of unwanted surface water (thermokarsts) may also occur.

The long term performance of embankments constructed in permafrost regions are subject to potential problems most commonly associated with area dominated by ice rich soils and occurring in the form of thaw and/or creep settlements. The potential for these problems is increased in areas of warmer permafrost or where salinity levels within the pore ice are elevated. The current rail embankment design has been completed based on subsurface conditions encountered during the site investigations. Besides geometry and costs, the rail alignment has been selected and optimized based on various siting studies and alternatives assessments, using information on the permafrost conditions collected during the site investigations. The preferred alignment has been selected to reduce the potential/risk for construction or long-term problems and in consideration of the ease to which mitigation of these potential problems can be achieved. Further refinement will be undertaken as the project advances.

Specific problem areas within the RSA that will require special mitigating designs include, but not limited to the followings:

Potential Creep Settlement Areas

Embankments thicker than 3 m should be constructed with side slopes no steeper than 5H:1V or with toe buttresses to minimize the rate of creep settlement in the underlying ice rich permafrost between stations:

- kp-0 km to kp-26
- kp-95 km to kp-97
- kp-105.5 km to kp-127

Table 6-2.4 Mitigation Measures for Effects/Risks Associated with Sensitive Landforms at the Mine Site

Structures/Issue	Potential Hazard and Effects to Sensitive Landforms	Proposed Mitigation
Construction of structural foundations over ice rich or thaw sensitive permafrost ground	heavy structure experiencing creep settlement over ice-rich permafrost due to settlement thawing of surficial soils causing failure or movement of foundations melting of massive deposits below or adjacent to structure causing settlement or movement problems potentially leading to environmental effects	geotechnical investigations optimize structure locations to avoid problem areas use footings/piles founded on bedrock where possible use spread footings placed on gravel pads, insulated or chilled with thermal syphon use adfreeze piles for spread footings with air space between the building and the ground surface

Table 6-2.4 Mitigation Measures for Effects/Risks Associated with Sensitive Landforms at the Mine Site (Cont'd)

Structures/Issue	Potential Hazard and Effects to Sensitive Landforms	Proposed Mitigation
Storm water /runoff management and drainage water pooling near infrastructure foundations	• surface water induced thermal degradation leading to thaw settlement or weakening of soils/foundations	• maintain surface grading of the entire site to prevent ponded water • provide drainage ditches and diversion berms as necessary • berms may be lined with geotextile.
Failure of ice-rich overburden slope above open pit.	thermal degradation could lead to failure of slope or increase sediment reporting to open pit erosion could further effect stabilized thermal regime leading to issues slope failure could affect people or equipment working at lower elevations within the pit	Geotechnical investigations cut slopes will be designed to address stability issues. ice rich slope will be constructed with thermal and erosion protection barrier diversion ditches may be used where seasonal flows can affect the slope
Stability of Waste Rock Dumps, Ore stockpiles of waste rock material	• covering of unfrozen ground with waste materials could lock in heat, thus changing the thermal conditions and possibly thawing ice rich foundation soils. • weakening of thaw sensitive soils during summer dumping • weakening of thaw sensitive soils due to surface water flows effecting thermal regime • slope failure • with the presence of ice rich foundations soils, creep settlement may occur within the underlying foundations, leading to the development of cracks within the dump and at the dump surface.	• adequate design of slopes • surface ice and snow should be removed from the footprint during the winter prior to placement of waste rock. • a stability buttress may be required at the toe in some locations to prevent minor localized stability issues due to thaw. • Management of surface runoff to minimize thermal effects and erosion. • Ongoing monitoring of the slopes. Cracks will be monitored and repaired as required to minimize inflow of surface water and subsequent ice wedge formation. • - drainage control measures
Impoundment Structures (tank farms and ponds)	induced thermal degradation leading to thaw settlement or weakening of soils	Locate stormwater and sewage effluent polishing ponds away from ice-rich soils line stormwater ponds which collect and treat runoff from the waste rock stockpile and ore stockpiles Line bulk fuel storage facility (tank farm)
Access Roads	• See Milne Inlet Tote Road discussion	• See Milne Inlet Tote Road discussion
Solid Waste Site	• Induced thermal degradation leading to thaw settlement or weakening of soils	• Permafrost may aggregate into the pad (rise up) over time but won't increase active layer thickness (may actually decrease thickness) • Ensure adequate fill over soils with low bearing capacity

Table 6-2.4 Mitigation Measures for Effects/Risks Associated with Sensitive Landforms at the Mine Site (Cont'd)

Structures/Issue	Potential Hazard and Effects to Sensitive Landforms	Proposed Mitigation
Machine and Equipment Pads	• induced thermal degradation leading to thaw settlement or weakening of soils	• • Permafrost may aggregate into the pad (rise up) over time but won't increase active layer thickness (may actually decrease thickness) • Ensure adequate fill over soils with low bearing capacity

Potential Thaw Settlement and Instability Areas

Protective embankments designed to prevent thaw susceptible or ice rich materials close to surface from thawing and compromising the stability of the embankment should be established between stations:

- kp-26 to kp-42
- kp-44 to kp-47
- kp-51 to kp-58
- kp-61 to kp-72
- kp-127 to kp-132.5

With the exception of some localized occurrences of near surface ice or thaw susceptible soils, the remaining segments of the alignment should maintain adequate stability and tolerable settlements when constructed using standard embankment sections.

Mitigation through the application of standard embankment design and construction guidelines has been adopted for the Railway embankments. Key considerations are summarized below:

- Excavations will be minimized, especially in areas of known ice rich permafrost.
- Prior to embankment construction, ground disturbance will be minimized and vegetative or organic cover left in place to provide the maximum protection of the thermal regime.
- In areas where excavation is required, the foundations will be over excavated and backfilled with 1.5 m of non frost/thaw susceptible fill to minimize frost heaving and settlement.
- Cut slopes into ice-rich or thaw sensitive materials will be established at a minimum 3H:1V and protected with thermal and erosion protection material if required.
- In areas where ice rich or thaw sensitive material is present, slopes will be excavated at 2H;1VIn areas of thaw sensitive active layer, stabilization berms will be used to minimize the effect of permafrost degradation at the toes causing overall instabilities (causing longitudinal cracks forming along the crest of the embankment due to uneven thaw settlement).
- For high embankment fills on ice rich materials, the side slopes may be flattened significantly or stabilization berms constructed to reduce the creep deformation potential.
- For summer construction, woven geotextile may be required over thaw unstable ground.
- Proper runoff collection and diversions drainage system will be used to control runoff and erosion from affecting the modified thermal regime. As part of basic design, thermal modeling will be conducted for

each typical embankment condition and configuration to identify the actual permafrost protection measures required and to predict the nature of the active layer and the effect that construction will have on the thermal regime over the life of the Project. The thermal modeling will incorporate potential warming trends resulting from climate change based on world recognized global warming scenarios as proposed by the Arctic Climate Impact Assessment (Arctic Council and International Arctic Science Committee, 2005).

- Thaw settlements and surface sloughing of cut slopes is expected, particularly during the first few thaw seasons after construction. The behaviour of both cut slopes and embankment fills will be monitored throughout the first few thaw seasons and remedial measures will be implemented as

  necessary. For example, it is expected that many of the cut slopes will need to be regarded as thaw settlements occur. Silt fences, erosion protection and other measures will be installed as necessary to prevent siltation of adjacent drainage courses and water bodies.

A summary of some specific effects/risks and mitigation measures associated with sensitive landforms along the Railway alignment are summarized on Table 6-2.5.

Steensby Port

Steensby Port is typically dominated by bedrock outcrops or bedrock close to surface. In the thin deposits of overburden within the lower depressions, some evidence of ice rich permafrost were noted underlying a layer of wetter organic material. Additionally, some thaw-sensitive soils may be present near surface below the organic layer in these depressions and mid slopes along the Steensby Inlet shoreline.

All structures at Steensby Port will be founded on spread footings or steel pipes placed in or on bedrock.

2.3.3 Assessment of Residual Effects

Construction and mining activities have the potential to create meaningful changes to sensitive landforms. The nature of interaction of potential effects is a change to the thermal regime of sensitive landforms resulting from Project infrastructure and activities, which is negative in direction. Engineering and geotechnical design and controls will mitigate changes to the thermal regime and have been described in the previous sections. For all infrastructure associate with the Milne Inlet Tote Road, Mine Site, Railway and Ports monitoring and maintenance will be essential for mitigating problems that may arise associated with degradation of the permafrost. As mitigation will occur, the assessment of residual effects takes this into account. Using the assessment criteria defined in Volume 2, the residual effects are assessed as:

- The magnitude of the effects is a change will not be distinguishable from natural variation and will be within regulated values (Level 1).
- The extent of the effects will be confined to the PDA (Level 1).
- The frequency of how often the effect occurs will be negligible as the mitigative measures will ensure that no effects occur (negligible)
- The duration is the length of time over which a Project effect will occur which will be negligible as there is negligible frequency (negligible).
- The reversibility is the likelihood of the sensitive landforms to recover from the effect will be negligible as there is negligible frequency and duration (negligible).

While soils will be disturbed and there will be residual effects, soils are important as a matrix for vegetation and wildlife habitat which are assessed later in this volume.

As changes are expected to be limited to within the PDA, the potential residual effect to permafrost is predicted to be not significant.

Table 6-2.5 Mitigation Measures for Effects/Risks Associated with Sensitive Landforms along the Railway

Structures/Issue	Potential Hazard and Effects to Sensitive Landforms	Proposed Mitigation
Massive ice or ice rich soils below high embankments or in areas of cut	• high embankments may experience creep settlement over time • cut areas may cause thermal degradation and settlement • thaw weakening of soil leading to instability of slopes • construction disturbance or new ponding of water could affect thermal regime causing settlement	• Geotechnical investigations • alignment routed around problem areas to maximum extent possible • minimize cuts • adequate design of embankments (i.e., ventilated/cooling embankments, flatter slopes in problem areas, stabilizing berms over excavation and backfill in cuts, etc.) • over-excavation and backfill with non-thaw susceptible fill. • regular inspections and maintenance
Cut slope in ice rich overburden upslope of the rail	• slope failure could block, interrupt or even destroy section of rail line • blockage of culverts • effect to thermal regime effecting longer term integrity of embankment permafrost foundations • shutdown of rail operations	• Geotechnical investigations • minimize cuts in ice rich permafrost • cut slopes will be designed to address stability issues. • ice rich slope will be constructed with thermal and erosion protection barrier, if required • diversion ditches or berms may be placed at the top of cut slopes to prevent surface water from flowing down the face of the slope
Bridge abutment failure due to thawed areas or effects of flows on thermal regime	• failure of bridge causing operational shutdown • costs of repairs • injury or fatality • environmental effects	• Geotechnical investigations • adequate design of bridge abutments (i.e., maximize use of bedrock, rock socketed and adfreeze piles, refrigerated pile groups, thermal protection above pile caps, etc.) • instrumentation and monitoring for notification in event of potential failure, if required

2.3.4 Prediction Confidence

High Confidence in Prediction: Based on the degree of coverage during the baseline studies and geotechnical investigation programs, including:

- Identification of geologic and sensitive landforms and potential hazards from aerial photos in the Mine Site, Railway, and Steensby Port areas;
- Site reconnaissance and surface mapping for all areas;
- Geotechnical drilling using diamond drilling techniques;
- Excavation of shallow test pits by hand and mini-excavator;
- Collection of soil and bedrock samples for on-site and laboratory testing;
- Installation and monitoring of thermistors;

- Oriented core drilling for rock mass classification; and
- Geophysical surveys were carried out by EBA in April and May of 2008.

Additional studies and investigations will be required as the level of design advances to gain greater knowledge of the issues and conditions present within the RSA, thereby increasing the confidence level that all potential issues and effects have been identified with adequate mitigation measures incorporated into the designs and work plans.

2.4 SUBJECTS OF NOTE

2.4.1 Soils

There are a series of potential project effects to the surficial soils that are mostly unrelated to permafrost (although can result in effects to permafrost). These effects include the following:

- Soil contamination
- Soil structure alteration
- Soil destabilization and erosion

The following provides additional detail relating to these effects.

Soil Contamination

Spills can have a serious effect on soils and ultimately water quality. Baffinland will provide training in and implement a Spill Contingency Plan (Volume 10, Appendix 10C) to mitigate the potential for adverse effects to soil and water resources quality in the event of an accidental spill or release during normal construction or operating conditions. Both Baffinland employees and contractors will be bound by the procedures in the Plan. Appropriate bunded containment will be provided around areas where spills could occur, such as storage tanks, and areas where chemicals, fuels, or lubricants are being handled or used will be underlain by a suitable liner or paved to prevent any accidental spills from reaching the underlying soils.

Appropriate sorptive materials for the materials stored or in use in a particular area will be provided and kept stocked in an easily accessible location, so that in the event of a spill or accidental discharge, the spill can be contained and wiped up immediately.

Soil Structure Alteration

Due to the generally unsuitability of local soils for revegetation purposes, and because effects will be limited in general to direct Project facility footprints, alteration of soil structure is considered to be a Subject of Note. Ground-clearing and construction activities within the PDA in areas where natural soils are left in place will cause substantial disturbance to soil structure. Compaction of soils (either directly via earthmoving equipment or indirectly by burial under a foundation or other covering) has the potential to alter the soils' natural structure; decreasing its water storage capacity and ability to support vegetative growth and wildlife.

In all cases, mitigation measures consist of limiting the area of disturbance to the extent practical to avoid disruption of native soils outside of Project component footprints. Reestablishment of soil structure within Project component footprints may occur over the extreme long-term post-closure in areas where closure activities will consist of infrastructure removal and/or regarding, such as along the Railway alignment, Milne Inlet Tote Road and other access roads, and in the port areas.

Soils Destabilization and Erosion

Soil destabilization and erosion are potential effects in all areas where the naturally occurring topography and soils are altered as a result of Project implementation. Most of these activities are expected to occur during construction, when the majority of ground clearing and earthworks will be performed. Similar effects could also occur during closure, from activities involving removal and/or recontouring of various Project components including roads, airstrips, the Railway, waste rock stockpiles, support infrastructure including buildings and the Milne Port and Steensby Port facilities. During operation, such activities as quarrying and open pit mining have the potential to affect local soils and to cause erosion, either by way of wind, runoff, or slope instability.

Although widespread across all five Project location PDAs, soil destabilization and erosion are easily mitigated by using Best Management Practices for sedimentation and erosion control; effects are thus are expected to be minor. Erosion protection and control measures are described in the Surface Water and Aquatic Ecosystems Management Plan in Appendix 10D-2. Limiting the zone of disturbance to the minimum necessary during construction and operation is the main mitigative action that will take place.

Effects associated with erosion of topsoil will be mitigated by instituting Best Management Practices for sediment and erosion control for all Project facilities, including topsoil stockpiles Revegetation of disturbed areas has been determined to be ineffective as a mitigative action in the region, due to the thin and generally poor quality of local soils and the difficulty involved in trying to re-grow Arctic flora. Implementation of the following control measures during ground clearing will greatly reduce any erosion or sediment loading that may arise from the stripping activity:

- Use geotextile silt fencing, silt traps, and/or other methods to reduce sediment transport within the construction site; overland flow from the construction area should be avoided
- Divert “clean” water away from the works area
- Suppress dusting on roads by wetting or application of a dust control agent
- Grade the site and channel surface flow into ditches to reduce flow velocities and decrease the potential for erosion
- Collect and pump runoff to settling facilities or treat potentially affected water, including water used to decontaminate equipment, and affected runoff
- Inspect and maintain silt control measures
- Provide temporary storm water retention capacity
- Proof-roll subgrade or stockpile materials
- Implement a site-wide operational surface water quality-monitoring program to assess effects of site runoff on receiving surface water bodies and effectiveness of construction control measures.

Stream bank erosion is addressed in the Surface Water and Aquatic Ecosystem Management Plan (Appendix 10D-2).

To the extent practical and based on the designs in the Mine Closure and Monitoring Plan (Appendix 10G), land disturbance will be mitigated during reclamation. Disturbed areas will be re-graded to approximate surrounding contours and to enhance stability and to decrease the potential for erosion.

A sediment control monitoring program will be implemented to detect potential issues arising from soil destabilization and erosion and assess whether these changes are naturally occurring variations (e.g., suspended sediment increases during spring thaw) or Project-related effects. Monitoring measures for this program are detailed in the Surface Water and Aquatic Ecosystem Management Plan (Appendix 10D-2).

2.4.2 Wetlands and Eskers

It is estimated that there are approximately 125 km^2 of wetlands in the Regional Study Area (RSA) as described in Volume 6, Section 3.2.2.1, Table 6-3.4. This represents approximately 0.41% of the RSA.

Eskers that are known to reside on or near the Project Development Area are described in Section 2.1.1.2 and 2.1.3 of this Volume.

2.4.3 Aesthetics of Natural Environment

The Project will have an effect on the aesthetics of the environment during the duration of the Project. The Project infrastructure, dust generated, and noise will be the main project components and activities that will affect aesthetics. Table 6-2.6 describes the potential effects on the aesthetics of the natural environment.

2.4.4 Palaeontological Resources

Palaeontological resources (including fossils) are protected by the Nunavut Archaeological and Palaeontological Sites Regulations (SOR/2001-220). Without a Class 1 or Class 2 permit it is not permissible to search for palaeontological sites or fossils, or survey a palaeontological site. Further without a Class 2 permit, it is not permissible to excavate, alter or otherwise disturb a palaeontological site, or remove a fossil from a palaeontological site. A "Class 1 permit" allows the permittee to survey and document the characteristics of an archaeological or palaeontological site, so long as the site is not disturbed. A "Class 2 permit" allows the permittee to survey, document characteristics, and excavate an archaeological or palaeontological site. As well, a "Class 2 permit" allows fossils to be removed from a palaeontological site, thus, altering or disturbing an archaeological or palaeontological site. It is required that upon completion of an excavation, the site is restored, as much as practicable, to its original state. Proposed quarries have been identified within the formations along the Tote Road. A Class 2 permit will be obtained prior to any excavation activities that may be required within the Tote Road quarries.

Table 6-2.6 Potential Effects on the Aesthetics of the Natural Environment Resulting from Project Components and Activities

Location	Current Condition	Effect of project components and activities on Aesthetics
Milne Port	Infrastructure (Camp, tank farm, lay down area and airstrip)	Infrastructure, air quality (dust), noise
Milne Inlet Tote Road	Tote Road	Dust, noise
Mine Site	Predevelopment infrastructure (Camp, tank farm, lay down area and airstrip)	Mine Site infrastructure, open pit, ore stockpiles, waste rock stockpile, noise Visual effect: Modification of Nulujaak as a landmark (mining of top, creation of large waste rock stockpiles)
Railway	Mid-rail camp	Railway (long term embankment and tunnels), communication towers , noise
Steensby Port	Exploration camp	Port Infrastructure, air quality (dust), noise

2.5 IMPACT STATEMENT

The Project will have a not significant residual effect on sensitive landforms. The Project will affect sensitive landforms within the PDA but the extent of the effect relative to the RSA is minor. The Mine Site, the Railway and Steensby Port will be built so that they do not disturb sensitive landforms outside the PDA. Effects to Sensitive Landforms are limited to the PDA. No cumulative effects are expected.

2.6 AUTHORS

This impact statement was prepared by Charlotte Dubec and Richard Cook and reviewed by Kevin Hawton, P.Eng., all of Knight Piésold Ltd. Additional information based on the 2011 Geotechnical Investigation program was provided by Ramli Halim, P. Eng of Hatch Ltd., and Bruce Smith, P. Eng of Thurber Engineering Ltd.

SECTION 3.0 - VEGETATION

Vegetation within the Mary River Project area is described in the Vegetation Baseline Study Report (Appendix 6C). Baseline studies were conducted during each of the summers of 2005 through 2008. A total of 833 plots were surveyed across the terrestrial RSA, focusing mainly on the PDA.

A total of 155 vascular plant species were recorded, a vegetation classification system was developed and a species list was compiled. No plant species considered to be "rare" in Canada were found to occur in the survey locations. One unusual association was found, and has been proposed for special protection. Plant species abundance data derived from the vegetation plots were used in the development of an Ecological Land Classification (ELC), described in Appendix 6D. To help develop an understanding of Inuit Qaujimajatuqangit (IQ) regarding the traditional use of plants by Inuit, studies were carried out with Elders in Pond Inlet. Metals analysis of samples of surface soil and plant foliage from 56 baseline stations in the Local Study Area was conducted to establish a baseline of metal concentrations in plants and soil.

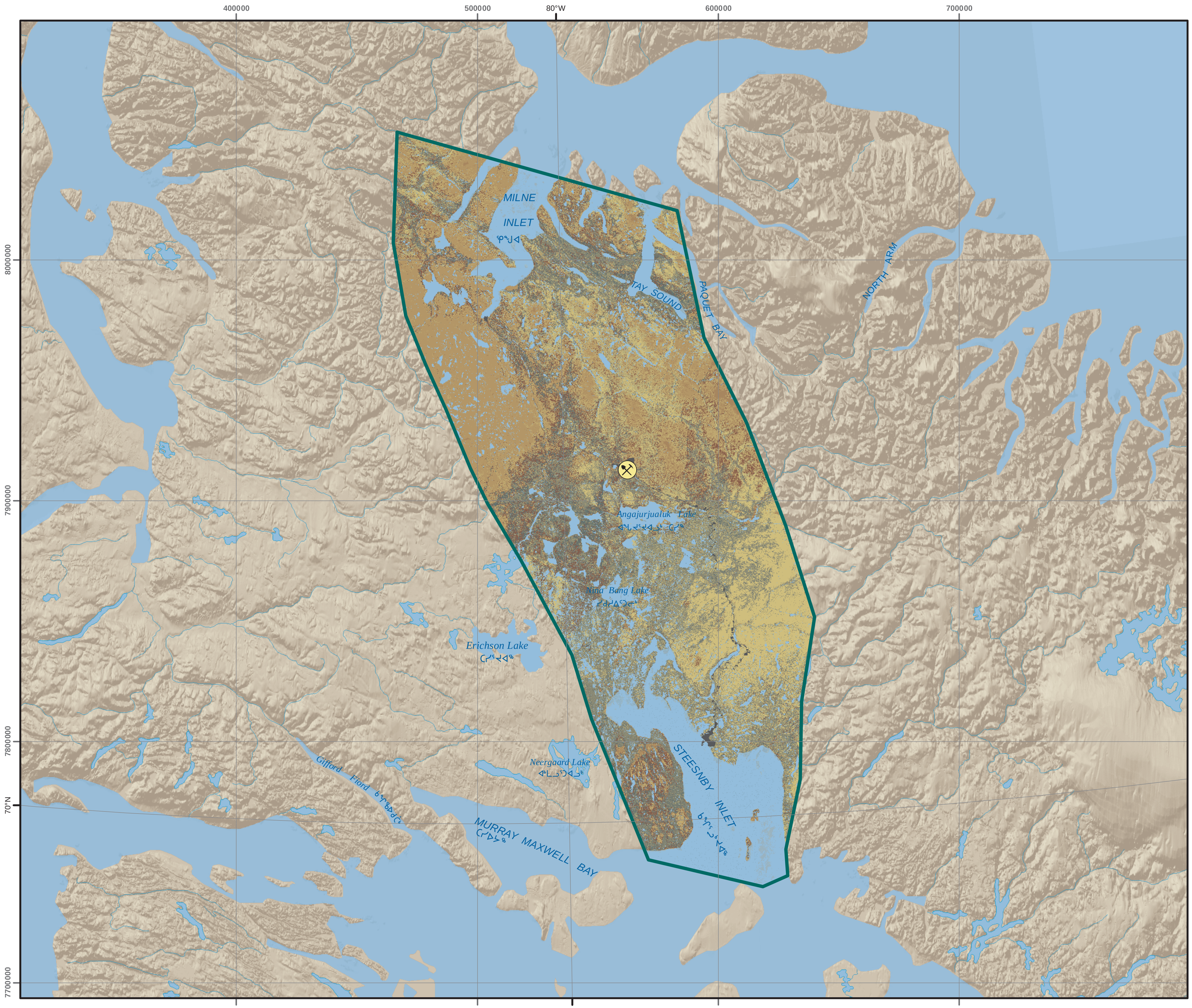
The Regional Study Area (RSA) was identified to ensure that the range of direct and indirect potential disturbances as a result of the Project's activities could be examined and potential effects could be spatially quantified. The RSA was chosen to represent vegetation distribution and abundance at an ecologically relevant scale and to reflect the regional vegetation. The RSA also had to be a reasonable size so that surveys and information could be gathered in an economical fashion and provide information that is directly relevant to Project monitoring and mitigation. The RSA is a 30,711 km^2 area centred on the Project's PDAs (Figure 6-3.1). The southern end of the study area centres on Steensby Port, the northern portion includes Milne Inlet, and the central portion includes many large lakes to the south and west of Angajurjualuk Lake - the largest lake in the RSA. The RSA for assessing the effects on vegetation is the same as that used for the baseline Ecological Land Classification (Appendix 6D).

3.1 ISSUES SCOPING

Baffinland conducted a number of vegetation studies, public consultation meetings, and personal interviews to acquire baseline information, identify traditional uses of plants, and to scope potential issues of perceived project effects. The key issues that are addressed for the Project's effects on vegetation were identified through several consultation processes that included the following elements:

- Community scoping meetings;
- Review of previously completed studies on vegetation in the region;
- Review of other project EISs;
- Mary River Project team meetings;
- Traditional plant uses interviews and workshop with Pond Inlet Elders;
- Soils investigations carried out in 2007 and 2008; and
- Guidance provided by the Nunavut Impact Review Board's (NIRB) EIS guidelines.

Vegetation was identified as a Valued Ecosystem Component (VEC) based on ecological, social and/or legislated importance, and its potential to interact with the Project.



LEGEND

Mary River Project Study Specifics

- ....Mary River Project
- ....Potential Development Area
- ....Regional Study Area - Vegetation

Vegetation Classification

- Wetlands
- Wet sedge - Graminoids and bryoids
- Tussock graminoid tundra
- Moist to dry non-tussock graminoid/Dwarf shrub tundra: 50-70% cover
- Dry graminoid prostrate dwarf shrub tundra: 70-100% cover
- Prostrate dwarf shrub - Dryas/heath, usually on bedrock
- Sparsely vegetated bedrock
- Sparsely vegetated till-colluvium
- Bare soil with cryptogam crust - Frost boils
- Barren
- Ice/snow
- Unclassified
- Water

NOTES:

Potential Development Area and Regional Study Area for vegetation provided by Knight Piésold Consulting (2010).

Projection: North American Datum 1983 UTM Zone 17N

Scale 0 10 20 30 40 50 Km

Baffinland Iron Mines Corporation

Figure 6-3.1. Vegetation Communities within the Mary River Regional Study Area.

EDI Environmental Dynamics Inc.

16 December 2010

FIGURE 6-3.1

WHITEHORSE, YT SAVED: J:\Yukon\Projects\2010\10_Y_0550\Mapping\Fig6_3_1VgRSA_16Dec2010

While preparing the EIS guidelines for the Mary River Project, the Nunavut Impact Review Board (NIRB) also conducted a number of additional community meetings to scope key issues to be considered in the environmental assessment of the Project. The NIRB guidelines generally seem to reflect many of the concerns identified during Baffinland's consultations, where there were concerns about effects on vegetation and a desire to predict the overall effects on plant abundance, diversity, health and use by humans. The NIRB guidelines related to vegetation effects (8.1.8.2) are summarized below:

i) Potential impacts to abundance and diversity of vegetation due to Project activities causing surface disturbance;
ii) Potential impacts to specific vegetation coverage and species composition from construction, operation, and reclamation activities in the Project area;
iii) Assessment of the potential loss, disturbance, and/or changes to vegetation abundance, diversity, and forage quality as a result of Project components and activities, including potential effects from airborne fugitive dust fall, airborne contaminants from emission sources…;
iv) Potential impacts on vegetation abundance and diversity from the transfer/introduction of invasive or exotic species into the LSA via Project equipment and vehicles, including aircraft and ships;
v) Potential impacts to vegetation of cultural or practical value to Inuit;
vi) Potential direct and indirect loss of vegetation and associated habitat from construction of the railway;
vii) Potential impacts on vegetation quality due to dust fall from soil erosion, surface disturbance, fine iron ore transport, etc.;
viii) Discussion of proposed vegetation quality monitoring, specifically contaminant loadings of species directly consumed by humans (e.g., lichen) and/or indirectly consumed through food chain associations; and
ix) Discussion of the management measures for minimizing/mitigation of disturbances to plant associations, including progressive reclamation/re-vegetation plans for disturbed areas, and measures to reduce the potential for establishment of invasive species in the area.

3.2 VEGETATION

There are three measurable parameters that allow for the prediction of effects of the project on vegetation:

- Vegetation abundance and diversity;
- Vegetation health; and
- Culturally valued vegetation.

As no plant species with formal recognition as "rare plants" were identified during baseline studies, rare vegetation was not included as an issue for the EIS. If any plants designated as rare are found during future studies, steps will be taken to protect their habitats.

Vegetation Abundance and Diversity

Vegetation abundance and diversity can be affected through direct loss of vegetation within the footprint of the Project, or through indirect loss from project infrastructure that cause changes to the microclimate directly adjacent to project infrastructure. Dust deposition and emissions also have the potential to cause changes in vegetation abundance and diversity, but this issue is addressed within the measurable parameter vegetation health.

Plant inventory work completed as part of the vegetation baseline indicates that there are roughly 155 vascular plant species present in the RSA (Appendix 6C). No rare plants or communities were identified. For the purposes of the assessment, vegetation diversity is described using ELC models that identified 10 plant communities within the RSA (Appendix 6D).

In general, any physical disturbance to plant cover will likely result in the loss of plants in the immediate area. All project activities will occur within the PDA, so direct loss of vegetation will occur solely within the PDA. During the construction phase, direct habitat loss will occur primarily due to surface disturbance including compaction, burial, and removal. During the operations phase, additional vegetation loss will occur as ore extraction expands within Deposit No. 1. During the closure phase, the Project footprint should not expand, but there may be incidental vegetation loss due to some reclamation activities.

Indirect changes to vegetation abundance and diversity are possible, but this loss would be limited to a few cases and will not occur at the scale of the RSA. Indirect changes to vegetation abundance and diversity that could occur as a result of Project activities include introduction of invasive plant species, changes to surface drainage, permafrost, erosion, and snow accumulation patterns.

Proposed reclamation activities will provide physical and chemical stability and will be designed to promote natural re-vegetation. Experimental plots conducted during operations, examining progressive rehabilitation using local native species, may identify suitable progressive re-vegetation techniques that could become incorporated into future closure plans (Appendix 3B, Attachment 10, Section 5). The effects to vegetation will be long-term as natural re-vegetation is expected to occur slowly.

Vegetation Health

Vegetation health can be affected by dust deposition and combustion emissions. Dust can physically inhibit plant function, or plants can uptake metals in dust either directly through tissue or via roots in soil. Plants can uptake emissions by-products directly or accumulation of available nitrogen, or be indirectly affected by acid deposition resulting in soil acidity.

Dust (TSP)

Dust (Total Suspended Particle — TSP) deposition will occur as a result of construction, operation and closure activities. Dust will be transported downwind and deposited according to the local atmospheric conditions and particle size. The probable dust deposition scenarios are characterized in the air quality baseline report (Appendix 5B) and the air quality impact assessment (Volume 5, Section 2.0). The effects of dust on vegetation will depend on the type of dust, the deposition load, and the type of exposure. Possible routes of exposure include physical blocking of stomata, uptake by the leaf surface and/or deposition onto the substrate with subsequent uptake by roots.

The direct effects of dust on vegetation include decreased chlorophyll and photosynthesis (Spatt and Miller, 1981) and blocking or covering the stomata, resulting in a physical inhibition to function. This in turn can result in reduced growth and health of a plant.

The effects of road dust on Arctic vegetation are fairly well understood. The effects of road dust to vegetation increase with proximity to the road. Dust deposition on snow has been found to reduce the albedo (reflectivity of incident sunlight) of Arctic tundra, resulting in increased soil temperature, increased depth of thaw, and altering the onset of thaw (Hope *et al*., 1991; Auerbach, 1992; Auerbach *et al*., 1997). Auerbach *et al.* (1997) noted a decrease in biomass in acidic and non-acidic tundra communities with virtually no mosses adjacent to the road. Spatt and Miller (1981) observed a decline in species abundance with a TSP deposition concentration of 1.0 to 2.5 g/m²/d and observed some effects for deposition rates of 0.07 to 1 g/m²/d.

Some Arctic plants such as *Sphagnum* moss are particularly sensitive to an increase in pH due to the calcareous component of gravel road dust (Auerbach *et al*., 1997; Farmer, 1993; Walker and Everett, 1987). Spatt (1978) concluded that a long term loss in the vitality of *Sphagnum* near a road could be expected. Walker and Everett (1987) saw a complete elimination of *Sphagnum* within 20 m of a road in some sections along their study area but also observed a partial replacement with other mosses including *Ceratodon purureus*, *Bryum* spp., and *Polytrichum juniperinum*. In less heavily affected areas, total moss diversity often increases. Several other common minerotrophic species appear to have increased due to nutrient enrichment from a road. Most mosses, however, are affected by the smothering and desiccating effects of dust, and in areas of the highest dust concentrations, all bryophytes are eliminated within a few meters of the road (Walker *et al*., 1985). Forbes (1995) found lichens and mosses in Arctic tundra to be significantly reduced at distances up to 200 m from a quarry.

Blueberry (*Vaccinium uligiosum*) and Labrador tea (*Ledum palustre*) appear to be sensitive to dust (Walker *et al.*, 1985) and white Arctic heather (*Cassiope tetragona*) appears to be particularly sensitive to road dust. Some plant mortality was observed in high dust areas along the Yukon River-Prudhoe Bay haul road (Walker and Werbe, 1980). The effects on vascular taxa were noted as more subtle by Werbe (1980) and were difficult to determine due to lack of long term monitoring in the highly affected zone that was up to 10 m from the edge of the road.

Metals in Dust

Metals (e.g., iron, nickel) and metalloids (e.g., arsenic, antimony), from this point forward referred to as metals, concentrations in dust can potentially affect the health and productivity of vegetation either by contact with foliage or uptake from soils. Assessing potential effects related to metals is complex soil pH and soil texture have a profound effect on whether or not changes in metal concentrations in soil and or plants will have an effect. Plant species can have very different tolerances and requirements to metals and other nutrients. Generally, plant roots provide a significant barrier to metals, which provides effective exclusion of metals from moving into the plant. Conversely, plant roots are effective at seeking and actively transporting certain metals and other nutrients they require into the plant (Baker, 1987).

It is well understood from scientific literature that plants exhibit a remarkable ability to adapt to and live on soils that contain a wide range of metal concentrations. For these reasons plants occupy surface soils in regions that have exceptionally high concentrations of naturally occurring metals without any symptoms of toxicity. Similarly, plants also occupy regions that are extremely deficient in metals considered essential for basic plant function and metabolism.

Although plants are able to regulate their nutrient supply, they are limited by how much of a particular element they can either absorb or exclude from their roots (Kabata-Pendias, 2001). When concentrations of a particular element are below a desirable range, known as a deficiency zone, plant health is compromised but will improve as the concentration of the element increases. Eventually, there is no longer an improvement in growth with increasing concentrations, known as the luxury zone. In this range, plants are able to effectively obtain required nutrients, even with increasing concentrations. A toxicity zone is eventually reached with increasing concentration, at which point the plant can no longer maintain homeostasis, and plant health gradually deteriorates. Nutrient requirements of plants are dependent on many factors including the element in question, plant species, mycrohizal associations, and the chemistry of the soil. It is difficult to predict plant health knowing only the total concentration of a metal in the soil since soil type (i.e., clay, sand, organic) and soil pH are primary factors that determine bioavailability of metals in soil (Sauvé *et al.*, 2002).

Bioavailable metals are the proportion of the bulk metal in soil that is in an ionic form that is soluble and can potentially interact with plant roots. As pH is lowered, metals are released from the soil matrix as ions into a water solution within the soil. Once in ionic form, metals are said to be bioavailable, and have a greater capacity to potentially affect plant health (Turgut *et al.*, 2004). Due to this interaction with metals, pH is widely recognized as having the most significant effect on metal bioavailability (Sauvé *et al.*, 2002; Raskin and Ensley, 2000). Increasing pH has the opposite effect where metals become less soluble and bioavailable to plants.

Nutrition is an important consideration for plant health since a large difference between the nutrient concentration in soil and the nutrient requirements of plants is often substantial (Kabata-Pendias, 2001). The amount of a nutrient required by a plant to perform specific functions determines whether the nutrient is a macronutrient or a micronutrient. Generally, nutrients at a dry weight concentration of greater than 0.1 % in plant biomass are considered to be macronutrients. Nitrogen and phosphorus are both macronutrients having concentrations in the range of 1,000–5,000 mg/kg and 800–3,000 mg/kg respectively in dry weight biomass. Nutrients at concentrations less than 0.1 % in plant biomass are considered micronutrients. Nickel and copper are micronutrients that are typically found at concentrations of 1–10 and 5–25 mg/kg in dry weight biomass respectively (Marschner, 1995). These values can vary substantially based on naturally occurring conditions and the species of plant. Cobalt and arsenic are not considered plant nutrients as these elements are generally not required in plant metabolism (Marschner, 1995; Sauvé *et al.*, 2002).

In most naturally occurring soils, metals are tightly bound to molecular compounds (organic ligands and cysteine proteins), resulting in low bioavailability (Sauvé *et al.*, 2002). Organic ligands such as ammonia (NH_3) are molecules that surround metal in a complex ion, rendering it less bioavailable. Nitrogen ions and nitrogen containing proteins such as cysteine ($C_3H_7NO_2S$), common in the organic matter of soils, are also powerful metal complexing agents that cause metals to be less bioavailable. For example, ammonia is a nitrogen containing ligand that readily surrounds copper metal atoms (Cu^{2+}) to form $Cu[(NH_3)4]^{2+}$ in soil causing it to be less bioavailable (Sauvé *et al.*, 2002).

The City of Greater Sudbury Urban Soil Study (Jones *et. al*., 2004) was undertaken in part to determine if the concentrations of metals in Sudbury, Ontario, area pose a risk to humans, plants, or animals. Metals have accumulated in the soils in the vicinity of Sudbury as a result of air emissions from smelters and other mining-related activities, beginning over 100 years ago. The six metals and metalloids of concern included arsenic, cobalt, copper, lead, nickel and selenium. Various exposure routes were studied including ingestion of wild blueberries. Arsenic, cobalt and selenium were not detected in any of the wild blueberry samples; all were below screening criteria.

The majority of metals deposition related from Project activities are expected to result from the mining, handling and stockpiling of iron ore. The ore is largely composed of iron (generally > 64 % iron) but does contain a number of other trace metal components. Metals are naturally occurring in the RSA and are represented by baseline conditions. Dust released during Project activities will contain metals and these metals will not degrade in the environment once released.

Atmospheric Emissions

Nitrogen Emissions

Nitrogen is a primary macronutrient for plants. It is a part of all living cells, enzymes, proteins and metabolic processes (Lewis, 1986). Although the majority of nitrogen taken up by plants is through the roots, plants are also capable of absorbing nitrogen through their stomata during gas exchange (Mansfield, 2002). Nitrogen is the limiting nutrient for plant growth in almost all terrestrial ecosystems, including the Arctic, and plant biomass tends to increase when nitrogen is added to the soil (Robinson, 2002).

Atmospheric nitrogen oxides can encourage growth in plants at relatively low concentrations, particularly in nitrogen-limited environments like the Arctic. However, high concentrations of atmospheric or deposited nitrogen can result in a variety of negative effects on plants. Toxic levels of atmospheric nitrogen have the potential to alter chemical and metabolic processes in plants that can result in a reduction in growth rate and an increased susceptibility to environmental stresses (Mansfield, 2002). Deposited nitrogen has the potential to accumulate in the soil over time, which gradually increases the acidity of the soil and the availability of metals. This change in soil chemistry has the potential to affect species composition and abundance by altering the competitive ability of plant species (Ashenden, 2002).

Higher atmospheric nitrogen oxide concentrations result in an increased shoot to root ratio for plants, which may potentially result in a reduced ability to withstand drought stress from increased transpiration loss (WHO, 2000). Plants weakened by natural stresses have a lower threshold of sensitivity to airborne pollutants (Alexeyev, 1995).

Lichens are particularly sensitive to changes in atmospheric chemistry, as they depend primarily on the atmosphere for nutrients but lack a protective cuticle to control their intake of both nutrients and pollutants. This is particularly relevant in Arctic climates where many habitats are lichen-dominated (Nash and Gries, 1995). Changes in species abundance and composition are likely if increased nitrogen is applied in significant quantities for more than five years, although long-term effects on growth from increased atmospheric NO_2 are poorly understood (WHO, 2000).

Many plant species are adapted to low nitrogen conditions and react differently to changing nitrogen levels. This is further complicated by the fact that certain concentrations of nitrogen are toxic for different species, and that the effects of nitrogen deposition tend to be cumulative over time (Bobbink and Lamers, 2002). Thus, a change in nitrogen content in the soil may alter the competitive ability of many plant species, changing the competitive dynamics of the affected area (Ashenden, 2002). Increased nitrogen content tends to result in a higher proportion of deciduous shrubs, herbs, and grasses, whereas mosses and lichens tend to get shaded out by the faster growing, taller vascular plants (shrubs, herbs, and grasses). *Sphagnum* mosses are an example of a group of species that are negatively affected by excessive nitrogen input (Bobbink and Lamers, 2002).

Bobbink and Lamers (2002) indicated that the relative severity of the effect of airborne nitrogen is dependent on the duration and total amount of the inputs, the form of nitrogen input, the sensitivity of the plant species, and the abiotic conditions of the ecosystem. These factors are all influential on how nitrogen affects the local ecology. The interaction between these factors is complex because many factors interact and operate over differing time scales. The four main categories of effects on the local ecology are:

- Direct toxicity of nitrogen oxides to individual plant species;
- Soil acidification through lowering of acid neutralizing capacity by leaching of base cations and an increase in metal bioavailability;

- Gradual accumulation of available nitrogen in the soil that can affect species composition; and
- Higher susceptibility to environmental stresses and disturbances such as drought, frost, pathogens, and herbivores.

Sulphur Emissions

Sulphur is also essential for plant growth and development, in particular for the production of plant proteins. It also encourages plant growth and increases plant resistance to low temperatures (Abrol and Ahmad, 2003). As a result of this Project, sulphur emissions (to the environment) will be in the form of sulphur dioxide (SO_2), mostly from fuel combustion and refuse incineration.

Sulphur dioxide can be detrimental to plant health. Lichens are particularly sensitive to elevated SO_2 in the atmosphere, as they allow for passive gaseous exchange and are unable to exclude excess sulphur (Nash and Gries, 1995). Sulphur can also be deposited as dry deposition, and foliar injuries or changes in growth patterns in plants can result (Legge and Krupa, 2002). The duration and frequency of exposure determines the extent of injury to flora.

Sulphur dioxide negatively affects plants when it is found at a concentration beyond the biochemical threshold level. This means that when more SO_2 is absorbed by the plant than it is capable of processing through metabolic and chemical processes, photosynthesis, respiration and other cellular processes are disrupted (Malhotra and Hocking, 1976).

The symptoms of SO_2 exposure on plants can be placed into two categories (Legge and Krupa, 2002). Acute symptoms are the result of short-term exposure to high concentrations of SO_2, and often result in a yellowing or browning of the foliage of plants. Chronic symptoms occur when plants are exposed to lower concentrations of SO_2 for the entire life cycle of the plant and are characterized by a reduction in the rate of plant growth and biomass production. Acute and chronic symptoms can co-occur and the effect of both can potentially be observed on the same plant (Malhotra and Hocking, 1976).

Interspecies competition is also altered by excess SO_2 input, which may decrease the abundance of perennial plants and increase the abundance of annual plants (Legge and Krupa, 2002). According to the WHO (2000), the critical level of atmospheric SO_2 for adverse effects on natural vegetation is 20 $\mu g/m^3/a$. Lichens are more sensitive, with a critical level of 10 $\mu g/m^3/a$ (WHO, 2000). However, local populations of some plant species can evolve higher resistance to SO_2 relative to other populations of the same species (Legge and Krupa, 2002).

Acid Deposition

Acid deposition is the general term for the transfer of atmospheric pollutants to the earth's surface either by wet or dry deposition. Sulphur oxides, sulphates, nitrogen oxides, nitrates, and ammonium compounds are the main sources of increased acidity in the environment, with sulphur compounds having the greatest effect. Higher concentrations of these compounds in the atmosphere increase the likelihood of negative effects on local vegetation. Wet deposition is the most common pathway from the atmosphere to the local ecosystem, but in arid areas like the Arctic, dry deposition plays a significant role in soil and water acidification (AMAP, 2006). Vegetation can be directly affected; however, the primary effects are changes in the soil and water chemistry (Ashenden, 2002).

The parent material, substrate texture, weathering rate, base cation availability and vegetation cover are factors in determining the susceptibility of soils to acidification. However, acidification in the Arctic is a sub-regional issue, and typically a concern only occurs in areas immediately downwind of non-ferrous smelters (AMAP, 2006). Because the Mary River Project does not include any non-ferrous smelters, and since the only sources of sulphur dioxide within the Project footprint are from vehicle operations and power generation, both of which will abide by required regulations, it was determined that soil acidification is not a significant issue for this Project and will not be discussed further.

Culturally Valued Vegetation

Construction, operation, and closure activities may affect culturally valued vegetation. All the effects to culturally valued plants will be within the PDA. Consequently, effects to plants within the RSA that are currently valued and used by Inuit because of Project activities are expected to be small.

Interviews with Elders from Pond Inlet during the traditional plant use study identified 18 plant species that are currently or have historically been used by local Inuit (see Appendix 6C). Today the plant species that are most commonly used by Inuit include blueberries (*Vaccinium uliginosum*), crowberries (*Empetrum nigrum*) and mountain sorrel (*Oxaia digyna*).

Blueberry plants grow in abundance on sheltered slopes throughout the RSA. In good abundant years, large quantities of berries are produced on loose mats of foliage on the glaciofluvial terraces from Milne Inlet to the Mine Site, where the soil is well-drained yet moist enough to support them. They are particularly abundant to the east of Camp Lake. They are also common around the Ravn River crossing, on islands in Angajurjualuk Lake, and throughout the first valley south of the Mary River along the railway alignment. Production of blueberry fruit is high from the top of the decline where the proposed railway descends from Cockburn Lake to Steensby Port. The area around Cockburn Lake produces abundant and large blueberries. On the Cockburn cliffs and lower slopes, blueberry plants form thick carpets.

Crowberries, locally known as blackberries, were observed within only one plot along the Milne Inlet Tote Road, but are known to occur in many areas on north Baffin Island. IQ identifies crowberry picking spots at Pond Inlet and near Milne Inlet. Crowberry is relatively common along the Railway alignment, but not nearly as common as blueberry. Crowberry is found on glaciofluvial terraces, on sandy till surfaces, and on eskers - places where the soil is somewhat sandy and well-drained. The tops of eskers are the most common crowberry habitat.

Mountain sorrel is scattered throughout the RSA and grows where there is reliable moisture. Mountain sorrels does not grow in large patches, but is mostly found as individual plants. Consequently, predicting mountain sorrel coverage within the region is not possible.

3.2.1 Assessment Methods

Assessment methods for vegetation follow the general methodology presented in Volume 2, Section 3, to assess potential changes to documented baseline conditions based on Project implementation. The assessment of the Project's effect on vegetation is based on three measurable parameters:

- Vegetation Abundance and Diversity;
- Vegetation Health; and
- Culturally Valued Vegetation.

All parameters are assessed using quantitative procedures. Assessment methods are described for each measurable parameter below. The magnitudes of the effects were determined relative to the scale of occurrence within the Regional Study Area (RSA).

3.2.1.1 Vegetation Abundance and Diversity

New disturbance within the PDA will be the main cause of reduced plant abundance and diversity. For the purpose of quantifying the effects of the Project, we make three assumptions to simplify the assessment:

- New disturbance within the footprint of the Project will remove all vegetation within the entire PDA for the life of the Project.
- All land is terrestrial habitat and, therefore, is potentially vegetated; though much of the RSA is considered barren or sparsely vegetated.
- Regeneration of the disturbed area is a slow process and will not occur until beyond the life of the project.

To assess the predicted effects of the Project on vegetation abundance and diversity we identified the amount of new disturbance that the Project will cause (i.e., PDA), and the local diversity of vegetation, as described by plant community types identified through ELC mapping (Appendix 6D). The plant community types identified by the ELC mapping were restricted to exclude water, snow/ice (mostly sea ice), and "unclassified". The rationale was that the water class is not suitable terrestrial vegetation habitat; the snow/ice class was mostly within the Steensby Port area and is likely sea ice; and the unclassified ELC class consisted of pixels within the sea water in Steensby Inlet.

To quantify the predicted reduction in vegetation abundance due to Project activities, a comparison of the total available vegetated area before and after the mine development within the RSA is done by subtracting the PDA area from the RSA (Figure 6-3.1). The change in terrestrial habitat indicates the reduced abundance of vegetated area due to the Project activities that could physically remove the vegetation. The results of the analysis will be an overestimate of the reduction of vegetation because much of the PDA is sparsely or non-vegetated terrain; therefore, the results are best described as a reduction in terrestrial habitat. To quantify the predicted reduction in vegetation diversity due to Project activities, we compare the area represented by each of the plant communities identified during ELC mapping before and after the mine development within the RSA. The ELC units within the PDA are extracted from the ELC map, allowing a comparison of the ELC map before and after the potential effect. The representation of each vegetation community within the PDA and the reduction of vegetation communities from the RSA are summarized.

3.2.1.2 Vegetation Health

Effects of the Project on plant health is assessed by use of thresholds for each contaminant beyond which effects on plant health are known or suspected to occur.

Dust (TSP)

There are no known dust deposition thresholds specific to effects on vegetation. Health Canada/Environment Canada's national ambient air quality objectives for particulate matter (CEPA/FPAC Working Group, 1998) state that for the lack of quantitative dose-effect information, it is not possible to define a reference level for vegetation and dust deposition. In the absence of published thresholds for dust effects on vegetation, the High Lake Project (Wolfden Resources Inc., 2006), a proposed base metal mine in western Nunavut, developed thresholds for the magnitude of effect on vegetation health ranging from 4.6 $g/m^2/a$ for a low magnitude effect to ≥50 $g/m^2/a$ for a high magnitude effect (Table 6-3.1). Spatt and Miller (1981) observed a decline in species abundance with a deposition rate of 1.0 to 2.5 $g/m^2/d$ and observed some effects for deposition rates of 0.07 to 1 $g/m^2/d$. For human health purposes, Alberta has

Table 6-3.1 Dust Deposition Rates and Criteria for Potential Effects on Vegetation Health

Source of Information	Dust (TSP) deposition rate	Equivalent annual dust deposition rate (g/m2/a)	Comments
High Lake Impact Assessment (Wolfden 2006)	1.0–4.6 g/m²/a	1.0–4.6	Predicted low magnitude effect on vegetation health
	4.6–50 g/m²/a	4.6–50	Predicted moderate magnitude effect on vegetation health
	50–200 g/m²/a	50–200	Predicted high magnitude effect on vegetation health
Spatt and Miller (1981)	0.07 g/m²/d	26	Some effects to *Sphagnum* species
	1.0–2.5 g/m²/d	365–913	Decline in *Sphagnum* species abundance
Alberta	5.3 g/m²/30 d	64	Alberta Guidelines for Residential and Recreational Areas (human health)
Ontario	4.6 g/m²/a	4.6	Ontario Ambient Air Quality Criteria (human health)

a dust deposition criterion for residential and recreation areas of 5.3 g/m^2/30 day and Ontario has an annual deposition criterion of 4.6 g/m^2/a.

The thresholds developed for annual TSP deposition in the High Lake Project are considered relevant thresholds for the effects of annual TSP deposition on vegetation health for the Mary River Project. To align with the categories used for air quality monitoring for the Mary River Project, the following annual TSP depositions thresholds are used:

Low: 0–5.0 g/m²/a;

Moderate: 5.0–55 g/m²/a; and

High: ≥ 55 g/m²/a.

Metals in Dust

Thresholds that link atmospheric deposition of metals to concentrations in vegetation or soil have not yet been developed, and no Arctic specific soil quality guidelines exist. However, the U.S. Environmental Protection Agency Ecological Soil Screening Levels (U.S. EPA EcoSSLs) contain specific screening criteria derived to be protective on the conservative end on the exposure of select metals and health effects to plants. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health include guidelines for metals in soils that are considered protective for agricultural settings. The agricultural land use guidelines provided by the Canadian Council of Ministers of the Environment (CCME) are the most conservative, relative to CCME guidelines derived for all other land uses. U.S. EPA EcoSSLs and CCME guidelines are derived from Canadian and U.S. regulatory agencies and are widely used across North America for determining whether certain metals concentrations in soils merit further consideration.

In order to assess the magnitude of potential metals concentrations in soil outside of the PDA on vegetation health, a prediction of future metal concentrations in soils as a result of Project activities was required. In

2010, the predicted future metal concentrations in soil beyond the Milne Port, Mine Site and Steensby Port PDAs based on estimated incremental metal deposition rates and existing maximum baseline metal concentrations in soils (Appendix 6G-2). An addendum to this report is provided in Appendix 6G-2 which includes updated estimated incremental metal deposition rates based on revised modelling from Volume 5 of this FEIS. This approach builds on two levels of conservatism from the work included in Volume 5, which used maximum expected metal concentrations in dust, and calculations in Appendix 6G-2, in which 120g TSP/m^2/a was used to calculate incremental metal deposition on soils. This deposition rate is a conservative estimate as it corresponds to locations outside of the PDA and operational areas that would incur the greatest dust deposition. One hundred percent of the metals deposited are predicted to stay within the soil with no loss to runoff. Not all metals analyzed in dust samples underwent the estimation of future soil concentrations. The rational for the exclusion of certain metals (Appendix 6G-1) was either a result of the deposition being insignificant or that there would be insufficient exposure to these elements in soil, vegetation or ore dust to represent a situation of extreme exposure to caribou.

Total estimated future soil concentrations (predicted incremental metal deposition + existing baseline metals in soil) were used to screen for metals based on the U.S. EPA EcoSSLs for the protection of plant health. The U.S. EPA EcoSSLs are considered as the most applicable levels for this assessment as these levels are derived from specific literature pertaining to plant health. If U.S. EPA Eco SSLs for certain metals were not available, the CCME guidelines were used. Metals not represented in either U.S. EPA or CCME guidelines were not considered further.

For metals represented in the U.S. EPA and CCME soil screening levels, the magnitude of effects from predicted metal concentration in soil on plant health were determined as follows:

Low: Effects below the soil screening criteria;

Moderate: Effects greater than the soil screening criteria; and

High: Effects that are an order of magnitude greater than soil screening criteria.

Atmospheric Emissions

The World Health Organization (WHO, 2000) established critical levels of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) emissions at which detrimental effects on vegetation begin to occur. Annual mean concentrations of 30 µg/m^3 were associated with the eradication of sensitive lichen, but it was recommend that an air quality guideline of 10 µg/m^3/a of SO_2 be established (WHO, 2000). Determining critical loads of NO_2 are less clear because increasing levels of NO_2 may or may not be beneficial. However, based on available information, the WHO (2000) suggested a critical level of atmospheric concentrations of NO_2 of 30 µg/m^3 as an annual mean before detrimental effects are recognized in plants.

The WHO (2000) guideline for nitrogen deposition to natural systems range from 5–20 N kg/ha/a. Graham *et al.* (1997) suggest that 5–15 N kg/ha/a is a critical load for Arctic and alpine heaths. To summarize the available guidelines, critical levels beyond which plant health may be affected includes:

- Annual atmospheric concentration of SO2 ≥ 10 µg/m^3/a on lichens;
- Annual atmospheric concentrations of NO2 ≥ 30 µg/m^3/a; and
- Annual deposition of nitrogen ≥ 12 kg N/ha/a.

Based primarily on WHO recommended guidelines that are roughly equivalent to the available dispersion modeling data, the magnitude of effects of potential SO_2 and NO_2 emissions are as follows:

Low:	< 5 µg/m^3/a SO_2 <7.5 µg/m^3/a NO_2
Moderate:	5–10 µg/m^3/a SO_2 7.5–30 µg/m^3/a NO_2
High:	>10 µg/m^3/a SO_2 > 30 µg/m^3/a NO_2

Similarly for deposition of nitrogen:

Low:	0–6 kg N/ha/a
Moderate:	6–12 kg N/ha/a
High:	> 12 kg N /ha/a

Models were developed as part of the Air Quality assessment (Volume 5, Section 2) for the concentrations, rates and dispersion patterns of TSP and atmospheric SO_2 and NO_2. From those models, emissions isopleths were developed at several concentration ranges above and below threshold levels for effects on plant health. The resulting isopleths were overlaid on the vegetation class data (minus the area of vegetation within the PDA — accounted for in the section on Abundance and Diversity) to estimate the area of each class affected by annual rates of deposition of dust (TSP), and annual concentration of NO_2. Annual deposition (N kg/ha/a) was calculated from the predicted 30 day nitrogen deposition rate presented in µg/m²/second (kg/ha/yr = µg/m²/second *315.36).

Some vegetation classes will be more sensitive to dust and emissions than others. Based on the literature review summarised above, estimates of sensitivity () were applied to the ten terrestrial vegetation classes identified in the Ecological Land Classification (Appendix 6D). Two specific vegetation types not included in the ELC but described in the vegetation baseline report include riparian willow shrub lands/ riparian shoreline shrub, and snowbank associations. Both of those communities are relatively tolerant of dust and emissions because of generally moist habitats and willow generally being generally tolerant species. The sensitivity classes are used to summarise the potential effects of dust and emissions on the various vegetation classes.

3.2.1.3 Culturally Valued Vegetation

Many traditionally culturally valued plants were identified during a community workshop with local Inuit Elders. Only a few species are still regularly used, including blueberry, crowberry, and mountain sorrel. The distribution of most of these plant species could not be modeled; however, blueberry is modeled for the RSA. The blueberry model predicted the percent of blueberry cover for the RSA. The change in abundance of blueberry plants within the RSA is quantitatively assessed by comparing blueberry abundance before and after Project development using the same methods and assumptions used to assess changes to vegetation abundance.

Table 6-3.2 Vegetation Classes Predicted to be Sensitive to Annual TSP Deposition, NO2 Emissions, and Nitrogen Deposition

Vegetation Class	Predicted Sensitivity to TSP, NO2 Emissions and N Deposition	Comments
Wetlands (Emergent sedge and non-tussock sedge associations)	Low	Due to more nutrient rich habitat and diluting effect of water.
Wet sedge - Graminoids and bryoids (Moss association, sedge-moss wet meadow)	High	Grow in acidic habitats with sphagnum that is sensitive to dust (Farmer 1993).
Tussock graminoid tundra (Tussock sedge association)	Low	Generally moist habitat, relatively good growing conditions in moist soils.
Moist to dry non-tussock graminoid/dwarf shrub tundra: 50–70 % cover (Shrub-sedge tundra)	Moderate	Some low shrub species appear to be sensitive to dust (Walker et al., 1985).
Dry graminoid prostrate dwarf shrub tundra: 70–100 % cover (Dry slope with forbs, dry cliff ledges)	Moderate	Some low shrub species appear to be sensitive to dust (Walker et al., 1985).
Prostrate dwarf shrub-Dryas/heath, usually on bedrock (Heath tundra grading to Dryas-xeric sedge association)	High	Nutrient poor habitats.
Sparsely vegetated bedrock (Lichen-rock associations)	High	Moss, lichen and heath components.
Sparsely vegetated till-colluvium	High	Low vegetation cover, nutrient poor.
Bare soil with cryptogam crust - frost boils (Dry slope with forbs, calcerous substrate)	High	Low vegetation cover, nutrient poor.
Barrens (Purple saxifrage barrens, avens and xeric sedge association, Luzula association)	High	Extremely sparse vegetation in nutrient poor habitat.

NOTE(S):
1. VEGETATION CLASSES GENERATED FOR THE ECOLOGICAL LAND CLASSIFICATION (APPENDIX 6D) AND ROUGH EQUIVALENTS FROM THE DETAILED VEGETATION CLASSIFICATION OF THE VEGETATION BASELINE (APPENDIX 6C).

3.2.2 Potential Effects and Proposed Mitigation

3.2.2.1 Vegetation Abundance and Diversity

Direct loss of terrestrial habitat due to development of facilities at the Mine Site and the mine itself will cause a reduction of 27.4 km² of terrestrial habitat (Table 6-3.3). Approximately 0.5 km² of surface disturbance has already occurred at the Mine Site as a result of the original exploration and bulk sampling activities. Milne Inlet, the Tote Road and laydown areas at the Mine Site were first developed during the 1960s, and have been upgraded during exploration activities and for the bulk sampling program. Expansion will occur at the

Table 6-3.3 Summary of Predicted Loss of the Terrestrial Habitat within and Outside the PDA

Project Component	Loss of terrestrial habitat within PDA (km^2)	Potential Direct Loss of Vegetation
Milne Inlet Port	0.33	Existing area of disturbance at Milne Inlet (328,450 m^2)
Milne Inlet Tote Road	0.50	Existing loss of terrestrial habitat from existing road surface. (e.g., 99 km x 5 m wide surface)
Mine Site	27.4	Additional loss to existing footprint of 522,600 m^2 (0.52 km^2). Minor loss of vegetation with expansion of the footprint of mine and infrastructure areas, but all vegetation loss will occur within the PDA
Railway	47.6	Moderate losses of vegetation, including blueberry and crowberry habitat, all within the PDA
Steensby Port	24.2	Additional loss to existing footprint of 56,000 m^2 (0.06 km^2). Vegetation will be lost within the PDA; however, overall loss will be minor on a regional scale
Total	**100**	

mine site during development. All of the changes will be within the PDA. Given that each of these components already exists, loss of vegetation because of these infrastructures will be limited. A conservative approach was used in the assessment by assuming that the entire PDA is currently pristine.

Direct loss of terrestrial habitat because of the Railway and Steensby Port footprints will result in a total loss of 72 km^2. All of the vegetation loss within the Railway and Steensby Port footprints will be from new disturbance.

All plant communities and species documented during baseline studies will likely be present after mine closure. Comparison of the representation of plant communities within the RSA after removing the plant habitat within the PDA, indicates that none of the plant communities will be significantly or disproportionately affected by the Project. Less than 1 % of the area occupied by each plant community within the RSA will be removed in the PDA (Table 6-3.4).

Loss of vegetation abundance and diversity could occur from dust deposition and other pollutants within the RSA. Dust and pollutant deposition is summarized in the vegetation health section below. Establishment of invasive species within the RSA is unlikely. Baffinland intends to mitigate the potential effect by ensuring that equipment brought to the Project site has been cleaned of soils that could contain plant seeds that do not currently occur within the RSA, and by allowing natural re-vegetation of disturbed areas.

Mitigation measures:

- Project activities will be planned and conducted to minimize the project footprint within the PDA.
- Project vehicles will stay on the established roads within the PDA during operation, limiting new disturbance to the PDA.
- It is not anticipated that disturbed terrestrial habitat will not be reseeded during construction, operation and closure. Re-vegetation of the terrestrial habitat will be allowed to occur naturally, unless it is determined by progressive rehabilitation studies (Volume 3, Attachment 10), that re-seeding with native species is preferable and can be accomplished without introducing invasive plant species.

- Equipment brought to the Project site will be cleaned of soils that could contain plant seeds that do not naturally occur in the RSA. The mitigation will reduce the likelihood of invasive plant species getting established within the RSA due to Project development activities.

Table 6-3.4 Predicted Loss of Broad Vegetation Community Types as a Result of Disturbance within the PDA

RSA Vegetation Cover Classes	Baseline RSA		Affected RSA	
	Area (km^2)	% of RSA	Affected Area (km^2)	Change (%)
Wetlands	124.9	0.41	0.2	-0.17
Wet sedge - Graminoids and bryoids	1,276.9	4.16	6.2	-0.49
Tussock graminoid tundra	1,726.3	5.62	7.2	-0.42
Moist to dry non-tussock graminoid/dwarf shrub tundra: 50–70 % cover	2,546.8	8.29	16.2	-0.64
Dry graminoid prostrate dwarf shrub tundra: 70–100 % cover	71.8	0.23	0.5	-0.64
Prostrate dwarf shrub - Dryas/heath, usually on bedrock	4,124.9	13.43	21.3	-0.52
Sparsely vegetated bedrock	4,295.6	13.99	29.7	-0.69
Sparsely vegetated till-colluvium	2,922.2	9.52	9.2	-0.31
Bare soil with cryptogam crust - Frost boils	2,783.4	9.06	12.8	-0.46
Barrens	3,673.4	2.25	2.7	-0.08
Water/Ice/Snow/Unclassified	7,165	23.33		
Total	**30,711**	**100**	**110**	**-0.36**

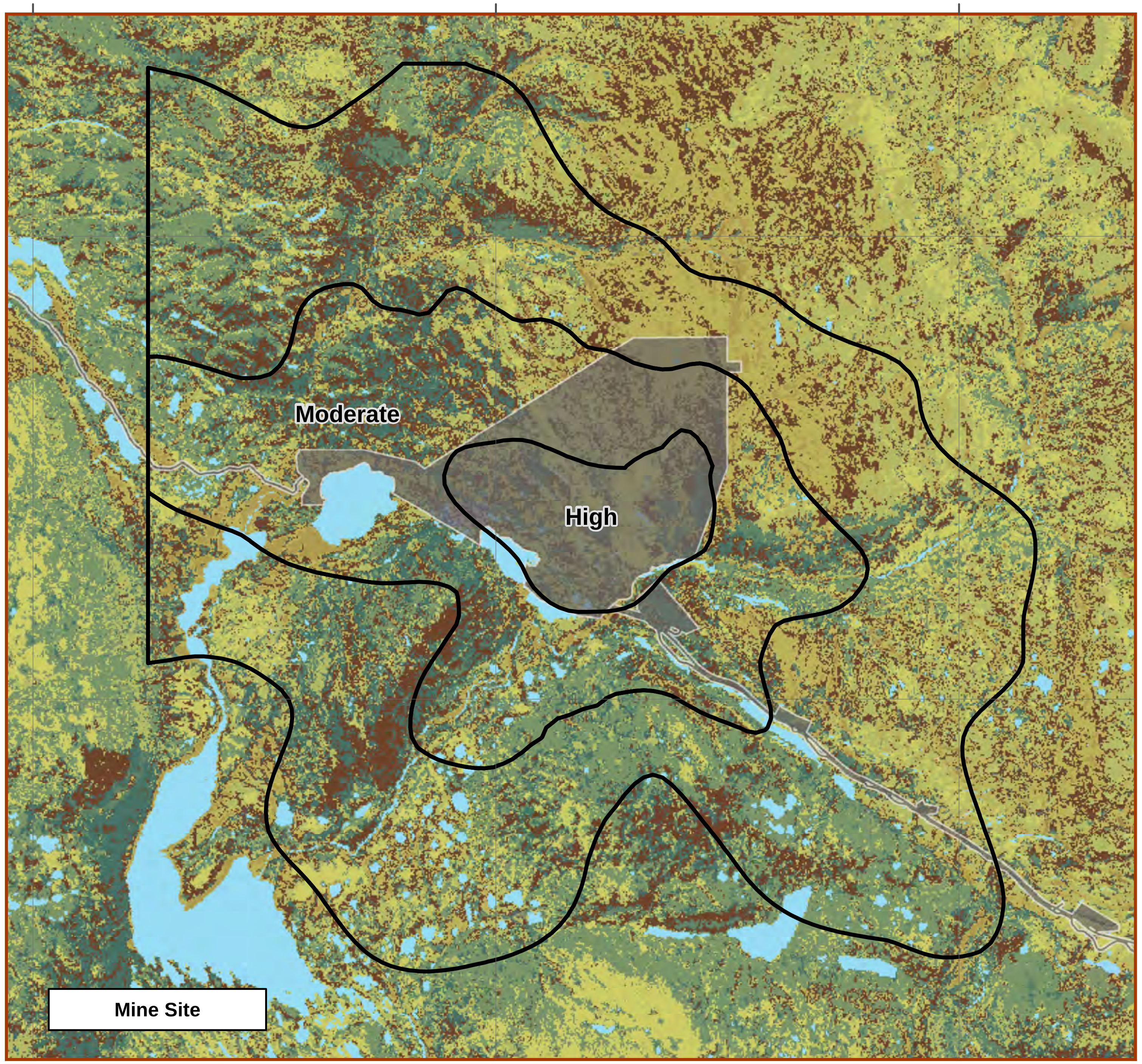
3.2.2.2 <u>Vegetation Health</u>

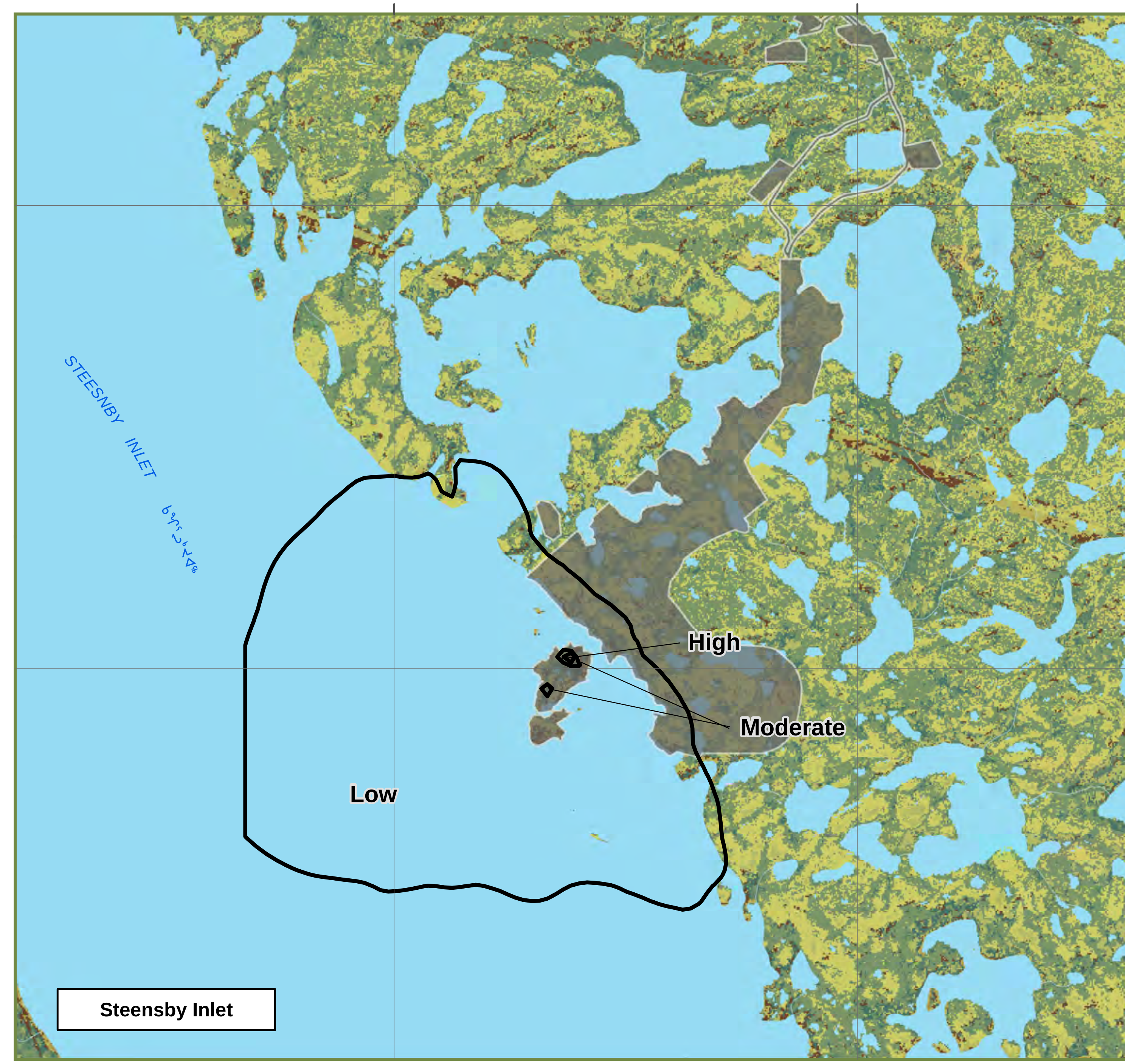
Dust (TSP)

A total of 226 km^2 (0.10 % of the RSA) of vegetated habitat could be affected by annual dust deposition. The largest area affected by annual TSP deposition will be at the Mine Site, followed by Steensby Port and then Milne Port. Plant health may be affected in 0.5 km^2 of terrestrial habitat surrounding the Mine Site (outside of the PDA) where the threshold of 55 $g/m^2/a$ TSP could be exceeded. Due to prevailing winds and less terrestrial habitat in the Steensby port area, it is not expected that the 55 g TSP/m^2/a threshold will not be exceeded outside of the PDA at Steensby Port (Table 6-3.5; Figure 6-3.2).

Table 6-3.5 The Area Outside the PDA Affected by Annual TSP Deposition on Vegetated ELC Units

Project Location	Area (km^2) Affected by Annual Dust (TSP) Deposition			
	Low (0–5.0 $g/m^2/a$)	Moderate (5.0–55 $g/m^2/a$)	High (> 55 $g/m^2/a$)	Total Terrestrial Area Outside of PDA Affected by Annual TSP
Milne Port	0	0	0	0
Mine Site	162.2	60.8	0.5	223.5
Steensby Port	2.9	0	0	2.9
Total	165.1	60.8	0.5	226.4





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Annual TSP Deposition

Vegetation Classification

- Wetlands
- Wet sedge - Graminoids and bryoids
- Tussock graminoid tundra
- Moist to dry non-tussock graminoid/Dwarf shrub tundra: 50-70% cover
- Dry graminoid prostrate dwarf shrub tundra: 70-100% cover
- Prostrate dwarf shrub - Dryas/heath, usually on bedrock
- Sparsely vegetated bedrock
- Sparsely vegetated till-colluvium
- Bare soil with cryptogam crust - Frost boils
- Barren
- Ice/snow
- Unclassified
- Water

N W E S

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Potential Development Area, Regional Study Area and ELC imagery for vegetation provided by Knight Piesold Consulting, 2010.

TSP, NO2, N deposition isopleths provided by RWDI Air Inc., 2011. These data were modified by EDI for the purpose of map display.

Projection: North American Datum 1983 UTM Zone 17N

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Figure 6-3.2. Vegetation Classes Affected by Annual Dust (TSP) Deposition.

EDI Environmental Dynamics Inc.

Date: 11/01/2012

ᑎᑎᕋᐅᔭᕐᓯᒪᔪᖅ **FIGURE 6-3.2**

No vegetation classes considered sensitive to dust deposition are disproportionally affected by dust, and most of the habits will remain intact within the RSA (Table 6-3.6). Some of the communities predicted to be more sensitive to disturbance may experience declined growth of sensitive species, reduced biomass, or changes in community composition. All areas experiencing dust deposition during the winter may experience earlier green-up as a result of earlier snow melt. The extent of areas experiencing earlier snow melt is unknown and unpredictable.

Dust will also be generated along the Milne Inlet Tote Road, Railway, and during construction of the borrow sources. The air quality assessment (Volume 5, Section 2) identified the predicted dust effects along the linear transportation corridors, with dust deposition expected to be greater on and near the corridors. Much of that area will be encompassed within the PDA where vegetation removal is predicted to be complete (addressed in the Vegetation Abundance and Diversity section).

Mitigation of dust effects on vegetation will be addressed by those measures used to mitigate effects on air quality as described in Volume 5, Section 2.

Table 6-3.6 Vegetation Classes Affected by Annual Dust (TSP) Deposition

RSA Vegetation Cover Classes	Baseline RSA Area		Area (km2) affected by Annual Dust (TSP) Deposition			RSA affected by TSP	
	Area (km2)	% of RSA	Low (< 5.0 g/m2/a)	Moderate (5.0–55 g/m2/a)	High (> 55 g/m2/a)	Area (km2)	% of class in RSA
Wetlands	125	0.41	0.3	0.2	0.0	0.4	0.3
Wet sedge - Graminoids and bryoids	1,277	4.16	7.7	4.0	0.0	11.7	0.9
Tussock graminoid tundra	1,726	5.62	17.9	11.6	0.1	29.6	1.7
Moist to dry non-tussock graminoid/Dwarf shrub tundra: 50–70 % cover	2,547	8.29	29.5	9.2	0.0	38.7	1.5
Dry graminoid prostrate dwarf shrub tundra: 70-100 % cover	72	0.23	0.2	0.1	0.0	0.3	0.4
Prostrate dwarf shrub – Dryas/heath, usually on bedrock	4,125	13.43	33.9	8.8	0.1	42.8	1.0
Sparsely vegetated bedrock	4,296	13.99	15.9	3.7	0.0	19.6	0.5
Sparsely vegetation till colluvium	2,922	9.52	19.7	6.0	0.1	25.7	0.9
Bare soil with cryptogam crust – Frost boils	2,783	9.06	35.9	15.0	0.1	51.1	1.8
Barrens	3,673	11.96	4.1	2.3	0.0	6.4	0.2
Water/Ice/Snow/Unclassified	7,165	23.33					
Total	30,711	100	165.1	60.8	0.5	226.4	0.7

NOTE(S):
PREDICTED HIGH SENSITIVITY TO TSP VEGETATION CLASSES (

Table 6-3.2) ARE HIGHLIGHTED IN GREY.

Metals in Dust

The majority of dust (TSP) is expected to be generated from the mining, handling and stockpiling of ore. The ore is largely composed of iron with a number of trace metals. Dust released during Project activities will contain metals and these metals will persist in the environment once released.

The air quality impact assessment contained in Volume 5, Section 2, provides an assessment of expected metals deposition from dust for construction and operation activities at the Mine Site and Steensby Port. Based on dust deposition predictions provided Volume 5 Section 2, a portion of emitted dusts are expected to settle in areas outside of the PDA the Mine Site and Steensby Port. Potential effects of dust that settles within the PDA are not considered further since vegetation removal is predicted for the entire PDA and is addressed in the Vegetation Abundance and Diversity section of this report.

A portion of dust will deposit directly on vegetation and some foliar uptake may occur but will likely be minimal in comparison to root uptake. Potential foliar uptake will be limited for much of the year due to the absence of leaves or minimal metabolic processes during sub-zero temperatures. Snow cover will also limit dust contact with vegetation for much of the year. Thick cuticles common on Arctic plant species should act to limit foliar uptake of metals by limiting transpiration rates, metabolic processes and leaf abrasion of windblown soils and snow. For these reasons direct foliar uptake of metals is not considered further.

Metals in dust that extend beyond the PDA will add to naturally occurring metals in soils and have the potential of being taken up into vegetation through roots. Baseline metal concentrations in soil and plants were established for vegetation plots sampled during the vegetation baseline study (Appendix 6C). Baseline metal concentrations in plants and soils are naturally occurring and are considered to be supportive of plant health in the RSA. However, additional metals that could be introduced to soils from dust deposition do have the potential to affect plant vegetation over time.

Based on comparisons against the U.S. EPA Eco SSLs and CCME guidelines, where they existed, it is apparent that several metals could exceed the soil criteria guidelines based on a conservative maximum deposition rate of 120 $g/m^2/a$ (Appendix 6G-2) metal concentrations in soil at the end of Project life (21 years) as shown in Table 6.3-7. Predicted high, moderate and low magnitude effects are assigned in relation to the screening criteria.

All metals with the exception of seven are predicted to be below screening levels (low magnitude) in soils outside of the PDA after 21 years of operation. Only arsenic and manganese are predicted to be an order of magnitude higher than screening levels (high magnitude). It is predicted that the effects from metal toxicity, if any, will occur primarily to the more sensitive vegetation classes, including the sparsely vegetated classes found on shallow soils with little to no organic content (e.g., colluvium and bedrock).

Several monitoring and mitigation measures could be employed during Project construction, operation and closer to either reduce atmospheric deposition of metals on soils outside of the PDA or to monitor potential occurrence and or effects of increasing metals in soil and or plant foliage:

- Air quality monitoring to validate predicted metals in dust associated with Project activities;
- Monitoring program to validate predicted metal deposition rates and or concentrations in soils outside of the PDA;
- Monitoring program to validate soil pH in locations outside of the PDA; and
- Monitoring program to establish metal concentrations in foliar tissues and examine vegetation for symptoms related to potential metal phytotoxicity outside of the PDA.

Mitigation of emissions on vegetation will be addressed by those measures used to mitigate effects on air quality as described in Volume 5, Section 2. Additionally, based on results of monitoring activities, there are mitigation measures that could be employed to mitigate dust deposition or minimize potential effects of metals on plant health. Mitigation measures could include further dust emissions controls and or soil amendments (e.g., lime) in localized areas that are showing adverse effects from metal toxicity. Soil amendments would act to adjust soil chemistry to immobilize metals in soil thereby reducing the bioavailability and potential toxicity to plants.

Table 6-3.7 Total Predicted Soil Metal Concentration in Comparison to U.S. EPA EcoSSLs and CCME Soil Guidelines Assuming 120 g TSP/m²/a Deposition Rate

Metal	Total Predicted Future Soil Metals Concentration (mg/kg)	U.S. EPA EcoSSLs (mg/kg)	CCME Soil Criteria for Agricultural Land Use (mg/kg)	Predicted High, Moderate, Low Magnitude Effect
Aluminium	19 500	[1]		Low
Arsenic	121	18	12	High
Barium	73.3		750	Low
Cadmium	1.52	32	1.4	Low
Cobalt	17.4	13		Moderate
Chromium	90.9		64	Moderate

Table 6-3.8 Total Predicted Soil Metal Concentration in Comparison to U.S. EPA EcoSSLs and CCME Soil Guidelines Assuming 120 g TSP/m²/a Deposition Rate (Cont'd)

Metal	Total Predicted Future Soil Metals Concentration (mg/kg)	U.S. EPA EcoSSLs (mg/kg)	CCME Soil Criteria for Agricultural Land Use (mg/kg)	Predicted High, Moderate, Low Magnitude Effect
Copper	77.5	70	63	Moderate
Iron	127000	[2]		Low
Lead	31.9	120	70	Low
Manganese	4330	220		High
Nickel	60.5	38	50	Moderate
Selenium	2.17	0.52	1	Moderate
Silver	1.48	560		Low
Thallium	0.303		1	Low
Uranium	5.99		23	Low
Vanadium	63.6		130	Low
Zinc	93.5	160	200	Low

NOTE(S):

1. U.S. EPA (2003a) reports that total or available aluminium in soils is not a suitable or reliable predictor of toxicity. it is recommended that aluminium only be considered when soil ph is <5.5 since aluminium solubility (which determines bioavailability to plants) is ph dependent. based on limited baseline soil ph data that was collected within the various project study areas, soil ph is in the slightly acidic to neutral range (6–7.5). therefore aluminium does not merit further study.
2. U.S. EPA (2003b) reports that identifying a specific benchmark for iron in soils is difficult since iron's bioavailability to plants and the resulting potential toxicity are dependent upon site specific soil conditions such as ph and moisture. the u.s. epa recommends that the site specific measured ph be used in part to determine the expected valence state of iron and associated chemical compounds, and the resulting bioavailability and potential toxicity in the location of study. in well-aerated soils between ph 5 and 8, the iron demand of plants is higher than the amount available. thus, plants have evolved various mechanisms to enhance iron uptake. soil ph in baseline soils was in the ph 6–7.5 range and therefore is slightly acidic to neutral. this indicated that iron would not likely be of concern to terrestrial plant health

Atmospheric Emissions

The largest terrestrial area affected by nitrogen dioxide emissions (outside of the PDA) is the Mine Site, followed by Steensby Port. The threshold of ≥ 30 µg $NO_2/m^3/a$ is exceeded in a 0.2 km² area outside of the PDA at the Mine Site and Steensby Port (Table 6-3.9; Figure 6-3.3).

All vegetation classes are present in each of the areas affected by NO_2 emissions. There are no vegetation classes that are disproportionally affected by nitrogen dioxide emissions outside of the PDA (Table 6-3.10). Overall, 0.02 % of the RSA is affected by NO_2 emissions. The range of effects on individual vegetation classes ranges from 0.00–0.06 % of individual class availability throughout the RSA (Table 6-3.10). The greatest effects are predicted to be on the more sensitive vegetation classes, including the sparsely vegetated classes found on shallow or no soils (e.g., colluvium and bedrock). Mitigation of emissions on vegetation will be addressed by those measures used to mitigate effects on air quality as described in Volume 5, Section 2.

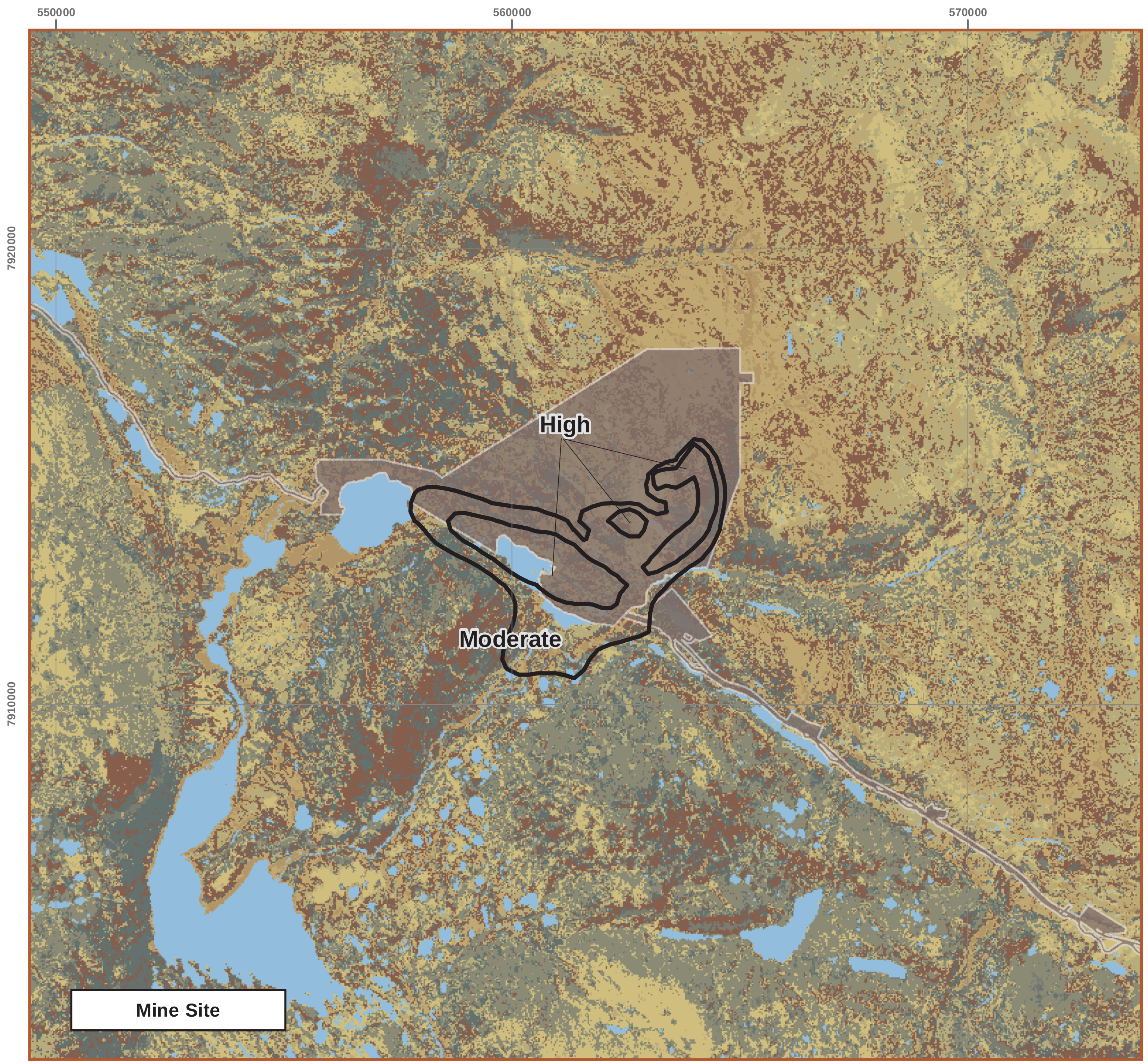
An area of 20.3 km² outside of the PDA could be affected by nitrogen deposition, and 0.8 km² could exceed the threshold of ≥12 kg N/ha/a (

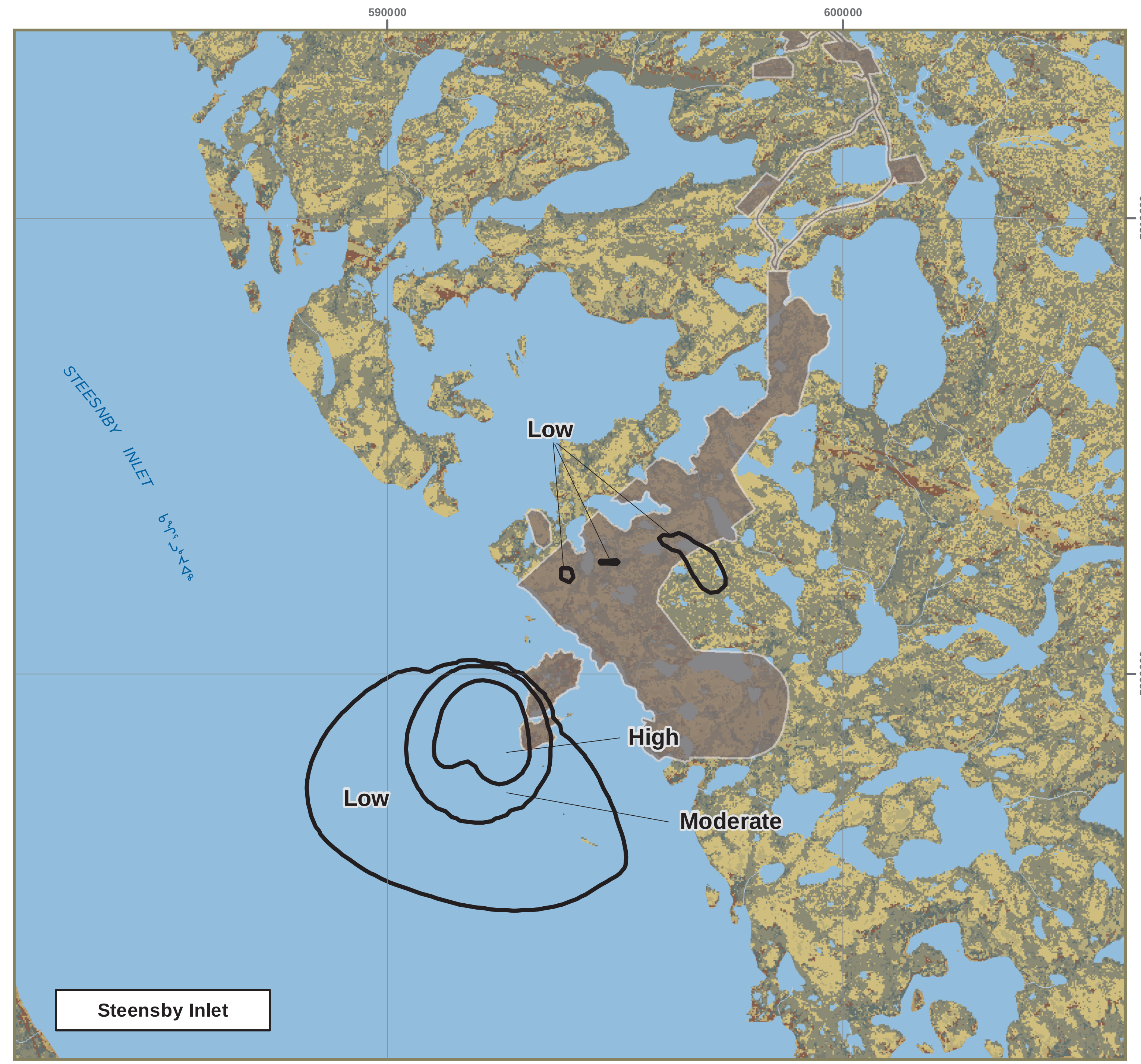
Table 6-3.11; Figure 6-3.4). No vegetation classes will be disproportionately affected by atmospheric nitrogen deposition (Table 6-3.11). All potential exceedences of the 12 kg N/ha/a measure ≤0.2 km²; therefore, the effect of N deposition on vegetation classes will likely be minor. The sensitive vegetation classes are those associated with drier habitats, heath, and moss/lichen dominated units. Mitigation of nitrogen deposition on vegetation will be addressed by those measures used to mitigate effects on air quality as described in Volume 5, Section 2.

The most noticeable effects on vegetation may occur in areas where the thresholds potentially exceeded for all three air quality parameters (i.e., annual TSP deposition, annual NO_2 emission concentrations, and annual deposition of nitrogen). This could occurs in an ~463 ha area at the Mine Site. The only area where all three air quality parameters could be exceeded outside of the PDA is ~25 ha of the lake adjacent to the mine camp. The vegetation within the PDA is assumed to be removed through construction and operation activities, and that loss is accounted for in the abundance and diversity section. Sulphur dioxide is not evaluated because of low emissions and deposition, and thresholds not being reached within the air quality LSA (Volume 5, Section 2.6.3 – Potential Effects and Proposed Mitigation).

Table 6-3.9 The Area Outside of the PDA Affected by Atmospheric Nitrogen Dioxide on Vegetated ELC Units

Project Location	Area (km^2) Affected by Annual Nitrogen Dioxide Emissions			
	Low (<7.5 µg/m^3/a)	Moderate (7.5–30 µg/m^3/a)	High (>30 µg/m^3/a)	Total Terrestrial Area Outside PDA Affected by Annual NO_2
Milne Port	0	0	0	0
Mine Site	0	4.2	0.2	4.5
Steensby Port	0.2	0.3	0.2	0.7
Total	0.2	4.6	0.4	5.1





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Annual Nitrogen Dioxide Emissions

Vegetation Classification

- Wetlands
- Wet sedge - Graminoids and bryoids
- Tussock graminoid tundra
- Moist to dry non-tussock graminoid/Dwarf shrub tundra: 50-70% cover
- Dry graminoid prostrate dwarf shrub tundra: 70-100% cover
- Prostrate dwarf shrub - Dryas/heath, usually on bedrock
- Sparsely vegetated bedrock
- Sparsely vegetated till-colluvium
- Bare soil with cryptogam crust - Frost boils
- Barren
- Ice/snow
- Unclassified
- Water

Scale 0 1 2 3 4 5 Km

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Potential Development Area, Regional Study Area and ELC imagery for vegetation provided by Knight Piesold Consulting, 2010.

TSP, NO2, N deposition isopleths provided by RWDI Air Inc., 2011. These data were modified by EDI for the purpose of map display.

Projection: North American Datum 1983 UTM Zone 17N

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Figure 6-3.3. Vegetation Classes Affected by Annual Nitrogen Emmissions.

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Date: 1/11/2012

FIGURE 6-3.3

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Table 6-3.10 Vegetation Classes Outside the PDA Affected by Atmospheric Nitrogen Dioxide (NO_2) Emissions

RSA Vegetation Cover Classes	Baseline RSA Area		Area (km2) Affected by NO2 Emissions			RSA Affected by NO2	
	Area (km2)	% of RSA	Low (<7.5 µg/m3/a)	Moderate (7.5–30 µg/m3/a)	High (>30 µg/m3/a)	Area (km2)	% of class in RSA
Wetlands	125	0.41	0.0	0.0	0.0	0.0	0.01
Wet sedge - Graminoids and bryoids	1,277	4.16	0.0	0.3	0.1	0.3	0.03
Tussock graminoid tundra	1,726	5.62	0.0	0.9	0.1	1.0	0.06
Moist to dry non-tussock graminoid/Dwarf shrub tundra:50–70 % cover	2,547	8.29	0.0	0.8	0.0	0.9	0.03
Dry graminoid prostrate dwarf shrub tundra: 70–100 % cover	72	0.23	0.0	0.0	0.0	0.0	0.01
Prostrate dwarf shrub – Dryas/heath, usually on bedrock	4,125	13.43	0.0	0.4	0.0	0.5	0.01
Sparsely vegetated bedrock	4,296	13.99	0.0	0.1	0.0	0.2	0.00
Sparsely vegetated till colluviums	2,922	9.52	0.1	0.6	0.0	0.7	0.02
Bare soil with cryptogam crust – Frost boils	2,783	9.06	0.0	1.1	0.1	1.2	0.04
Barrens	3,673	11.96	0.0	0.3	0.0	0.3	0.01
Water/Ice/Snow/Unclassified	7,165	23.33					
Total	30,711	100	0.2	4.6	0.4	5.1	0.02

NOTE(S):

1. PREDICTED HIGH SENSITIVITY TO NO_2 EMISSION VEGETATION CLASSES (
2. Table 6-3.2) ARE HIGHLIGHTED IN GREY.

Table 6-3.11 Area Outside the PDA Affected by Nitrogen (N) Deposition on Vegetated ELC Units

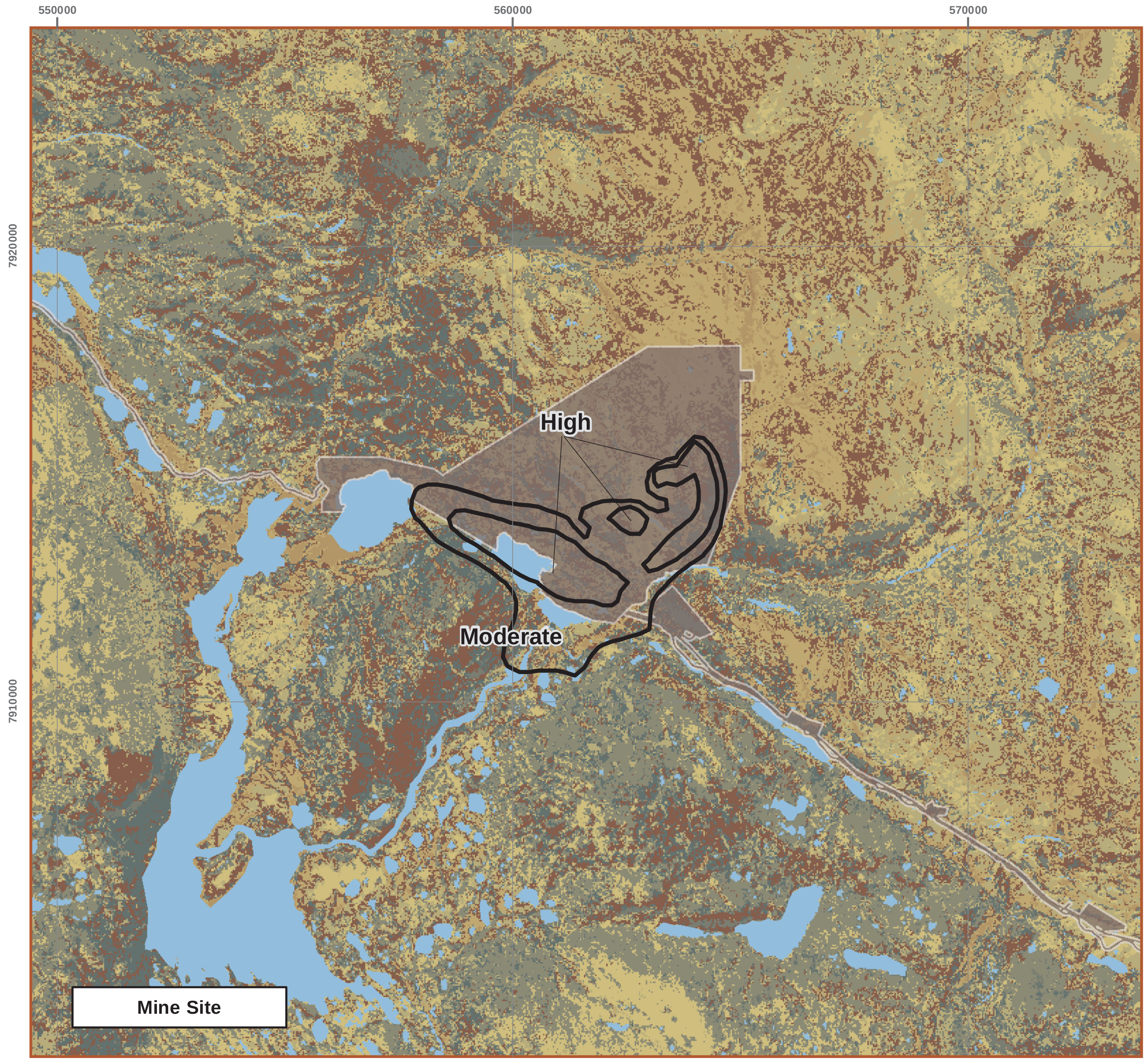
Project Location	Area (km^2) Affected by Annual Nitrogen Deposition			
	Low (<6 kg N/ha/a)	Moderate (6–12 kg N/ha/a)	High (>12 kg N/ha/a)	Total Terrestrial Area (PDA) Affected by N Deposition
Milne Port	na	na	na	na
Mine Site	9.7	6.0	0.5	16.2
Steensby Port	3.1	0.6	0.3	4.1
Total	12.8	6.6	0.8	20.3

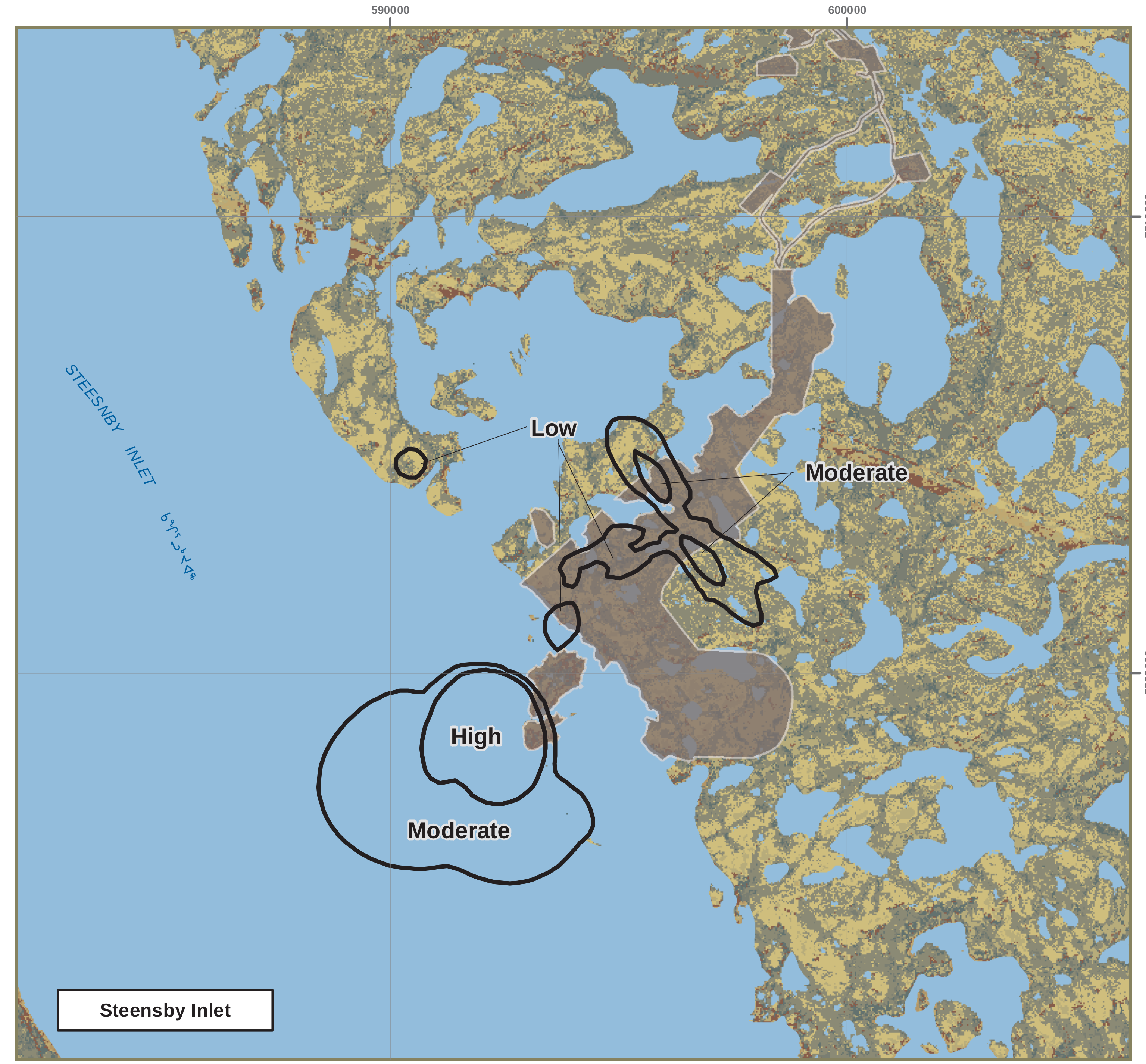
Table 6-3.12 Vegetation Classes Outside the PDA Affected by Atmospheric Nitrogen (N) Deposition

RSA Vegetation Cover Classes	Baseline RSA Area		Area (km2) Affected by Nitrogen Deposition			RSA Affected by Nitrogen Deposition	
	Area (km2)	% of RSA	Low (<6 kg N/ha/a)	Moderate (6–12 kg N/ha/a)	High (>12 kg N/ha/a)	Area (km2)	% of class in RSA
Wetlands	125	0.41	0.0	0.0	0.0	0.1	0.06
Wet sedge - Graminoids and bryoids	1,277	4.16	0.8	0.4	0.1	1.3	0.10
Tussock graminoid tundra	1,726	5.62	2.3	1.3	0.1	3.8	0.22
Moist to dry non-tussock graminoid/Dwarf shrub tundra:50–70 % cover	2,547	8.29	1.6	1.1	0.1	2.8	0.11
Dry graminoid prostrate dwarf shrub tundra: 70–100 % cover	72	0.23	0.0	0.0	0.0	0.0	0.06
Prostrate dwarf shrub – Dryas/heath, usually on bedrock	4,125	13.43	3.0	1.1	0.1	4.2	0.10
Sparsely vegetated bedrock	4,296	13.99	1.5	0.3	0.1	1.9	0.04
Sparsely vegetated till colluvium	2,922	9.52	0.7	0.6	0.1	1.5	0.05
Bare soil with cryptogam crust – Frost boils	2,783	9.06	2.5	1.5	0.2	4.1	0.15
Barrens	3,673.0	11.96	0.3	0.3	0.1	0.6	0.02
Water/Ice/Snow/Unclassified	7,165	23.33					
Total	30,711	100	12.8	6.6	0.8	20.3	0.07

NOTE(S):

1. PREDICTED HIGH SENSITIVITY TO N DEPOSITION VEGETATION CLASSES (
2. Table 6-3.2) ARE HIGHLIGHTED IN GREY.





LEGEND ᑐᑭᒥᔾᖏᑦ

Potential Development Area ᐱᕙᓪᓕᐊᔪᓕᕆᕕᐅᑐᐃᓇᕆᐊᓖᒃ

Annual Nitrogen Deposition

Vegetation Classification

- Wetlands
- Wet sedge - Graminoids and bryoids
- Tussock graminoid tundra
- Moist to dry non-tussock graminoid/Dwarf shrub tundra: 50-70% cover
- Dry graminoid prostrate dwarf shrub tundra: 70-100% cover
- Prostrate dwarf shrub - Dryas/heath, usually on bedrock
- Sparsely vegetated bedrock
- Sparsely vegetated till-colluvium
- Bare soil with cryptogam crust - Frost boils
- Barren
- Ice/snow
- Unclassified
- Water

N W E S

Scale 0 1 2 3 4 5 Km

NOTES ᖃᐅᔨᒪᔾᑲᐃᑦ

Potential Development Area, Regional Study Area and ELC imagery for vegetation provided by Knight Piesold Consulting, 2010.

TSP, NO2, N deposition isopleths provided by RWDI Air Inc., 2011. These data were modified by EDI for the purpose of map display.

Projection: North American Datum 1983 UTM Zone 17N

Baffinland Iron Mines Corporation

Figure 6-3.4. Vegetation Classes Affected by Annual Nitrogen Deposition.

EDI Environmental Dynamics Inc.

Date: 1/11/2012

FIGURE 6-3.4

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_3_4_Ndep_16Dec2011_02.mxd

3.2.2.3 Culturally Valued Vegetation

Direct loss of blueberry cover because of the footprint of the Project will occur within the 100 km^2 PDA (Table 6-3.3). Even if the entire PDA is cleared, the reduction of blueberry cover will be minor and indistinguishable from the baseline condition (Table 6-3.13 and Figure 6-3.5) at the scale of the RSA. Furthermore, much of the Milne Port, Tote Road and Mine Site are already disturbed areas, so the reduction of blueberry cover will be small because there will be limited new disturbance in those areas. New disturbance will be mostly limited to Railway and Steensby Port footprints, which could result in a total loss of 72 km^2 of terrestrial habitat. Not all vegetation within the Railway and Steensby Port footprints will be removed and not all vegetation removed will be blueberry cover; consequently, this estimate of blueberry cover loss is likely an overestimate of the true effect.

Mitigations identified for reducing effects of the Project on vegetation abundance and diversity will be suitable for mitigating effects to culturally valued vegetation.

Table 6-3.13 The Expected Effect to Potential Blueberry Cover within the RSA

Blueberry Cover Categories	Baseline RSA (km^2)	Affected PDA (km^2)	RSA cover after effect (km^2)	Change (%)
Low (0–20 %)	23,628.2	98.9	23,529.3	-0.42
Med-Low (21–40 %)	324.1	2.6	321.5	-0.81
Med-High (41–60 %)	98.1	1.5	96.6	-1.55
High (61–80 %)	267.0	3.9	263.0	-1.47

3.2.3 Assessment of Residual Effects

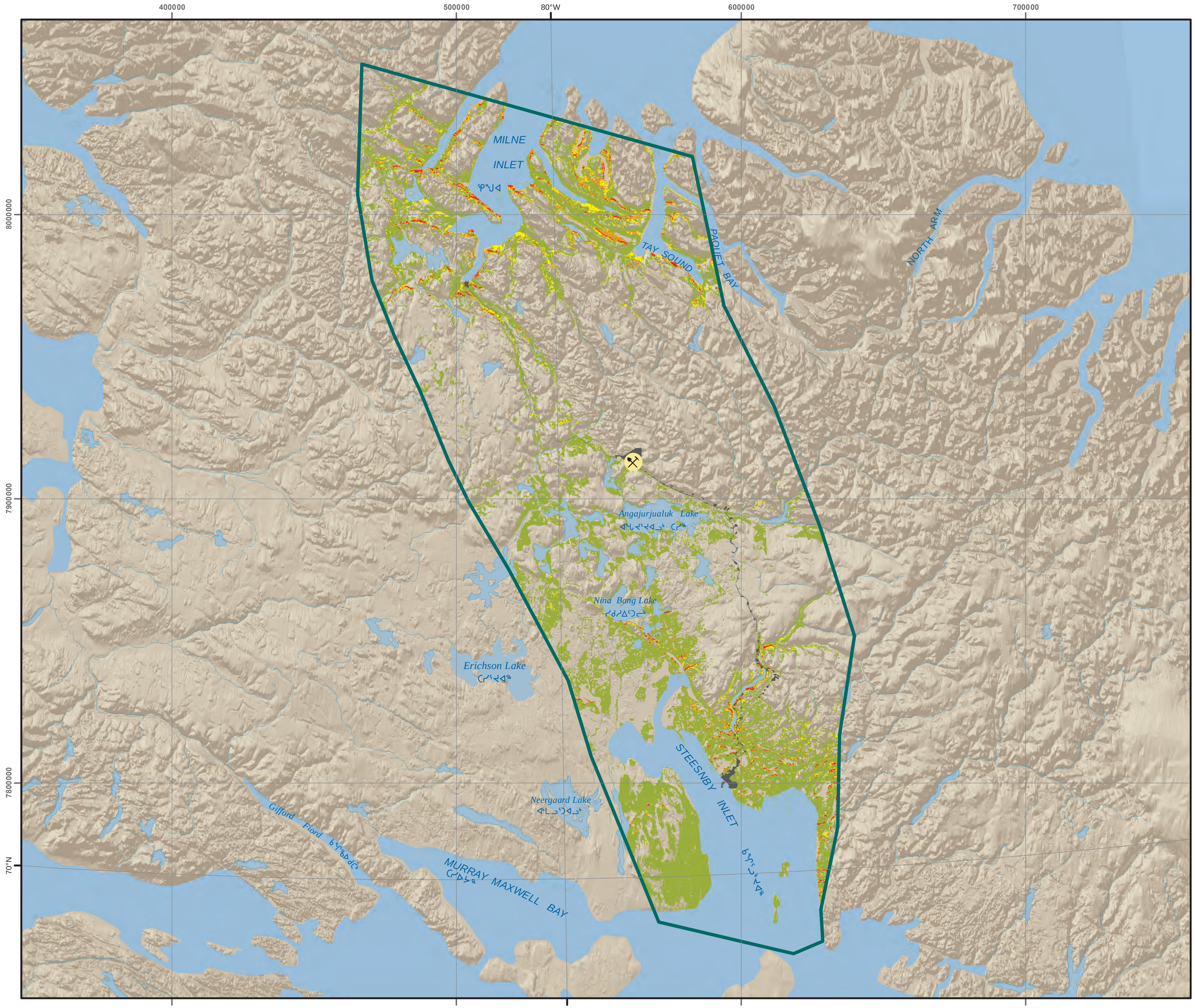
This section describes the potential residual effects that will remain after mitigations have been applied for each measurable parameter. After a discussion/description of the residual effects, the predictions are tabled and summarized for each measurable parameter using the language and evaluation criteria described in Volume 2, Section 3.

Vegetation Abundance and Distribution

Loss of vegetation within the PDA is a residual effect — it is not expected that disturbed areas will become re-vegetated until after closure of the mine. Some of the mine footprint may never return to baseline conditions. The predicted levels of vegetation abundance and distribution effects based on the evaluation criteria are summarized in Table 6-3.13.

Vegetation Health

During project construction, operation, and closure activities, it is predicted that annual dust deposition could occur outside of the PDA beyond the 55 g TSP/m^2/a threshold level, which may have an effect on vegetation communities. It is estimated that those effects would be limited to a small portion of vegetated areas in the RSA (<0.01 %), and small proportion of each vegetation class (<0.01 %) relative to their individual availability in the RSA. The effects would be reversible when the dust-producing activities cease.



LEGEND ᑐᑭᒋᔭᕐᒋᑦ

Mary River Project Study Specifics

.......Mary River Project ᓄᓘᔾᓂ ᐅᔭᕋᕐᓯᐅᕐᑐᑦ

.......Potential Development Area ᐱᕙᓕᐊᔪᓕᕆᕕᐅᑐᐃᓇᕆᐊᓕᒃ

.......Regional Study Area - Vegetation

Blueberry *(Vaccinium uliginosum)*
Groundcover (by percentage)

0.01% – 15%

16% – 40%

41% – 70%

71% – 80%

NOTES:

Potential Development Area and Regional Study Area for vegetation provided by Knight Piésold Consulting (2010)

Projection: North American Datum 1983 UTM Zone 17N

Scale 0 10 20 30 40 50 Km

Baffinland Iron Mines Corporation

Figure 6-3.5. Blueberry Cover within the Regional Study Area.

EDI Environmental Dynamics Inc.

16 December 2010

FIGURE 6-3.5

WHITEHORSE, YT SAVED: J:\Yukon\Projects\2010\10_Y_0550\Mapping\Fig6_3_5_BlueberryCover_16Dec2010

After project closure, when the air emissions and nitrogen deposition cease, the effects of nitrogen additions to the ecosystems will persist. This can result in long-term effects on plant community composition and individual species resilience. The prediction is that those effects will be limited to only small proportions (<0.1 %) of the more sensitive vegetation classes within the RSA. The predicted levels of vegetation health effects based on the evaluation criteria are summarised in Section 3.2.1.

Metals contained in dust will likely accumulate to some degree in soils beyond the PDAs, although the affected area is expected to be relatively small in comparison to the RSA. Plant responses to metals in soil are extremely varied and dependant on the species in question, but are primarily determined by soil pH. Since soil and substrate pH were found to be in a neutral range of 6 to 7.5 (based on baseline results) within the Project study area, bioavailability of metals is expected to be maintained at low levels, thereby minimizing or preventing potential phyto toxic effects. The prediction is that any effects will be small in extent and could be minimized by several monitoring and mitigation measures during the life of the Project and upon closure. The predicted levels of vegetation health effects resulting from metals in soils based on the evaluation criteria are summarised in Section 3.2.1.

Culturally Valued Vegetation

Loss of blueberry cover within the PDA of the Project is a residual effect — it is not expected that blueberry cover will return to the pre-development state until after closure of the mine. Some of the blueberry-producing habitat will likely be permanently changed. The predicted levels of vegetation health effects based on the evaluation criteria are summarised in Section 3.2.1.

3.2.4 Prediction Confidence

Vegetation Abundance and Diversity

High confidence in prediction. Effects are expected to be limited to the PDA. If any changes to vegetation abundance and diversity occur outside of the PDA due to dust, NO_2 emission or N deposition, the magnitude and the extent of the effects will be small. The establishment of invasive vegetation in the area because of the project can be mitigated. Consequently, effects of the Project on vegetation abundance and diversity will be not significant at the scale of the RSA.

Vegetation Health

Moderate confidence in prediction. Prediction confidence is moderate for the effects on vegetation health. Thresholds have not been developed for dust effects on plants, and the literature acknowledges a lack of data of effects of atmospheric emissions and its effects on Arctic vegetation. The effects levels are an estimate based solely on available literature, much of which is based on research, and little in Arctic communities. The potential effects of metals on plants either from aerial deposition or uptake from soils are highly dependent on site-specific conditions and the plant species themselves. Under near neutral pH soil conditions such as those found in baseline soil studies, a significant barrier to metal uptake typically exists that prevents metals from being bioavailable to plants. If metals in soil have limited bioavailability, then the potential for effects on plant health is greatly diminished.

Culturally Valued Vegetation

High confidence in prediction. Effects will be limited to the PDA. If any changes to Culturally Valued Vegetation occur outside of the PDA, the magnitude of the effects and the extent will be small. Consequently, effects of the Project on culturally valued vegetation will be not significant at the scale of the RSA.

Table 6-3.14 Effects Assessment Summary: Vegetation

Issue	Magnitude/ Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Abundance and Diversity	**Level 1**: Effect will be indistinguishable from natural variation.	**Level 1**: The effect will occur within the PDA.	**Level 1**: The effect will occur once	**Level 2**: The effect will occur through operation phase.	**Level 2**: The effect is reversible with cost.	High	Not significant at the scale of the RSA.	High
Issue 2 Health (general)	**Level 1**: Effect will be indistinguishable from natural variation.	**Level 1**: The effect will occur within the Project footprint.	**Level 3**: The effect will be continuous through operation at the mine site and Steensby port	**Level 2**: The effect will occur through operation phase.	**Level 2**: The effect is reversible with cost.	Moderate - There is some uncertainty how and if vegetation will be effected by the project.	Not significant at the scale of the RSA.	Moderate
Issue 3 Health (metals in soil)	**Level 1**: Effect will be indistinguishable from natural variation.	**Level 1**: The effect will occur within and near the Project footprint at the Mine Site and Steensby Port.	**Level 3**: The effect will be continuous through operation phase at the Mine Site and Steensby Port	**Level 2**: The effect will occur through operation phase.	**Level 2**: The effect is reversible with cost.	Moderate - There is some uncertainty how and if vegetation will be effected by the project.	Not significant at the scale of the RSA.	High
Issue 4 Culturally Valued Plants	**Level 1**: Effect will be indistinguishable from natural variation.	**Level 1**: The effect will occur within and near the Project footprint.	**Level 1**: The effect will occur once.	**Level 2**: The effect will occur through operation phase.	**Level 2**: The effect is reversible with cost.	High	Not significant at the scale of the RSA.	High

3.2.5 Follow-up

Based on moderate confidence in the predictions of projects effects on vegetation health, some follow-up monitoring will be considered for vegetation health parameters. Details of the dust deposition rate monitoring is described in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1), and details of the soil and vegetation monitoring program are provided in the Terrestrial Environment Management and Monitoring Plan (Appendix 10D-11).

3.3 SUBJECTS OF NOTE

No rare plants were found during field surveys. One unusual example of the riparian shoreline shrub association with very tall willows (*Salix richardsonii*) was found near the Railway alignment south of Cockburn Lake. This cluster of Richardson's willows will be close to the Railway, and site-specific drainage measures have been applied in the design to preserve the moisture regime for the willows.

3.4 IMPACT STATEMENTS

3.4.1 Vegetation Abundance and Diversity

There is high confidence that project related activities will have a not significant effect on vegetation abundance and diversity within the Regional Study Area.

3.4.2 Vegetation Health

There is moderate confidence that project related activities will have a not significant effect on plant heath within the Regional Study Area.

3.4.3 Culturally Valued Vegetation

There is high confidence that project related activities will have a not significant effect on culturally valued vegetation within the Regional Study Area.

3.5 AUTHORS

Page Burt of Outcrop Ltd. was the primary author of the vegetation impact assessment. EDI Environmental Dynamics Inc. provided technical writing and GIS support. EDI edited the final version for the FEIS.

SECTION 4.0 - MIGRATORY BIRDS AND HABITAT

The marine and terrestrial bird communities of north Baffin Island are described in the bird baseline report (Appendix 6E). The bird species found on north Baffin Island are generally reflective of those expected in the eastern Canadian Arctic. Waterbirds (including seabirds, geese, ducks, loons, eiders, terns and gulls) are the dominant species present throughout the area, but numbers of raptors, songbirds, shorebirds, and other terrestrial species are also present. Field surveys in the Project Area documented 54 bird species within the marine and terrestrial RSAs, five of them Species at Risk listed by COSEWIC (2010) or SARA (Environment Canada, SARA 2010), including Peregrine Falcon (a common breeder within the terrestrial RSA), Short-eared Owl (documented within the terrestrial RSA but showing no signs of nesting there), and Ivory Gull, Ross's Gull and Harlequin Duck (all detected within the marine RSA, but no nesting sites were located). One additional Species at Risk, the Red Knot, has the potential to be found within the Project Area, but was not detected during baseline surveys.

The diverse environments of the marine and terrestrial RSAs offer an abundant supply of seemingly suitable habitat for birds. Staging and breeding areas are found in the Project Area for numerous species of birds including Snow Geese, Common and King Eiders, Brant, and Long-tailed Ducks, and include a known moulting area for Snow Geese prior to fall migration. Twenty-five species were confirmed to breed throughout the marine and terrestrial RSAs. No large, conspicuous seabird nesting colonies were recorded during Project surveys; however, several are known to exist within and adjacent to the marine RSA, particularly on Bylot Island, in Foxe Basin, and along Hudson Strait. Marine surveys did locate a large breeding colony of Snow Geese (>5,000 individuals) on the southwestern shores of Steensby Inlet.

IQ surveys conducted in the surrounding communities indicated that the marine and terrestrial RSAs contain several areas that are used seasonally by large numbers of various bird species. Community Elders indicated that most bird species in the area are migratory and typically arrive in late-April, May, and June, and start leaving in August. Breeding occurs throughout the area: most of the islands within the RSA are used as nesting grounds by various species of seabirds, gulls, terns and waterfowl, and some large colonies of seabirds and gulls are known along cliff habitats. Species such as geese, eiders, loons and ducks can be found nesting along coastlines or inland along freshwater lakes. Fall migration occurs between early August to late October depending on the species and the sex. Some birds, such as Common Raven, ptarmigan, and sometimes Snowy Owl, winter in the area, and some seabirds, such as Black Guillemot, also remain in the area year-round using the open shore leads in the winter.

Residents of all five communities indicated that harvesting of birds and their eggs is still important to them but much less so than in the past. The species that are most commonly harvested are Snow Goose, Common and King Eider, Arctic Tern (eggs only), and Long-tailed Duck.

4.1 ISSUES SCOPING

In order to characterize the pre-development conditions within the Mary River Project Area and identify important bird issues, a variety of baseline studies and scoping activities were completed. These included:

- A review of regional literature, including primary literature, Canadian Wildlife Service reports from the region, and long-term monitoring reports from research on nearby Bylot Island;
- A review of Environmental Impact Statements of other northern projects;

- Discussions with federal and territorial wildlife agencies (e.g., Canadian Wildlife Service biologists and biologists from the Government of Nunavut);
- Inuit Qaujimajatuqangit (IQ) studies: Several public consultation meetings and personal interviews were conducted in local communities to receive information on baseline data and to scope potential issues of perceived project effects (Volume 2); and
- Three years of field surveys (four for raptors) within the Mary River marine and terrestrial studies areas.

The information gathered from these various sources was combined to develop the baseline report (Appendix 6-E) and formed the basis of this assessment.

4.2 KEY INDICATORS

Valued Ecosystem Components (VECs) were identified for the project based on their ecological and social importance and relevance to the potential interactions with the Project. The scoping activities contributed to the identification of migratory birds and their habitat as a VEC for the Mary River Project. However, migratory birds include a wide variety of species that display a great diversity of behaviors and patterns of habitat use. As a result, several key indicator species (KIs) were selected to guide the assessment of effects on migratory birds and migratory bird habitats, based on input from regional biologists, the IQ studies, field observations and the professional judgment of project biologists. Six species/species groups were selected including: Peregrine Falcon, Snow Goose, Common and King Eider, Red-throated Loon, Thick-billed Murre, and Lapland Longspur. The following table outlines the rationale for each species selection; further detail on each of the key indicator species is included in the following sections. In addition, the assessment of project effects will also consider effects on Species at Risk within the Project Area.

Table 6-4.1 Key Indicator Species of Birds Selected for the Mary River Project

Key Indicator Species	Rationale for Designation as a Project Key Species
Peregrine Falcon	Listed as a species of 'Special Concern' under COSEWIC (2011) Abundant and widespread within the terrestrial RSA Will serve as a representative for other cliff-nesting raptors such as Rough-legged Hawks and Gyrfalcons
Snow Goose	Local breeder and abundant migrant within the Project Area, the terrestrial RSA also overlaps an important moulting area for the species IQ studies indicated that Snow Geese are an important harvest species for North Baffin communities
Common and King Eider	Although not listed by COSEWIC or SARA, both species have recently been identified as a 'Species of Interest' by the Canadian Wildlife Service because of an unexplained nationwide decline observed over the past decade (Suydam, 2000) Abundant migrant within the Project Area IQ studies indicated that Eiders are an important harvest species
Red-throated Loon	Loons are good indicators of high quality aquatic habitats and are relatively sensitive to environmental change (Strong, 1990; Dickson, 1992) Red-throated Loons were the most abundant and widely distributed species of loon found during field surveys

Table 6-4.1 Key Indicator Species of Birds Selected for the Mary River Project (Cont'd)

Key Indicator Species	Rationale for Designation as a Project Key Species
Red-throated Loon	Although IQ studies did not indicate that loons are culturally or economically important to local Inuit communities, a 1992 study on Igloolik Island found that 73 % of all Red-throated Loon eggs laid within the 10 km² study site over two breeding seasons were collected by residents of Igloolik (Forbes *et al*., 1992) Will serve as a representative for all four species of loons in the RSA, as well as other similar species of waterfowl (e.g., Long-tailed Duck)
Thick-billed Murre	Commonly detected species during marine studies with large, well-known colonies in portions of the marine study area Exhibits a unique, flightless migration which may interact with project shipping routes Will act as a key indicator for other seabirds
Lapland Longspur	Most commonly detected species of songbird and shorebird during field studies Will serve as an indicator species for other songbird species

4.2.1 Peregrine Falcon

Peregrine Falcon populations across Canada have been recovering from near extinction in the late 1960s (Bromley 1992, Enderson *et al*. 1995, COSEWIC 2007a) and were only recently downlisted from 'Threatened' to 'Species of Special Concern' in 1992 (COSEWIC, 2007a). *Tundrius* Peregrine Falcons breed from the north slope of the Yukon, east across the Low Arctic Islands and Nunavut, north to south Baffin Island, Hudson Bay, Ungava and northern Labrador (COSEWIC 2007a), and are generally considered abundant and widespread throughout most of their recognized breeding range in Nunavut (CESCC 2011). The Mary River baseline surveys found Peregrine Falcon were widespread throughout the terrestrial RSA. In 2011 (when the most intensive surveys for cliff-nesting raptors were conducted), a total of 64 occupied nesting territories were located within the RSA. The number of Peregrine Falcons observed in the area was unexpectedly high given that North Baffin Island is generally considered to be beyond the northern extent of their breeding range (e.g., the COSEWIC status report (COSEWIC 2007a) does not acknowledge north Baffin Island as being within its breeding range). However, abundant nesting and foraging habitat is present within the study area. Peregrine Falcon breeding habitat is typically limited by the presence of suitable nest sites (usually on a cliff ledge or crevice) near good foraging areas with a sufficient prey base. Peregrine Falcons prey primarily on other bird species such as colonial seabirds, shorebirds, waterfowl, other waterbirds, ptarmigan, and songbirds (COSEWIC 2007a). Although in some areas, small mammal species such as lemmings and juvenile Arctic ground squirrels (*Spermophilus parryii*) also comprise a major portion of the diet (Court *et al.* 1988 and others *In* COSEWIC 2007a).

Peregrine Falcon's wide-spread distribution both in and out of the RSA allows for monitoring and evaluation of potential effects of the Project. Peregrine Falcons will also serve as a useful key indicator for other cliff-nesting raptors in the area such as Rough-legged Hawks and Gyrfalcons that have similar nesting habitat requirements.

4.2.2 Snow Goose

Snow Geese breed in the High Arctic from Greenland to Wrangel Island, and from Hudson Bay and Foxe Basin to northern Ellesmere Island, making them one of the most northerly breeding birds in the world (Batt 1998, Mowbray *et al.* 2000). The presence of Snow Geese within the north Baffin region is well documented, and several large nesting colonies are known in the region including Bylot Island (over 669,000 Greater Snow Geese in 1996, LePage *et al*. 1998), the Great Plains of the Koukdjuak (nesting population of >1.7 million Lesser Snow Geese, Latour *et al*. 2008), Prince Charles and Air Force Island (140,000 Lesser Snow Geese, Latour *et al*. 2008), Bay of God's Mercy, Ell Bay and Bear Cove on Southampton Island, Dewey Soper Migratory Bird Sanctuary, and North Spicer Island (Dickson *et al*., in prep.) among others.

Baseline studies for the Mary River Project found that the Mary River marine and terrestrial RSAs see abundant use by Snow Geese throughout spring, summer and fall. Thousands of Snow Geese migrate through the area (presumably on the way to and from nesting grounds on Bylot Island), using the RSAs for migratory stop-over sites in the spring and fall. These stop-over locations are most heavily concentrated in the Steensby Inlet region, especially within the marine waters and low-lying tundra areas adjacent to the Steensby coastline (inland to approximately 10 km). During the breeding season, a relatively small number of Snow Geese appear to nest within the terrestrial RSA; however, in the southwest section of the terrestrial RSA, aerial surveys located a breeding colony of over 5,000 Snow Geese on the southwest shore of Steensby Inlet. Also, from mid-July to late August thousands of geese return to the RSA to rest, forage, and to moult their feathers before continuing their fall migration south. The majority of the moulting observations made during the Mary River baseline surveys were located in the southwest section of the RSA, south of the Mary River mine site and west of the proposed rail alignment. This roughly corresponds to a Special Management Area proposed by Environment Canada based on the results of a 1993 survey conducted by CWS in this area. The CWS survey yielded an estimated total of 22,145 moulting Greater Snow Geese over the 7200 km^2 survey block, most of which were believed to be sub adults and failed breeders (Reed *et al*. 1993).

IQ studies indicated that Snow Geese are an important harvest species for North Baffin communities as the birds, eggs and down feathers are all harvested. Since Snow Geese are both culturally and ecologically important within the RSA and Sirmilik National Park, and because of their high numbers and sensitivity to disturbance (Bechet *et al*., 2004), this species was selected as a key indicator species.

4.2.3 Common and King Eider

Common and King Eider are large, diving seaducks that spend most of the year in coastal marine ecosystems at high latitudes. In Canada, they are found right across the Arctic from Baffin Bay to the Beaufort Sea. Both species are often seen flying in large flocks of thousands of individuals. The two species display somewhat differing habitat selection during nesting: Common Eider are usually closely tied to marine habitats and tend to nest on coastal islands or islets, often in large colonies, (Goudie *et al*. 2000), while King Eiders typically nest inland from the Arctic coastline, often along freshwater lakes and ponds (Suydam 2000); however, both species make extensive use of marine habitats throughout the remainder of the year. Eiders have been rated as *Sensitive* by the Government of Nunavut (CESCC, 2011) and although they are not listed by COSEWIC and SARA, they have recently been identified as a *Species of Interest* by the Canadian Wildlife Service because of an unexplained nationwide decline observed over the past decade (Suydam, 2000).

The Mary River bird studies documented large migratory flocks of Common and King Eiders in the coastal waters of the marine RSA during their spring and fall migrations. They also recorded four King Eider nests within the terrestrial RSA and females Eiders were seen raising broods in Steensby Inlet. No Common Eider nests were located by Project surveys, however, three were reported along the north coast of Steensby Inlet by other researchers in 2011 (Alexander Anctil, pers. comm.). No Common Eider colonies are known in the vicinity of the terrestrial RSA; however, documented colonies are present in other parts of the marine RSA including Turton Island and Southampton Island in Foxe Basin, and Fraser Island and Markham Bay within Hudson Strait (Latour *et al*., 2008). IQ studies indicate that Eiders are of similar community importance as Snow Geese in terms of harvesting and consuming and some Inuit still use Eider feathers in clothes, pillows, and quilts.

4.2.4 Red-throated Loon

It has been established by studies around the world that loons are good indicators of high quality aquatic habitats and that they are relatively sensitive to environmental change (Strong, 1990; Dickson, 1992). Many studies have used loons in monitoring programs as a surrogate indicator of changes to the health of aquatic ecosystems in response to various sources of environmental effects. For example, loons have been used as a management indicator species for six U.S. monitoring programs in the Great Lakes (Strong, 1990), and by the Canadian Wildlife Service near Tuktoyaktuk, Northwest Territories (Dickson, 1992).

All four species of North America's loons (Red-throated, Common, Pacific, Yellow-billed) were recorded breeding within the RSA; however, Red-throated Loons were the most abundant and widely distributed. Red-throated Loons are a migratory species that breed primarily in the Arctic. They are the smallest of the five loon species and although their populations in Canada are currently considered stable, there are indications that they may be starting to decline. They are primarily fish-eaters that nest alongside fresh water ponds but are known to stage, forage, and even raise their young in coastal marine waters. Their natural predators include gulls, jaegers, and Arctic foxes.

Although IQ studies did not indicate that loons are culturally or economically important to local Inuit communities, a 1992 study on Igloolik Island found that 73 % of all Red-throated Loon eggs laid within the 10 km^2 study site over two breeding seasons were collected by residents of Igloolik (Forbes *et al.*, 1992). It can be argued that this species is ecologically important to the local environment based on their abundance, distribution, and position in the food-chain. Combined with their documented ability to demonstrate measurable indications of environmental disturbances, their distribution both in and out of the Project footprint, and their conspicuous nature making them relatively easy to survey, it was determined that the Red-throated Loon was a suitable key indicator species to represent all four species of loons in the RSA, as well as other similar species of waterfowl (e.g., Long-tailed duck).

4.2.5 Thick-billed Murre

Thick-billed Murres are one of the most abundant species of marine bird in the northern hemisphere; the population in the eastern Canadian Arctic is estimated at 1.95 million (summarized in Wiese *et al*., 2004). They have been observed throughout the Bylot Island and Pond Inlet area as well as southern Foxe Basin and Hudson Strait. They first appear in the area in early May and lay eggs by mid June. They begin to hatch in mid-July and begin to leave the area by September. Thick-billed Murres nest in large colonies on coastal cliffs (Tuck, 1961). Most often, they build their nests on a cliff ledge, out in the open, but they have occasionally been recorded laying eggs in caves or crevices (Gaston and Nettleship 1981, Gaston *et al*. 1993). During the spring and summer months, they are usually associated with the edge of land-fast ice (Bradstreet 1979, 1982). Key marine foraging habitats for Thick-billed Murres are typically located within 30 km of the breeding colony (Mallory and Fontaine 2004). Their primary diet is fish and marine macro-invertebrates (Tuck, 1961; Croll *et al.,* 1992).

Thick-billed Murres begin nesting in late June and early July. Clutch size is one egg, but replacement clutches may be laid if the first is destroyed early in the breeding season (Tuck 1961). During incubation, Thick-billed Murres typically remain near the colony, but some may forage up to 175 km away from it (LGL Ltd. 1982). Incubation requires 30–35 days, and the young hatch in early August. One of the adults accompanies the flightless chick when it leaves the nest 18–25 days after hatch.

Migration movements of Thick-billed Murres are not entirely understood (Gaston *et al.* in print, Huettmann and Diamond, 2000). During the latter half of August, several hundred thousand adult and chick Thick-billed Murre from the southern Baffin Island area colonies depart east through Hudson Strait in a flight-less migration following the direction of surface currents. Most murres from eastern Hudson Strait are in offshore waters by early September and arrive in the northern Labrador Sea within a few days, followed by murres from western Hudson Strait colonies (Orr and Ward 1982). Murres from a large colony on southeast Baffin Island may migrate through central Davis Strait, or east to west Greenland (Orr and Ward 1982). Some colonies along Hudson Strait may migrate to southwest Greenland, but are more likely to move directly down the Labrador coast to Newfoundland (Gaston 1980). These migrations can extend over distances of as much as 1,000 km before the chick matures enough to fly, and leaves pairs vulnerable to oil spills and to drowning by entanglement in fishing gear (Gaston 1982). Migration can be rapid with movements up to 40 km/day (Gaston 1982).

There were numerous sightings of Thick-billed Murre during the aerial surveys in the marine RSA, particularly in Hudson Strait. Colonies are well known and identified.

4.2.6 Lapland Longspur

The Lapland Longspur is one of the most visible and most abundant terrestrial birds breeding throughout the Arctic (Hussell and Montgomerie 2002). It was the most commonly detected songbird species during the terrestrial studies at Mary River, with densities ranging from 4 to 42 (average of 24) birds per km^2. These densities are similar to densities reported for Lapland Longspur in other studies within the Canadian Arctic. Within their breeding range, Lapland Longspurs are most commonly found in wet, hummocky, tundra meadows, typically on relatively flat ground, however, they will also use drier, well-vegetated slopes, including areas dominated by willows, heather or avens (Hussell and Montgomerie 2002). They feed primarily on seeds (particularly grass seeds), however, invertebrates are an important component of the summer diet (Hussell and Montgomerie 2002).

4.2.7 Species at Risk

There are six Species at Risk which could potentially be found within the Mary River Project Area. Five of these were documented in the Project Area during the field surveys (Table 6-4.2).

Table 6-4.2 Status of Avian Species at Risk with the Potential occur in the Mary River RSA

Species	Scientific Name	Species Status			Mary River Study Observations
		Nunavut[1]	COSEWIC[2]	SARA [3]	
Harlequin Duck, eastern population	*Histrioinicus histrionicus*	Sensitive	Special Concern	Special Concern (Schedule 1)	Detected in marine RSA
Ivory Gull	*Pagophila eburnea*	At Risk	Endangered	Endangered (Schedule 1)	Detected in marine RSA
Peregrine Falcon *tundris* subspecies	*Falco peregrinus tundrius*	Secure	Special Concern	Special Concern (Schedule 3)	Confirmed breeding in terrestrial RSA
Ross's Gull	*Rhodostethis rosea*	At Risk	Threatened	Threatened (Schedule 1)	Detected in marine RSA

Table 6-4.2 Status of Avian Species at Risk with the Potential occur in the Mary River RSA (Cont'd)

Species	Scientific Name	Species Status			Mary River Study Observations
		Nunavut[1]	COSEWIC[2]	SARA [3]	
Red Knot	*Calidris canutus*	At Risk	*Islandica* ssp. – Special Concern, *Rufa* ssp. – Endangered	*Islandica* and *Rufa* ssp. - No Status	Not detected
Short-eared Owl	*Asio flammeus*	Sensitive	Special Concern	Special Concern (Schedule 3)	Detected in terrestrial RSA

[1] CESCC 2011, [2] COSEWIC 2011, [3] Environment Canada, SARA 2011

Peregrine Falcon was selected as a key indicator for the FEIS and is addressed above. The remaining species are addressed in the following material.

Harlequin Duck (Special Concern)

Harlequin ducks are not common to Canada's Arctic regions. The eastern population breeds primarily in Labrador and Quebec; however, they are known to breed on the southern third of Baffin Island (mostly along Frobisher Bay and the eastern sections of Hudson Strait) and have been seen in small flocks in southern Foxe Basin and Hudson Strait (Environment Canada 2007a, Mark Mallory, CWS, pers. comm.). They nest along fast moving coastal and mountain streams and are often found foraging along rocky coastlines during other times of the year. Canada's eastern population of Harlequin Duck was listed as *Endangered* by COSEWIC in 1990 but has since been upgraded to *Special Concern* (COSEWIC 2010, Environment Canada, SARA 2010). Threats to this population include habitat loss, anthropogenic disturbances such as hydroelectric dams at their nesting grounds, and overhunting (Robertson and Goudie 1999). It is still illegal to hunt Harlequin Duck in the Atlantic Provinces, Ontario, Quebec, and in the eastern United States, where most birds winter.Three individuals (in one group) were seen as incidental observations in Hudson Strait in April, 2008 during the conduct of marine mammal surveys for the Mary River Project.

Ross's Gull (Threatened)

Ross's Gull is one of the rarest breeding gulls in North America and is considered a *Threatened* species in Canada (COSEWIC 2007c, Environment Canada, SARA 2010). Although very little is known about this species and no long-term studies exist for it in Arctic Canada, they have been recorded nesting in four locations in Canada, one of which is on Prince Charles Island in Foxe Basin (the other three locations are: Cheyne Islands, Nunavut; an unnamed island in Penny Strait, Nunavut; and Churchill, Manitoba; Environment Canada 2007c). A single adult in breeding plumage was recorded on Bylot Island in 1979 by both Renaud *et al*. (1981) and Lepage *et al.* (1998), independently. In Foxe Basin, a breeding pair was discovered on Prince Charles Island in 1984 by Tony Gaston (CWS) and in 1997 Bechet *et al.* (2000). Despite intensive surveys on Prince Charles and Air Force Island in 1996 and 1997, no additional birds were found (Johnston and Pepper 2009, Vicky Johnston, CWS, pers. comm., Mark Mallory, CWS, pers. comm.). Most of the world's population is thought to breed in eastern Siberia, and Canada's Ross's Gulls are thought to spend the winter in the Chukchi Sea, between Alaska and Russia (COSEWIC 2007c). All Ross's Gulls found in the project area were observed during aerial marine surveys in the following locations:

- One was seen in Steensby Inlet in August, 2008;
- Seventeen were seen in a group in West Foxe Basin in September, 2008 (along the west coast of Rowley Island); and
- A minimum of twenty-six were seen in West Foxe Basis in October, 2008 (on October 16 - a group of 3 was seen between North Spicer Island and the Melville Peninsula, and a single individual was seen on the west coast of Rowley Island; on October 18, 22 (a group of 12, a group of 8 and a group of 2) were seen north of North Spicer Island, and 4 individuals were seen between Igloolik and Jens Munk Island, and between Jens Munk Island and Rowley Island).

Interestingly, the Mary River baseline surveys resulted in the largest ever observation of Ross's Gulls in Canada (M. Mallory, CWS, pers. comm.) reflecting the potential for more nesting sites than previously known, and perhaps the paucity of observational seabird data in East Foxe Basin.

Ivory Gull (Endangered)

Very little is known about the endangered Ivory Gull and its general biology (COSEWIC 2010, Mallory *et al.* 2008) and they have only been observed occasionally in the RSA in the past ten years (in Foxe Basin and Eclipse Sound, Mark Mallory, CWS, Personal Communication). Ivory Gulls are known to nest on Brodeur Peninsula on northern Baffin Island as well as in the eastern Lancaster-Jones Sounds regions close to Bylot Island (Mallory *et al.* 2008). Some Ivory Gulls are thought to migrate through Foxe Basin and Hudson Strait each year as a few individuals have been seen migrating through Igloolik and Cape Dorset, outside of the RSA to the west (Mark Mallory, CWS, pers. comm.). However, the majority of Ivory Gulls that nest on Brodeur Peninsula are believed to winter either north of Bylot Island or in southwestern Baffin Bay and Davis Strait (Renaud and McLaren 1982, Mallory *et al*. 2008) and migrate there through Lancaster Sound or Eclipse Sound (Renaud and McLaren 1982). Three hundred and seventy-five individuals were seen in the floe edges near Pond Inlet during spring migration in 1979 (Renaud and McLaren 1982) and 75 were seen in this same location in the spring of 1994 (Lepage *et al.* 1998). It therefore appears that portions of the RSA may be used as a migratory pathway by this species but very little else is known about the life history of this species). Therefore, specific surveys for these species were not conducted. For baseline work on this project, Ivory Gulls were seen in the following locations, all observed during marine aerial surveys:

- One in Milne Inlet in September, 2007;
- One in Hudson Strait in April, 2008;
- Five (2 adults, 3 juveniles) in Milne Inlet in August, 2008;
- One in western Eclipse Sound in August, 2008;
- Three in West Foxe Basin in October, 2008 (one north of North Spicer Island, and one north of South Spicer Island);
- One in East Foxe Basin in October, 2008 (between South Spicer Island and Prince Charles Island); and
- One in Hudson Strait in October 2008.

Red Knot (Special Concern/Endangered)

Red Knot in the Canadian Arctic, with three subspecies present in Canada (COSEWIC 2007b); of these, two have the potential to be located in the Mary River RSAs. The breeding range of the *islandica* subspecies (*Calidris cantus islandica*) is found in the High Arctic regions of northeastern Canada and Greenland, including parts of Bylot Island and the northwestern end of Baffin Island. The breeding range of the *rufa* subspecies (*Calidris cantus rufa*) is located entirely within the Central Canadian Arctic and includes areas within Foxe Basin and southern Baffin Island (COSEWIC 2007b). They were not detected during the field surveys at Mary River; however, previous studies in the region have documented Red Knots breeding on Bylot Island (LePage *et al.* 1998), Prince Charles Island and Rowley Island (V. Johnston pers. comm. 2005 in COSEWIC 2007b), and the west coast of Baffin Island (RIGM pers. obs. in COSEWIC 2007b). Nesting habitat typically consists of barren areas (often with less than 5 % vegetation cover) such as windswept ridges, slopes or plateaus, generally at elevations less than 150 m above sea level and less than 50 m from the coast (COSEWIC 2007b). During the breeding season, they will forage in damp or barren habitats up to 10 km from the nest site (COSEWIC 2007b).

Short-eared Owl (Special Concern)

Short-eared Owls are widely distributed in small numbers throughout Canada including low Arctic areas, but they are not typically found as far north as Canada's Arctic islands (Holt and Leasure 1993). However, the species is an irruptive breeder, and nesting success appears to be, in part, a response to local small mammal populations (COSEWIC 2008). During the terrestrial field surveys at Mary River, three observations were made each in 2007 and 2008 (all single birds with no indication of nesting). Interestingly, in 2008, Short-eared Owls were also observed on Bylot Island (to the north of the terrestrial RSA) for the first time in over 20 years of study (Therrien 2010). Throughout the summer of 2008, a pair of Short-eared Owls were observed displaying territorial behavior indicative of nesting, although no nest was ever located, (Therrien 2010). 2008 was a year of lemming abundance on both Bylot Island (Therrien 2010) and within the Mary River RSA (Gauthier pers. comm. with M. Evans). In June 2009, a pair of Short-eared Owls were again seen on Bylot Island; however, they did not display territorial behavior and were not seen later in the summer; lemming abundance on Bylot Island in 2009 was low (Therrien 2010).

Austen *et al.* (1994) suggested the decline in Short-eared Owls is mostly related to habitat loss and degradation on its wintering grounds, with continuing habitat loss and degradation on its breeding grounds in southern Canada and pesticide use as secondary threats. In Arctic regions, Short-eared Owls typically nest in Arctic tundra and estuaries (Sinclair *et al. in* COSEWIC 2008); this is not expected to be a limiting factor on Baffin Island.

4.3 POTENTIAL PROJECT INTERACTIONS WITH BIRDS

There are several mechanisms or pathways through which the proposed Project could potentially affect bird KIs that use the project area for part or all of their annual cycle:

For marine species:

- Catastrophic accidents and release of oils or chemicals near colonies or feeding areas resulting in direct (on the birds themselves) or indirect (prey item) mortalities and long-term loss of foraging and brood-rearing habitat;
- Chronic leakage of chemicals into the marine environment resulting in direct or indirect mortality;
- Frequent but brief and localized disturbance of open-water marine migration, foraging and brood-rearing areas due to ship traffic along the shipping lanes; and
- Direct mortalities due to collisions with ships.

And for terrestrial species:

- Loss of habitat due to the project footprint;

- Reduced habitat effectiveness due to disturbance;
- Direct mortalities due to collisions with Project vehicles, aircraft, and permanent structures;
- Indirect mortalities due to increased access to the area by hunters;
- Indirect mortality due to increased predator population around the mine facilities as a result of increased availability of human food waste and other petroleum-based attractants, and/or an increase in the availability of nesting, roosting and denning habitat; and
- Indirect mortality due to effects to bird health through contamination of the surrounding environments.

All of these potential effects could occur during any or all of the three main Project phases (construction, operation, closure).

During the Arctic Bay Working Group Meeting, Elders generally felt that the proposed shipping activity in Foxe Basin would disturb the birds, although one resident indicated that he used to see birds resting on the deck of the *MV Arctic*, a ship that was regularly used at the Nanisivik Mine, and that he didn't think the birds would be negatively affected. One resident of Pond Inlet said that aircraft traffic there has caused birds to nest further from town. During the Hall Beach Working Group Meeting, most Elders said they didn't think birds would be affected by the shipping but some felt that "*…the birds would go somewhere else*" and hoped that the Project would use the eastern shipping route since the western route would disturb birds nesting on islands closer to their communities. Interestingly, Elders in Hall Beach felt that the Nanisivik Mine near Arctic Bay caused a decrease in Snow Goose colonies close to the mine, but residents of Arctic Bay did not mention this. Elders in Hall Beach did not feel that the Nanisivik Mine disturbed ducks, just geese.

4.3.1 Key Issues

Although there are a variety of pathways through which Project interactions could occur, Project effects can generally be grouped into three main categories or issues:

- Issue 1: Habitat loss;
- Issue 2: Potential mortality; and
- Issue 3: Effects to individuals' health.

These Key Issues have the potential to affect bird KIs during all three phases of the Project, resulting in changes in behaviour (e.g., migration, foraging, and breeding patterns) and in population abundance and distribution.

Issue 1: Habitat Loss (Direct and Indirect) — Habitat loss is the result of areas becoming unavailable for use by birds for migratory staging, nesting and raising young, foraging, and other life processes. It can occur in one of two ways: direct habitat loss occurs when areas are physically altered by Project activities, and indirect habitat loss occurs when Project activities (such as noise, visual or physical disturbance etc.) result in birds avoiding areas close to the Project footprint. In general, indirect effects persist only as long as Project activities are occurring, while direct effects may extend beyond the life of the Project.

Loss of habitat for staging during migration, nesting, and brood-rearing due to construction, operation, and closure activities will most likely be local scale effects restricted to the proposed Project footprint (direct habitat loss), and a surrounding zone of influence (indirect habitat loss). Since the 2006–2008 baseline studies indicated that there are no concentrated breeding colonies of birds (i.e., geese and/or seabirds) in the immediate vicinities of the proposed footprint, habitat loss will be restricted to species that nest in less dense groups (i.e., Eiders, some shorebirds) or solitary nesters (i.e., loons, other waterfowl, songbirds and shorebirds). Loss of coastal marine and terrestrial habitat for staging, foraging and brood-rearing will also likely be local scale effects restricted to the proposed footprints and a surrounding zone of influence. Baseline studies showed that there is an abundant supply of suitable staging, foraging and brood-rearing habitat available (i.e., not saturated with conspecifics) nearby and displacement to these nearby areas will have little to no effect on the foraging behavior and success of all birds during all three phases of the Project.

Shipping activity along the proposed shipping lanes is not expected to cause direct or indirect habitat loss as the disturbances associated with shipping activities are expected to be short (approximately 20 minutes or less per ship passing) and periodic (height of shipping activity will be approximately one ship passing through Steensby Inlet, Foxe Basin and Hudson Strait every 1.5 days during operation). The periodic requirement to move out of a ship's path will not be a significant energetic stress to birds, even for females with flightless young. Alterations to sea ice configuration caused by the passage of ice-breaking ore carriers in winter will also likely have little effect on polynyas and shore leads, as these are far from the proposed shipping lanes.

Canada's *Migratory Birds Convention Act* (1917, 1994) regulates the protection and conservation of migratory birds and prevents the disturbance or destruction of these birds, their nests, eggs and habitats. All species recorded in the RSA are migratory and therefore, will warrant special consideration and protection during all Project activities conducted between late May and October. If construction activity is in progress when migrating birds arrive (typically in late May and June) then most birds would become discouraged from nesting in these disturbed areas, would move to nearby areas that are less disturbed, and Project activities would be allowed to continue. During the first year of construction, displaced birds may be forced to forego breeding as they become confused and spend time seeking out new breeding habitats, or they may simply be able to move to nearby suitable habitat. These considerations will be discussed further below.

There is a lack of information about the level of disturbance required to cause birds to flush from or abandon their nest completely. Most information regarding nest disturbance relates to human approaches to within close proximity (within a few meters) of the nest, the capture of adults or young by researchers for banding purposes, or the handling of eggs by researchers. There does not appear to be any literature discussing bird responses to ship movements within close proximity to the nest site, and only limited information regarding aircraft-related disturbances.

In general, when adult birds leave the nest due to a disturbance, the eggs or nestlings are exposed to an increased probability of being predated and an increased potential for death from exposure. For cliff-nesting species, eggs or young being knocked off the ledge is an additional danger. Reduced nesting success has been linked to disturbance for many bird species including Black Guillemot, Thick-billed Murre, Northern Fulmar, Long-tailed Duck, and Common Eider (Cairns, 1980; Curry and Murphy, 1995). In contrast, nest disturbance appears to have little effect on the reproductive success of Black-legged Kittiwake or Glaucous Gull (Baird and Hatch, 1979; Gilchrist 1995).

Issue 2: Mortality — Increased mortality of birds can also result from direct and indirect means. Direct mortality refers to death of an individual as a direct result of Project activities (e.g., collisions with vehicles, aircraft, or permanent structures). Indirect mortality occurs through a secondary source (e.g., increased hunting due to increased access, or increased levels of predation due to increased predator abundance resulting from increased nesting habitat (buildings) or food availability (food waste).

Direct mortalities due to collisions with Project vehicles or permanent structures are possible but are not expected to occur in large enough numbers to significantly affect local populations. Direct mortalities due to collisions with aircraft are possible, especially for Snow Geese and Eiders that migrate through the RSA in very large flocks. The potential effects of this and possible mitigation for it are discussed below. Increased direct mortalities from hunting are not expected if best management practices are employed to prevent increased access into the area by hunters.

Issue 3: Health — The accidental introduction into the environment of contaminants such as hydrocarbons (oil and fuel spills) or metals (i.e., from ore dust released during loading operations) can have serious consequences for birds. Effects can be manifested directly, through contact with the substance, or indirectly through uptake of the substance through the food chain (i.e., increase in cadmium in murres between years; Donaldson *et al.*, 1997). Generally, populations of solitary nesting birds are at less risk to this type of effect because smaller numbers of individuals are likely to be exposed. In contrast, colonial nesting species are at greater risk because a larger proportion of the population is concentrated into a small area, and if that area is contaminated, a large number of birds would be vulnerable to exposure (Mallory and Fontaine, 2004).

Potential contaminants to the food chain from ore dust include metals present in Total Suspended Solids (TSP) deposition, such as: Arsenic (As), Cadmium (Cd), Cobalt (Co) and Manganese (Mn). Seabirds are useful in monitoring levels of trace element contaminants since they are widely distributed and at a high trophic level. Examination of organisms at higher trophic levels can provide an integrated view of the food web and bio-accumulation of contaminants is most apparent in these organisms.

Pathways for TSP contaminants to enter the food chain include ingestion of affected vegetation or prey species within the area of deposition. Of the 34 marine bird species found in the Regional Study Area (RSA) (for full list see APP 6E-2, Table A-1), those most likely to take up dust contaminants are: Canada Goose, Brant, Ross's Goose, Snow Goose and Tundra Swan. These herbivore species might graze on vegetation found in the deposition area around Steensby Port.

Prey species of marine birds, including mollusks and small fish, might also serve as pathways for contaminants. Bivalve mollusks may be consumed in the TSP deposition area by other members of the Family Anatidae (Waterfowl) such as the Common Eider, King Eider and Black Scoter (APP 6E-2, Table A-1). Bivalves like the blue mussel (*Mytilus edulis*) have been effectively used in Greenland to monitor metals in areas with mining activities since they parallel concentrations in surrounding sediment (Boening, 1999). Small fish are common in the diets of most other marine birds found near Steensby Port, however the bio-accumulation potential of dust contaminants in fish is low (Ciardullo *et al.*, 2008).

While metal concentrations have been investigated in tissues of arctic birds, definitive conclusions on potential toxicity and health effects remain elusive. For example, it has been suggested that cadmium bio-accumulates in some seabirds (Donaldson et al. 1997) but in other studies, a weak relationship was found between cadmium and health biomarkers, suggesting no influence on the health of birds (Fisk et al. 2005). Based on dust deposition rates (Volume 5, Table 5-2.12), the limited area of deposition (Volume 5, Figure 5-2.7 and Table 6-3.5) and low bio-accumulation potential of TSP contaminants in fish (prey species of marine birds), it is unlikely that accumulation of contaminants in birds species in the RSA will differ from current measurements in the Arctic (Wayland et al. 2001, Savinov et al. 2003).

Measures taken to mitigate impact of dust deposition are outlined in Volume 5, Section 2. Blue mussels (or similar bivalves species in the STP deposition area) might serve as useful bioindicators in a bioaccumulation study at Steensby Port.

Contamination of the marine environment through catastrophic oil spills from ships carrying fuel to the ports, or from smaller chronic ship or land-based fuel leaks, has the potential to cause adverse effects on local marine ecosystems and could extend beyond the boundaries of the RSA. The potential for accidents and malfunctions causing fuel spills is discussed in Volume 9, Section 3.

Discharges from ships (e.g., bilge water, grey water, ballast water) can alter water quality and food supplies (lower trophic level biota) in the immediate vicinity of the ship. The potential for effects can be minimized with environmentally appropriate operating procedures. Numerous federal and territorial regulations and guidelines help to minimize the risk of these types of effects on Canada's marine environments and are enforced under Canada's *Shipping Act* (2001) and Canada's *Arctic Waters Pollution Prevention Act* (1985).

4.4 ASSESSMENT METHODS

Assessment methods for birds follow the general methodology presented in Volume 2, Section 3, to assess potential changes to documented baseline conditions. The assessment of the Project's effect on bird KIs focused on the three key issues described above: Habitat Loss, Mortality and Health. Assessment methods included determination of measurable parameters and specific thresholds, assessment of project effects, identification of mitigation measures to limit any identified effects, determination of the residual effects (effects that remain after all mitigation attempts have been made to try to minimize Project effects), and an assessment of level of confidence that Project biologists have in the assessment based on available data.

The study area used in the assessment of Project effects on birds had both a marine component (the marine RSA) and a terrestrial component (the terrestrial RSA). The terrestrial RSA is equivalent to the study area used for the majority of the other terrestrial component (landforms, vegetation etc.) with the exception of terrestrial mammals. It encompasses a 30,719 km² area extending from Milne Inlet in the north, following an approximately 50- to 80-km wide corridor centered on the Milne Inlet Tote Road, Mary River mine site, and the proposed railway alignment, to Steensby Inlet in the south. Further details on the terrestrial RSA are available in Section 1 of this report and in the Bird Baseline Report (Appendix 6E). The marine RSA consists of a 50-km buffer on either side of the proposed port facilities and shipping lanes, bounded by the Nunavut Settlement Area Boundary. For the southern route, this includes all coastal and open water areas of Steensby Inlet, the central part of Foxe Basin, and the northern and central parts of Hudson Strait. For the northern route, this includes the southern half of Navy Board Inlet, Eclipse Sound, and all inlets and sounds south of it, Pond Inlet, and the water inside the Nunavut Settlement Area Boundary from Cape Walter Bathurst, Bylot Island, to Cape Jameson, Baffin Island. This study area is identical to the study area used in the Marine Mammals Baseline Report (Appendix 8A-2) which displays the location and extent of both the marine and terrestrial RSAs used for birds.

4.4.1 Measurable Parameters

Measurable parameters are variables related to the biology of KIs that can be used to monitor the predicted effects of Project activities. The Nunavut Impact Review Board (NIRB 2005) defines monitoring as "*the systematic observation of tracking of an activity to determine whether it is proceeding or functioning as expected. Through monitoring, the accuracy of environmental effect predictions is assessed*". For wildlife studies, measurable parameters tend to be either changes in habitat indices (habitat quality and/or availability) or changes in population parameters (e.g., the number of animals in a given area or annual reproductive rate). Measurable parameters should be directly linked to specific Project effects and be relatively easy to measure with short response times to the specified effects (i.e., they should not show delayed responses that take several years to measure accurately).

The following measurable parameters were identified for the bird KIs:

- Changes in the quality and availability of KI habitat;
- Changes in the overall abundance, distribution, and density of KIs in the RSAs; and
- Changes in the number of nests and/or nest success rates for KIs within the RSAs.

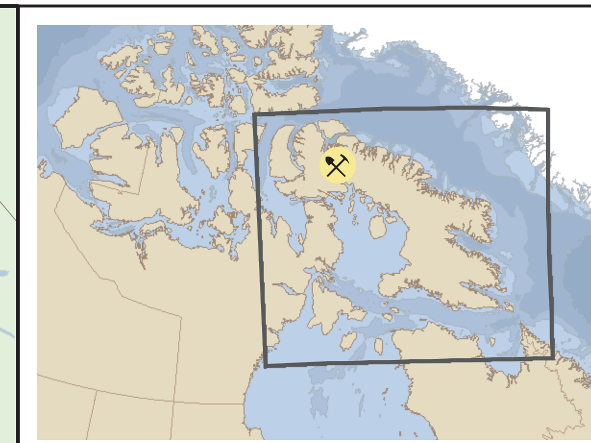
By comparing values measured for these parameters after Project activities commence to values collected simultaneously at appropriate unaffected control sites, and to pre-Project baseline data, extraneous factors such as natural variation (i.e., population cycles) or climate change can be eliminated as potential causes of any observed changes to a population (Underwood, 1994). This allows us to confidently link observed changes to Project effects, to monitor and measure the magnitude of these effects, and to promptly modify mitigation plans if specified criteria or indicator thresholds are exceeded.

4.4.2 Thresholds and Adaptive Management

Thresholds are specified limits of acceptable change to measurable parameters, beyond which adaptive management is implemented (Hegmann *et al*. 1999, AXYS 2001). Table 6-4.3 lists the upper threshold limits that have been proposed for this Project's bird KIs and their respective potential effects and measurable parameters.

Table 6-4.3 Potential Effects, Measurable Parameters and Thresholds for Key Indicators

Effect	Measurable Parameters	Thresholds (Magnitude and Extent)
Habitat Loss	Changes in the quality and availability of habitat within the RSA	Negligible to low change (<10 %) Moderate change (10–25 %) High change (>25 %)
	Changes in the density of birds within the RSA	
	Changes in nest occupancy rates or breeding success rates within the RSA	
Health and mortality	Change in population size due to mortalities within the LSA	Negligible to low change (<10 %) Moderate change (10–25 %) High change (>25 %)



LEGEND

- Mary River Project
- Terrestrial Bird Regional Study Area
- Marine Local Study Areas
- Marine Regional Study Areas

NOTES

Map Projection: North American Datum UTM Zone 17N
Graticule grid displayed in degrees, minutes, seconds.

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 25 50 100 150 200 Km

Baffinland Iron Mines Corporation

Mary River Project
Bird Marine and Terrestrial Study Areas

EDI

Date: 1/9/2012

FIGURE 6-4.1

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Adaptive management plans are implemented when unexpected effects are observed or if effects are larger than predicted and exceed specified thresholds. This assessment proposes three threshold levels (10 %, 10–20 %, 25 % change; see Table 6-4.3) for measurable parameters that will serve as triggers for adaptive management for the Mary River Project. Based on data from the 2006–2008 baseline studies and a review of mitigation plans used at other similar northern projects (e.g., Snap Lake Diamond Mine (De Beers, 2004), Diavik Diamond Mines (Diavik, 2005), Doris North proposed gold mine (Miramar, 2005), EKATI™ Diamond Mine (Rescan, 2005), Jericho Diamond Mine (Golder, 2005), High Lake Base Metals Mine (Wolfden Resources 2006), the upper threshold level for changes in abundance was set at 25 %. This assessment predicts that effects on birds within the LSA will be negligible, and therefore, adverse changes to the populations beyond 25 % are highly unlikely. However, if changes beyond 25 % are recorded, and are linked to Project activities (i.e., equal and simultaneous change are *not* observed in nearby control sites), then an immediate cessation of all Project activities in the affected area(s) between mid-May and October while a full review of previously prescribed mitigation measures is conducted for the species that has experienced the Level III change in abundance.

The following specific thresholds were also identified:

- Ship collisions resulting in the mortality of greater than 1 % of the Canadian population of Thick-billed Murres are considered significant.
- Ship collisions that result in mortality for any Species at Risk are considered significant.
- A single catastrophic event resulting in the release of contaminants to the marine environment is considered significant regardless of effects on species at risk or seabirds.

4.4.3 Assessment of Habitat Loss

The assessment of habitat effects for Peregrine Falcon, Snow Goose, Red-throated Loon and Eiders was a quantitative assessment based on habitat suitability modeling completed for these species. Habitat suitability modeling and mapping was conducted as a component of the baseline studies on birds within the terrestrial RSA and was based on the ecological land classification (ELC) conducted by Knight Piésold Ltd. and habitat suitability ratings developed by M. Evans. The models looked at nesting and foraging habitat for these KIs; nesting and foraging was quantified separately for Peregrine Falcon, and combined for Snow Goose, Eider, and Red-throated Loon. Within each of the models, habitats were rated as High, Medium, Low or Nil value for each of the KIs. For details on the methods and results of the habitat suitability modeling process, see sections 2.4 and 5 of Appendix 6E: Bird Baseline Report.

Determination of habitat effects resulting from the proposed Project involved:

- Mapping of the Potential Development Area (PDA) or Project footprint - this represents the area in which direct habitat loss is expected to occur, and included the Milne port and port camp, Steensby port and port camp, the Milne Inlet Tote Road, access roads, the rail alignment, airstrips, the Mine Site camp, and all bulk sample extraction and crushing areas;
- Creation of Zone of Influence buffers around the PDA using in ArcGIS – this represents the area in which indirect habitat loss is expected to occur:
  - For most of the PDA, two ZOI buffers were created, one from 0 to 250 m, and one from 250 to 500 m;
  - Around the airstrips, the second ZOI was extended to 3 km on either side of the airstrip and 5.4 km from the ends to account for the auditory and visual disturbance generated by aircraft upon takeoff and landing. The size of the airstrip buffer was based on recommendations from

Environment Canada: 5.4 km is the estimated distance that it would take for a Boeing 737 aircraft to reach a height of 650 m upon takeoff, the 3 km buffer on either side of the airstrip was based on a literature review by Environment Canada.

- Overlaying the PDA and ZOI buffers on the habitat suitability values and applying decreased habitat values within these areas:
  - Areas within the PDA were reclassified as ‘Nil’ or not suitable for bird use (this is expected to be the worst case scenario; some areas within the PDA may continue to see some use by birds);
  - Areas within 250 m of the PDA dropped two classes (e.g., from High to Low) to a minimum of Low;
  - Areas between 250 and 500 m of the PDA, or around airstrips, areas between 250 m and up to 5.4 km (see above), dropped one class (e.g., from High to Medium) to a minimum of Low;
  - Outside of the ZOI buffers, areas were assumed to be not affected by indirect habitat effects and were not reclassified.
- Comparing the habitat values during mine operation (i.e., those calculated using the above PDA and ZOI) with current habitat values (i.e., those calculated for the baseline; see Appendix 6E) to determine habitat loss during mine operation. These results were then summarized in table format for each of the bird KIs.

During the closure period there will be no active infrastructure, so the habitat suitability values for areas within the ZOI buffer are expected to return to pre-development values.

Habitat suitability modeling was not completed for Lapland Longspur or Thick-billed Murre; therefore, assessment of habitat loss was calculated slightly differently. For Lapland Longspur, baseline studies included the creation of a density map. This was similar to the habitat suitability maps created for the above species, but was based on observed densities of Lapland Longspurs during the Mary River field surveys. These densities were grouped into High, Moderate, Low and Nil density classes and mapped by habitat type. The effects assessment for Lapland Longspur used this density map and applied the same process as was used for the habitat suitability models to determine habitat effects. For Thick-billed Murre, the habitat effects assessment was qualitative based on an assessment of the location of the proposed shipping route in relation to known colonies and migration corridors within Hudson Strait.

4.4.4 Assessment of Mortality Risk and Health Risk

The assessment of mortality and health risks for bird KIs was a qualitative assessment based on the determination of relevant risk factors, the extent of potential effects, and the size of the local population for each of the bird KIs.

4.5 PEREGRINE FALCON

Peregrine Falcons are known to be relatively tolerant of disturbance and have been seen nesting on artificial structures in high traffic areas, e.g., concrete ledges on city buildings and bridges (Cade and Bird 1990), smokestacks (Cade *et al*. 1994) and power generating stations (Septon 1994). Breeding Peregrine Falcons have also demonstrated a certain degree of tolerance to mining and blasting activities, as evidenced by opportunistic nesting of falcons on the open pit walls at the EKATI™ mine in the Northwest Territories (Banci, pers. comm. with M. Evans). Holthuijzen *et al*. (1990) experimentally examined the influence of blasting noise at mines on the closely related Prairie Falcon, and recorded no observable effects to 140 dB blasts occurring 500–1,000 m from nests. Blasts in the range of 250–500 m flushed adults from their nests but the average recorded return time to the nest was only 1.4 min after a blast. Palmer *et al*. (2003) found that noise disturbance to Peregrine Falcons from jet aircraft over-flights 150 m above nests affected peregrine activity budgets and nest attendance patterns but did not affect overall food provisioning rates to nestlings. Ellis *et al*. (1991) found Peregrine Falcons to be tolerant of aircraft noise levels between 85–140 dB and whilst low-level jet flights (<1,000 m) caused a flight response in some pairs, nest abandonment or reproductive failure did not occur.

Protective buffers zones of various sizes have been suggested for Peregrine Falcons by various authors. Holthuijzen *et al.* (1990) recommended a buffer distance between nests and mine blast sites of only 125 m, but in the United States, most states have peregrine management plans that prescribe protective buffers ranging between 150–800 m although one recommends 4,800 m (U.S. Fish and Wildlife Service 1982; Ellis 1982; Hayes and Buchanan 2002). Richardson and Miller (1997) recommended buffers of 800 m based on a review of five Peregrine Falcon studies (although this was considered highly dependent on individual site characteristics), and Fyfe and Olendorff (1976) suggested that aircraft should not approach closer than 500 m above a nest.

Habituation to disturbance is highly likely by Peregrine Falcons, although it may take several years to occur (Ratcliffe 1962). Remotely located pairs that have little to no experience with disturbance from human activities are most reactive to human intrusions (White *et al*. 2002). Disturbed Peregrine Falcons can react in several different ways, depending on the magnitude of the disturbance, and tend to be most sensitive during the breeding season, especially during nest initiation and nestling stages (Fyfe and Olendorff 1976; Steenhof 1987; Cade *et al*. 1996; Environment Canada 2007b). Behavioural indications of disturbance include agitation, increased alertness, vocalizing, flushing from a nest resulting in incubation and brooding interruptions that can cause thermoregulation stresses to eggs or nestlings, and ultimately, nest abandonment. Birds disturbed enough to abandon their nest site will likely not return to the same territory the following year and will likely move to less disturbed areas (Fyfe and Olendorff 1976; Environment Canada 2007b).

4.5.1 Potential Effects and Proposed Mitigation

Issue 1 – Habitat

Based on the fact that Peregrine Falcons have nested on the walls of the EKATI™ open pit mine in the Northwest Territories (Vivian Banci, pers. comm.), it is possible that new habitat will be created by the Mary River open pit, or on rock cuts along the Railway. As such, Issue 1 has been defined as habitat changes recognizing that for Peregrine Falcons this will include the loss of habitat but may also include the creation of new habitat.

Baseline surveys were used to estimate pre-development Peregrine Falcon distribution and to assess current habitat quality and availability within the RSA. Cliff-nesting raptor nests within the RSA have been monitored since 2006 during the course of exploration and bulk sampling activities for the three year period of 2006–2008 and a confirmation survey of raptor sites in the RSA was conducted in early August 2011 to confirm nest site status of the 2006–2008 data. In 2011, 57 out of a known 64 occupied nest sites within the RSA were productive. Productivity was 2.89 for 2011, demonstrating that the population in the area is currently healthy and very productive.

A number of occupied raptor territories and nests are located within the footprint of the Potential Disturbance Area (PDA; Figure 6-4.4). In total, 11 nest sites were found within the PDA from 2006 to 2011, with 15 different pairs occupying the sites. In 2011, five occupied Peregrine Falcon nests were found within the Mine site and Steensby Port PDAs, along with three Rough-legged Hawk nests. One site (#339), located within the Steensby Port PDA, had two different species occupying it from 2007 to 2011 (Peregrine Falcon in two years and one Rough-legged Hawk). This site is likely an example of a high quality territory. No active Gyrfalcon territories or nests were found within the PDA in any of the survey years. As well, 30 Peregrine Falcon nests (and additional nests used by Rough-legged Hawk and other species) have been located within 5 km of the Project PDA. These nests may experience some indirect habitat loss due to sensory disturbances, but no direct habitat loss will occur.

Table 6-4.4 Distribution of Cliff-nesting Raptor Nest Sites within the Mary River RSA, 2006–2011

Species	Year	Nests within PDA	Nests within 5 km of PDA	Total Nests in RSA
Gyrfalcon	2006	0	3	4
	2007	0	3	3
	2008	0	3	5
	2011	0	4	6
Peregrine Falcon	2006	3	21	34
	2007	1	6	16
	2008	2	20	47
	2011	5	30	64
Rough-legged Hawk	2006	0	2	5
	2007	0	2	7
	2008	1	29	61
	2011	3	34	69
Vacant nests	2006	1	9	21
	2007	0	0	0
	2008	0	0	1
	2011	1	15	34

An assessment of habitat loss to nesting and foraging areas was conducted based on habitat suitability modeling. Habitat suitability maps for Peregrine Falcon nesting and foraging habitat were developed for the RSA based on Ecological Land Classification Modeling and are presented in Appendix 6E. Approximately 7 % of the RSA is currently considered high quality Peregrine Falcon nest habitat (Table 6-4.5). The model result that 93 % of the RSA contains moderate quality habitat is probably a model error because it is difficult to distinguish “cliffs” from rugged steep terrain. The project’s bird biologist (M. Evans) estimated that up to 35 % of the RSA contained suitable cliff nesting habitat (M. Evans, pers. obs.). Most of these cliffs are located in close proximity to seemingly productive tundra hunting grounds. Approximately 23 % and 56 % of the RSA contains high and moderate (respectively) quality Peregrine Falcon foraging habitat (Table 6-4.5).

The habitat effects assessment determined that within the RSA, 136 km^2 of high value nesting habitat (8.1 % of total high value habitat) and 311 km^2 of moderate value habitat (1.4 % of the total moderate value habitat) may be affected by Project activities (Table 6-4.5). Of the 136 km^2 of high value nesting habitat affected, 29 km² (1.7 % of the total high value habitat) will be completely lost to direct effects within the PDA, while the remainder will still be available to Peregrine Falcons, however, some sensory disturbance may be present. The effects assessment also concluded that 135 km² and 239 km² of high and moderate value foraging habitat respectively will be affected by the Project. This equates to 2.5 % of the total available high quality foraging habitat and 1.7 % of the total available moderate quality foraging habitat. Based on the fact that the habitat effectiveness is reduced as a result of direct loss to the PDA, and reduced effectiveness within a zone of influence due to sensory disturbances, there is a concomitant increase in nil and low quality habitat in both cases.

Table 6-4.5 Change in Effectiveness of Peregrine Nesting and Foraging Habitat within the Terrestrial RSA

Habitat Model	Habitat Rating	Baseline Conditions		Loss due to PDA and ZOI (km^2)		Post-development Conditions	
		Area (km^2)[1]	% RSA	Area (km^2)	% RSA	Area (km^2)	% RSA
Peregrine Falcon Nesting	High	1,686	7.1 %	-136	-0.6 %	1,550	6.5 %
	Medium	22,087	92.8 %	-311	-1.3 %	21,776	91.5 %
	Low	16	0.1 %	+447	+1.9 %	463	1.9 %
	Nil	1	<0.1 %	+107	+0.4 %	108	0.5 %
Peregrine Falcon Foraging	High	5,486	22.6 %	-135	-0.6 %	5,351	22.0 %
	Medium	13,683	56.3 %	-239	-1.0 %	13,444	55.3 %
	Low	5,145	21.2 %	+267	+1.1 %	5,412	22.3 %
	Nil	0	0.0 %	+107	+0.4 %	107	0.4 %

NOTE(S):
TOTAL AREA IN RSA = 30,711 KM^2. 6,397 KM^2 WAS NOT INCLUDED IN THE ELC MODELING EXERCISE.
HABITAT SUITABILITY VALUES WERE CLASSED AS: NIL (0-5), LOW (5.1 – 25), MODERATE (25.1-75), AND HIGH (75.1-100).

Overall, there appears to be abundant supply of suitable cliff-nesting habitat within the RSA, particularly in the eastern and southern areas, with adjacent productive tundra foraging habitat. The availability of nesting habitat for Peregrine Falcons and other cliff-nesting species does not appear to be limiting and it is suspected that any birds disturbed by Project activities may readily relocate to areas away from potential disturbances.

Milne Port and Milne Inlet Tote Road — The coastal tundra area in Milne Inlet provides foraging habitat for raptors, although the nearest identified nest is approximately 5 km away from the Port.

The Milne Inlet Tote Road is bound by steep cliffs on both sides for much of its length and provides an abundance of high quality cliff nesting habitat. No active Peregrine Falcon nests and were identified within the Milne Inlet Tote Road. Some nests are located as close as 100 m from the road, and may experience indirect habitat loss due to disturbance from road traffic through the construction phase given their close proximity to the road. However, current operations have not affected nesting at this location so it is thought that Project-related road traffic is unlikely to induce the falcons to leave the nest. The existing road is located within suitable foraging habitat but this habitat loss has already occurred.

Mine Site — The Mine Site will be a focus of activity throughout all Project phases, and four Peregrine Falcon nests and one Rough-legged Hawk nest have been identified in the PDA from 2006–2011 (Figure 6-4.2), with two sites occupied in 2011 (one Peregrine Falcon, one Rough-legged Hawk). The birds nesting at these locations will experience disturbances due to air and road traffic, and blasting and mining at Deposit No. 1.

Disturbances to foraging habitats adjacent to the Mine Site will occur throughout construction, operation, and closure phases of the Project. The existing Mary River camp and the mine infrastructure areas are located in low lying tundra areas that are considered typical falcon foraging habitat and the expansion of these areas during the construction phase will result in the loss of suitable foraging habitat. The open pit mine area and waste rock stock pile areas are characterized by high elevation and rocky habitat with very little vegetation, which are not considered suitable foraging habitat for Peregrine Falcons. Due to the abundance of suitable foraging habitat in the vicinity, these disturbances are expected to have minimal effects on peregrine foraging abilities.

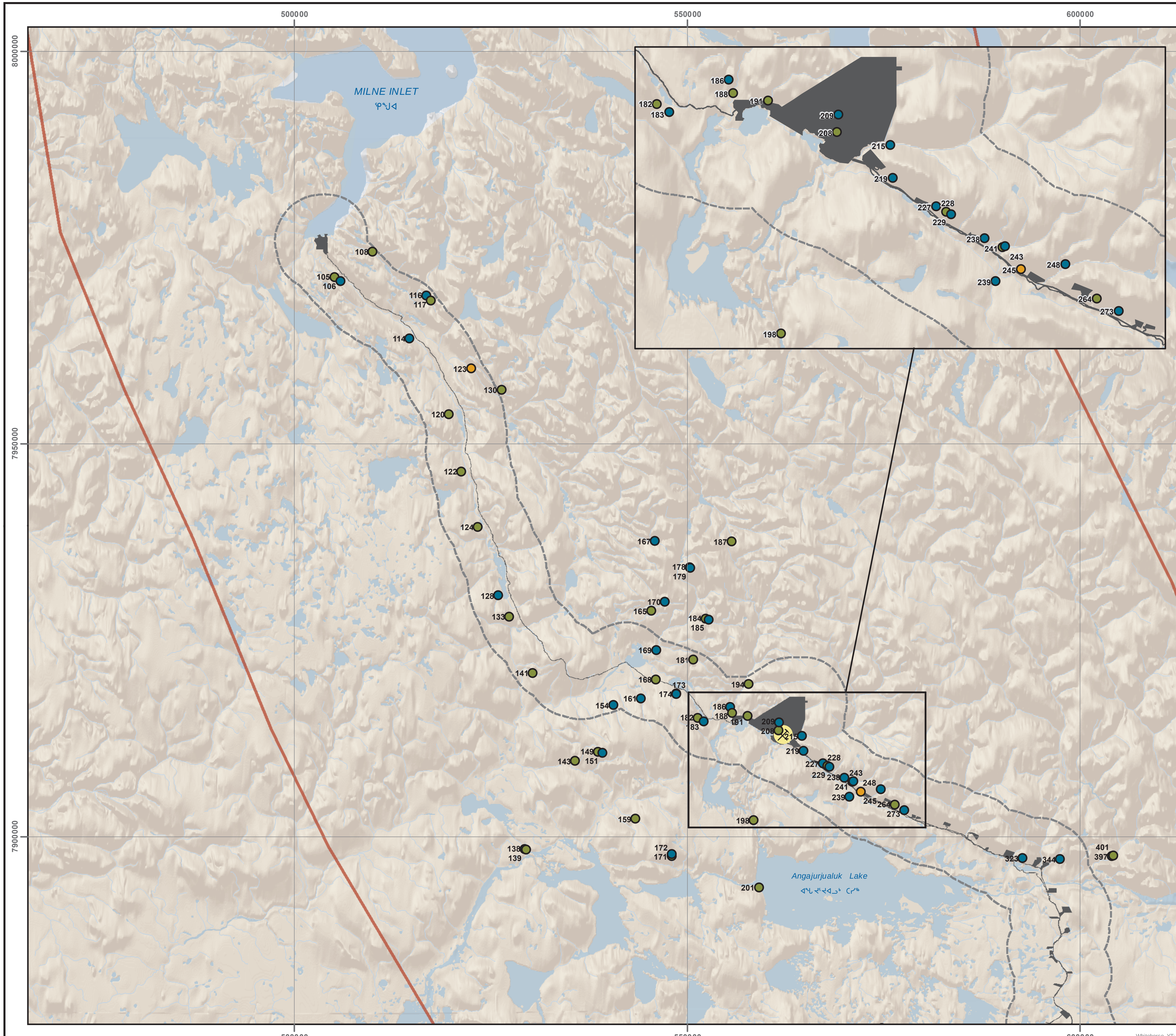
Railway — One Peregrine Falcon nest is located within the proposed Railway alignment. This nest will not be lost due to construction; however, once operation begins, train activity may cause these nesting birds to relocate to areas further away. Additional nests are present along the rail line (but outside of the PDA), regular intermittent disturbance to the nests will occur from Railway traffic (12 passes per day) through the operation phase of the Project. Due to the tolerant nature of nesting peregrines, operational disturbances from the Railway are expected to have minimal effects on nesting success. Regular train activity should not cause incubating birds to flush from their nests and is not expected to cause nest abandonment levels to increase.

Suitable foraging habitat exists along the entire length of the Railway, except for the steep valley of Cockburn Lake. Loss of foraging habitat will occur during the construction phase and will be confined to the width of the Railway (varying between 50-200 m).

Steensby Port — Steensby Inlet is an area of abundant Peregrine Falcon nesting habitat, and five active nests belonging to Peregrine Falcons (three) and Rough-legged Hawks (two) were located within the PDA at Steensby Port (Figure 6-4.3). All of these nests were occupied during 2011 surveys. These nests may require removal outside of the nesting period if a site-specific nest management is not possible (further investigation described below). There is an abundant supply of suitable nesting habitat in the immediate vicinity and throughout the RSA allowing the birds using these nests to use alternate nests or establish new nests if breeding territory is not saturated. The Steensby Port area consists of low-lying coastal plains that are known to be suitable foraging habitat for falcons. Therefore the footprint in this area will result in foraging habitat loss during construction and persisting through operation and closure. It is expected that these foraging areas will slowly return to useable conditions post-closure. Construction, operations, and closure in the Port footprint area will

produce constant noise disturbance (e.g., from trains and ore stockpiling activities, as well as aircraft traffic) but because there is an abundant supply of suitable foraging habitat outside the footprint, these disturbances will have only minor effects on the foraging behavior and success of falcons.

The construction and operation of the Steensby airstrip will cause high levels of noise disturbance to the other peregrine nest. Due to the relative tolerant nature of nesting peregrines operational disturbances are expected to have minimal effects on nesting success beyond 500 m.



LEGEND

- Mary River Project
- Potential Development Area
- Terrestrial Regional Study Area
- Raptor Nest Local Assessment Area
- Common Raven
- Gyr Falcon
- Peregrine Falcon
- Rough-legged Hawk

NOTES

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 2.5 5 10 15 20 25 Km

Baffinland Iron Mines Corporation

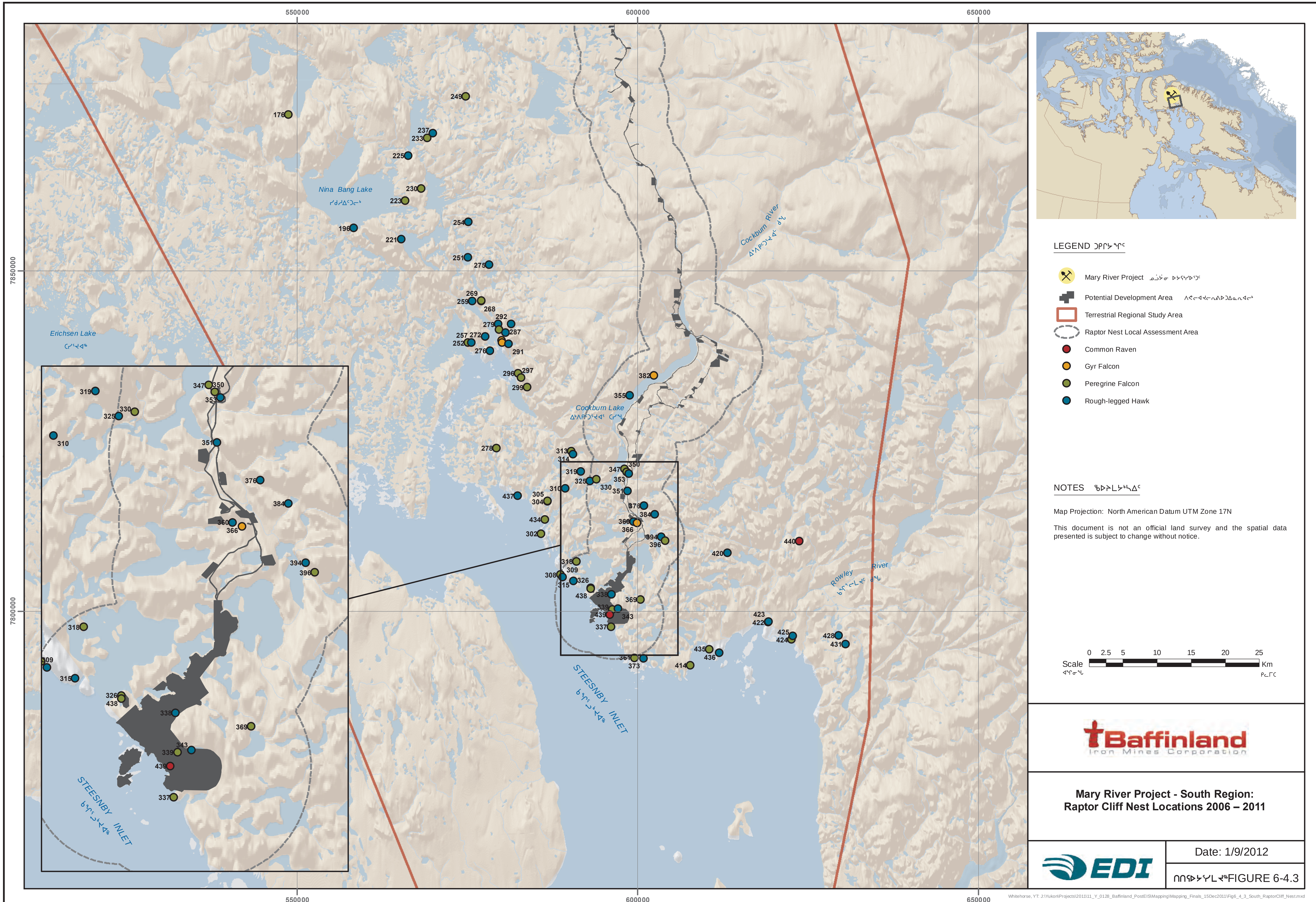
Mary River Project - North Region: Raptor Cliff Nest Locations 2006 – 2011

EDI

Date: 1/9/2012

FIGURE 6-4.2

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_4_2_North_RaptorCliff_Nest.mxd


550000
600000
650000
7850000
7800000
Nina Bang Lake
Erichsen Lake
Cockburn Lake
Cockburn River
Rowley River
STEESNBY INLET
LEGEND
Mary River Project
Potential Development Area
Terrestrial Regional Study Area
Raptor Nest Local Assessment Area
Common Raven
Gyr Falcon
Peregrine Falcon
Rough-legged Hawk
NOTES
Map Projection: North American Datum UTM Zone 17N
This document is not an official land survey and the spatial data presented is subject to change without notice.
Scale
0 2.5 5 10 15 20 25
Km
Baffinland
Iron Mines Corporation
Mary River Project - South Region:
Raptor Cliff Nest Locations 2006 – 2011
EDI
Date: 1/9/2012
FIGURE 6-4.3

Issue 2 — Mortality

Direct mortality to Peregrine Falcons could result from bird strikes with aircraft during take-off and landing, at the Mine Site and Steensby Port airstrips. However, mining developments in the Arctic typically do not result in increased direct mortality to raptors. Given reasonable traffic speeds, collisions with vehicles are rare, and there have been few cases of birds hitting infrastructure or being hit by vehicles (Wolfden Resources Inc. 2006). Direct mortality resulting from activities at the Railway, Milne Port and Milne Inlet Tote Road are predicted to affect few to no individuals during the construction, operations and closure phases of the Project. At the Mine Site and Steensby Port airstrips direct mortality of Peregrine Falcons can also be assumed to be limited to only a few individuals over the life of the Project, and given that these birds are abundant and well distributed throughout the study areas, a few individual mortalities will represent a low percentage of the population.

Peregrine Falcons are generally not harvested, unless with a permit. There is limited to no potential for increased harvest of Peregrine Falcon as a result of the Project. Given that the Project will have no-hunting policies for mine workers, mortality of falcons from harvest is not expected to increase.

Issue 3 — Health

Construction, operation, closure and post-closure activities may result in the release of contaminants into the Project area and surrounding environments, and they could be taken up in water or vegetation by birds such as Snow Geese. Potential sources of contaminants include those from accidental spills of oil, gas or chemical products, emissions from diesel generators and other equipment, and the generation of dust along roads, at the ore stockpiles, and at various other port facilities. Bird KIs may be exposed to contaminants through ingestion of plants, accidental soil ingestion while foraging, ingestion of water, epidermal contact with contaminated plants, soils or water, or direct inhalation of air and dust.

The construction and operation of the Project components will include procedures to control emissions and discharges from Project activities, as well as measures to avoid uncontrolled releases. Spill contingency plans, emission reduction measures, water treatment protocols and dust control measures will help to guard against unacceptable contaminant levels in the surrounding environment, and therefore effluent, dust and air emissions are expected to have minor to no effect on the health of birds.

Mitigation

The Project area has a high density of breeding Peregrine Falcons and although the above assessment has concluded that the project will have no population-level effects, the potential to disturb and disrupt individuals is possible and proper mitigation procedures will still be put in place The two main focuses will be on minimizing habitat loss (nesting and foraging habitat) and minimizing behavioural disturbances (disruption of migratory patterns, foraging and nesting behavior) by establishing 500 m protective buffers zones around all active nests. The boundaries of potential quarries to be used to supply railway construction were delineated based on this 500 m buffer zone from known nests. General mitigation procedures that will be applied in the overall zone of influence will focus primarily on the avoidance by Project personnel and equipment to the extent possible of known nests, or avoidance of areas where birds exhibit territorial behavior indicative of a nearby nest.

Within the Project footprint, supplemental adaptive measures and management will be applied to nests intersecting or completely within the PDA. Ontario is the only known jurisdiction to have completed a set of habitat management guidelines (OMNR 1987).Given the long-term use of Peregrine Falcon nesting sites, a nest-specific management plan will be prepared for each nest in a PDA for a 3 km radius. Each management plan will describe buffer zones above and below the nest sites; restrictions within the buffer zones and scheduling of activities should be prepared for each nest site. A site-specific management plan will allow buffers to be varied based on topography, line-of-sight, bird response, and history of disturbances at the nest site. If a pair of nesting falcons is established at an eyrie, efforts will be made to identify hunting areas (e.g., lakes, wetlands, forest openings, forest canopy) of the peregrines. If the prey habitat is left largely undisturbed, it may be possible to change some components of the habitat without affecting the Peregrine Falcons.

Breeding Peregrine Falcons have demonstrated a certain degree of tolerance to mining activities, as discussed above. However, they are still susceptible to disturbance during the breeding season, especially during nest initiation (when breeding pairs are more likely to abandon a nest site) and late nestling stages (when nestlings are susceptible to premature nest departure). Based on the results of previous published studies, and based on the results of the 2008 bulk sample monitoring program, 500 m no-disturbance buffer zones are suggested to minimize disturbance, to be adjusted on a nest-specific basis, according to the site-specific management plan. Peregrine Falcons are also protected by the Government of Nunavut's *Wildlife Act* which sets forth further regulations and guidelines designed to minimize disturbance to these birds. This information was incorporated into this mitigation and management planning process.

4.5.2 Assessment of Residual Effects

Residual effects on Peregrine Falcon could include unavoidable habitat loss from the Project footprint, disturbance of nesting habitat and nesting success, and disturbance of foraging habitat and behavior. Table 6-4.6 presents a summary of the predicted residual effects of the Project on the Peregrine Falcon and assesses their significance. For each of the three key issues, the potential residual effect is not significant. While some individual-level disturbance and displacement is expected to occur from various Project components during all or some of the Project phases, no change to the overall population is expected. Therefore, these potential residual effects are considered to have a low likelihood of causing an effect, have a low magnitude, remain within 1 km of the Project footprint, may be frequent but have short-term effects that are easily reversible. Direct mortality of any individual Peregrine Falcon due to Project activities is not expected, nor is any increase in contaminants levels expected to adversely affect falcon health.

Residual effects will eventually be eliminated after carefully planned closure and post-closure procedures are implemented although considering the revegetation rate in the Arctic (which is important to peregrine prey species such as ptarmigan, small birds, and small mammals) this process may take many decades.

IQ information was gathered during baseline studies and assisted in the characterization of pre-development conditions within the RSA. This IQ data also played a large role in the assessment.

Table 6-4.6 Residual Effects Assessment Summary: Peregrine Falcon

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints and LSA	**Level 1:** effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1:** habitat losses/disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortality (collisions, increased harvests)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently or occasionally (if at all) during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 1:** direct mortality is unlikely, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while an increase in contaminant levels may persist or be irreversible	**Level 1:** changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High

4.5.3 Prediction Confidence

The level of confidence of the assessment is considered to be high based on the analyses of a large database gathered during four years of intensive field work, discussions with local research agencies and the gathering of IQ knowledge, and the examination of results from previous mining projects in northern Canada. The degree of prediction confidence for the 2006–2011 bird data is considered high and the likelihood of a significant effect on Peregrine Falcon is considered low. Confidence is based on;

- A high degree of confidence in the data collected during four years of baseline studies, using standardized aerial survey methods;
- A high degree of confidence in the data analyses, consistent with other bird studies; and
- A high degree of survey coverage (100 %) of suitable terrestrial habitats.

4.5.4 Follow-up

A monitoring program for Peregrine Falcons is described in the Terrestrial Environment Management and Monitoring Plan (Appendix 10D-11). This monitoring program will be used to assess the accuracy of predictions by comparing measurable parameters from within the footprint and LSA to those recorded at appropriate control sites. Nest site management plans for each nest known to exist in the PDA will be developed prior to construction and follow-up monitoring of the success of those plans will be conducted.

4.6 SNOW GOOSE

4.6.1 Potential Effects and Proposed Mitigation

Issue 1 — Habitat

Thousands of Snow Geese used the Milne and Steensby Inlet portions of the LSA as a stop-over site when migrating through in spring (late May to early June) and as a stop-over and moulting site in fall (late August and early September). During these periods there is potential for disturbance from Project activities including construction, mine operation, port activities, and associated shipping, rail, road and aircraft traffic. Stop-over sites are crucial resting and refuelling locations for migrating birds, and moulting is a very energetically expensive process that requires a reliable supply of food with minimal levels of stress from predators or other activities. Traditional stop-over sites and moulting locations used by large numbers of birds each year provide these essential needs in a predictable fashion and therefore, protection of these areas is often vital to the conservation of species that use them. However, the majority of migrating Snow Geese recorded during the Project surveys did not stop directly within the port or other Project footprints. Instead, most were seen resting, foraging, and moulting in nearby areas, particularly to the west of the rail alignment and south of the proposed mine site. Project observations of moulting Snow Geese roughly correspond to a Special Management Area proposed by Environment Canada based on the results of a 1993 survey conducted by CWS in this area (see Figure 6-4.7). With the exception of a small section in the northeast corner of the proposed Special Management Area that overlaps the proposed rail alignment, the proposed Project footprint and ZOI buffers are located outside of this area. Although many Snow Geese will likely be displaced by Project activities, these birds are expected to move to nearby, less disturbed areas. It is likely that these changes could result in a shift in their migratory flight paths of approximately 1 km to either side of the port areas, but these changes will not affect this species. It is expected that any affected staging areas will rapidly return to useable conditions post-closure.

During the breeding season, a relatively small number of Snow Geese appear to nest within the bulk of the terrestrial RSA and these are mostly concentrated in well-vegetated lowland areas, often around small to mid-sized water bodies and/or wetlands. Aerial surveys did locate a breeding colony of over 5,000 Snow

Geese on the southwest shore of Steensby Inlet; however, this is outside of the Project footprint and all associated ZOI buffers (including the airstrip buffers approximating the effect of aircraft landing and take-off).

The effects assessment using habitat suitability modeling for Snow Goose within the terrestrial RSA indicated that there could be a loss of 28.2 km^2 and 544.2 km^2 of high and medium quality habitat respectively (Table 6-4.7). This equates to 2.4 % of the total high value habitat and 2.1 % of the total medium value habitat. Based on the fact that the habitat effectiveness is reduced as a result of direct loss to the project footprint, and reduced effectiveness within a zone of influence due to sensory disturbances, there is a concomitant increase in nil and low quality habitats.

Table 6-4.7 Change in Effectiveness of Snow Goose Habitat within the Terrestrial RSA

Habitat Rating	Baseline Conditions		Change due to PDA and ZOI (km^2)		Post-development Conditions	
	Area (km^2)[1]	% RSA	Area (km^2)	% RSA	Area (km^2)	% RSA
High	1,187	3.9 %	-28.2	-0.1 %	1,159	3.8 %
Medium	25,897	84.7 %	-544.2	-1.8 %	25,353	83.0 %
Low	3,326	10.9 %	+461.7	+1.5 %	3,788	12.4 %
Nil	152	0.5 %	+109.4	+0.4 %	261	0.9 %

NOTE(S):
TOTAL AREA IN RSA = 30,711 KM^2. 150 KM^2 WAS NOT INCLUDED IN THE ELC MODELING EXERCISE.
HABITAT SUITABILITY VALUES WERE CLASSED AS: NIL (0-5), LOW (5.1 – 25), MODERATE (25.1-75), AND HIGH (75.1-100).

Milne Port and Milne Inlet Tote Road — Snow Geese nest and moult in the Milne Port and Milne Inlet Tote Road areas and there will be some direct habitat loss due to the Project components and activities in these locations.

Mine Site — No Snow Goose nest sites were observed in close proximity to the Mine Site and little high value habitat is present in this area. However, it is possible that the thousands of geese migrating through in the spring and fall may change their flight pathways in response to noise and disturbance at Deposit No. 1. This deviation is not likely to affect their safe arrival at their breeding grounds.

Railway — The Railway will run through prime goose spring migration staging areas between the southern end of Cockburn Lake and the Steensby Port. It will also overlap a small section of the proposed Special Management Area for moulting Snow Geese. Direct effects to these habitats are expected to be limited to the width of the Railway and noise disturbance limited to a maximum of 500 m on either side.

Steensby Port — Thousands of migrating Snow Geese use the Steensby Inlet coastal flats to stage in late May to early June, and in late August to early September. During these periods there is potential for disturbance in these areas due to port activities and associated helicopter traffic. Construction, operations and closure in the port footprint area will produce constant noise disturbance, however because there is an abundant supply of suitable staging habitats in the immediate vicinity of the low lying coastal plains of Steensby Inlet, and the Snow Geese using this area should be able to find alternative sites. Therefore these disturbances will have only minor effects on the behavior of Snow Geese in the area. It is also expected that these staging areas would rapidly return to useable conditions post-closure.

Indirect habitat loss from ship traffic along the proposed shipping lanes is also not expected to cause significant effects to Snow Geese during migration or while raising young (e.g., large colonies on Bylot Island and on the southwestern coast of Steensby Inlet) as this species generally use large freshwater lakes to raise their young, when available, and otherwise are capable of avoiding the relatively slow moving ships, even when accompanied by flightless young.

The Proposed Special Management Area for Moulting Snow Geese — A 1993 survey conducted by CWS in the proposed Special Management Area yielded an estimated total of 22,145 moulting Greater Snow Geese over the 7200 km^2 survey block, most of which were believed to be sub adults and failed breeders (Reed *et al*. 1993). With the exception of a small section in the northeast corner, this area is outside of the Project footprint and all associated ZOI buffers (including the airstrip buffers approximating the effect of aircraft landing and take-off). Air traffic between the mine site and Steensby port will likely pass over the eastern portion of this area; however, to the extent possible, air traffic in this area will stay a minimum of 1110 m above ground during the moulting period, and 650 m above ground during the remainder of the migration and breeding season. Excessive hovering or circling over this area will be avoided. Other than environmental monitoring and research surveys, no other Project activities will occur in this area. See Figure 6-4.7.

<u>Issue 2 — Mortality</u>

Direct mortality due to collisions with aircraft flying in and out of the two port sites is possible, especially for Snow Geese that migrate through these areas in very large flocks. However, other mining developments in the Arctic have not resulted in increased mortalities to geese through aircraft collisions or any other means. Direct mortalities due to collisions with Project ships or permanent structures on land at the two port sites are also possible but are not expected. Direct mortalities from hunting are not expected to increase as best management practices will be employed to prevent increased access into the area by hunters. The Project will have a no-hunting policy for all mine workers, and workers will not be permitted to disturb wildlife under any circumstances. Therefore, the Project is not expected to increase the harvest of Snow Geese through increased site access or any other means.

Overall, direct mortalities resulting from port activities at Milne and Steensby Inlet are predicted to affect few to no individuals during the construction, operations and closure phases of the Project. Direct mortality of geese due to collisions with ships or aircraft can be assumed to be limited to a few individuals over the 21 year life of the Project and given that these birds are abundant and well distributed throughout the study area, a few individual mortalities would represent a very low percentage of the population.

Indirect mortality (of adult birds and/or eggs and young) because of increased predator abundance is not expected to occur due to project development. Projects in other northern settings have been associated with increased predation of prey species (Canadian Wildlife Service 2007). The Project will reduce the potential for project infrastructure to provide additional nesting habitats by implementing recommendations of the guidelines for Preventing Wildlife Attraction to Northern Industrial Sites (Canadian Wildlife Service 2007). For example, bird spikes will be installed on horizontal surfaces, particularly near heat sources; buildings will reduce the number of sheltered surfaces where nests could be established, and proper waste management to avoid changes to the carrying capacity of the habitat immediately adjacent to the project footprint. Terrestrial predators (e.g., foxes) could use project infrastructure for shelter or to acquire food sources. Terrestrial predators will be deterred from using the site by reducing their ability to den underneath buildings, appropriate waste management, and a ban on staff feeding wildlife that permanently or temporally occur within the Project site. Waste management is the primary mitigations to reduce the Project's interaction with terrestrial carnivores (see Section 5.3). Baffinland is confident that operational standards and management plans (Volume 10), and, where practical, the incorporation of the recommendations in the guidelines for Preventing Wildlife Attraction to Northern Industrial Sites (Canadian Wildlife Service 2007) will mitigate the potential for increased predation on avian prey species. Appendix 10B and 10D-4 describe the Project's waste management infrastructure, systems, and policies.

Issue 3 — Health

Construction, operation, closure and post-closure activities may result in the release of contaminants into the Project area and surrounding environments that could be taken up in water or vegetation by birds such as Snow Geese. Potential sources of contaminants that may be introduced into the environment include those from accidental spills of oil, gas or chemical products, emissions from diesel generators and other equipment, and the generation of dust along roads, at the ore stockpiles, and at various other port facilities. Snow Geese may be exposed to contaminants through ingestion of plants, accidental soil ingestion while foraging, ingestion of water, epidermal contact with contaminated plants, soils or water, or direct inhalation of air and dust.

The construction and operation of the Project components will include procedures to control emissions and discharges from Project activities, as well as measures to avoid uncontrolled releases. Spill contingency plans, emission reduction measures, water treatment protocols and dust control measures will help to guard against unacceptable contaminant levels in the surrounding environment, and therefore effluent, dust and air emissions are expected to have minor to no effect on the health of Snow Geese.

Mitigation

The potential effects on Snow Geese are generally expected to be localized to areas found directly adjacent to the Project Footprint, particularly areas adjacent to the proposed rail alignment and the Steensby Port. Mitigation measures to limit Project effects on breeding, staging and moulting Snow Geese are detailed in the relevant sections above and include guidelines relating to air traffic between the mine site and Steensby port.

4.6.2 Assessment of Residual Effects

Residual effects on Snow Goose could include the unavoidable loss of migratory stop-over and moulting habitats from the port footprints, and aspects of disturbance to these habitats adjacent to the footprints. Table 6-4.8 summarizes the residual effects of the Project on Snow Goose and assesses their significance. For each of the three key issues, the potential residual effect to Snow Goose is not significant. This assessment has determined that while some individual-level disturbance and displacement is expected to occur in a zone of influence during all of the Project phases, no changes to the overall Snow Goose population are expected. Therefore, these potential residual effects are considered to have a low likelihood of causing an effect, have a low magnitude, remain within 1 km of the Project footprint, and may be frequent but have short-term effects that are easily reversible. Direct mortality of any individual Snow Goose due to Project activities is not expected nor is any increase in contaminants levels expected that would adversely affect any individuals' health. Residual effects will eventually be eliminated after carefully planned closure and post-closure procedures.

Table 6-4.8 Residual Effects Assessment Summary: Snow Goose

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints and LSA	**Level 1:** effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1:** habitat losses/disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortalities (collisions, increased harvests)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently or occasionally (if at all) during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 1:** direct mortality is unlikely, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while an increase in contaminant levels may persist or be irreversible	**Level 1:** changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High

4.6.3 Prediction Confidence

High — Confidence is based on;

- Three years of baseline studies within the marine and terrestrial environments, and a high degree of survey coverage over suitable terrestrial and freshwater habitats and the coastal marine waters in Milne and Steensby Inlet that may be used for nearshore foraging and raising young; and
- A high degree of confidence in the data analyses, consistent with other bird studies.

4.6.4 Follow-Up

Nest searches will occur prior to any clearing of land and construction. Nest site mitigation will be implemented if active nests are found.

4.7 COMMON AND KING EIDER

4.7.1 Potential Effects and Proposed Mitigation

Issue 1 — Habitat

Hundreds of Common and King Eider used the two proposed port sites as migratory stop-over sites during their spring and fall migrations, and dozens of female Eiders were seen raising young in the marine waters of Steensby Inlet. No large nesting colonies of Common Eider were located along the shorelines of Steensby Inlet or Milne Inlet. Nesting was observed by King Eider along inland freshwater bodies (total of four nests located) and was reported for Common Eider along the coastline of Steensby Inlet (total of three nests). These birds may be displaced from coastal and terrestrial habitats used for staging, nesting, foraging, and brood-rearing by port construction at Steensby, and/or by sensory disturbances in habitats immediately adjacent to the Project footprint during construction, operation, and closure activities. Disturbed Eiders may abandon traditional nesting and foraging areas; however, it is predicted that they will simply move to less disrupted, seemingly suitable habitat, located as close as approximately 1 km distant from the zone of disturbance. This zone of disturbance will include both the port footprint areas as well as the turning radius of the ore carriers. Aerial and ground surveys in 2006–2008 indicated that there is an abundant supply of suitable coastal habitat (Common Eider) and inland tundra (King Eider) nearby for these species to move to. Although it is possible that during the first year of construction, displaced birds may be forced to forego breeding for a single year as they become confused and spend time seeking out and establishing themselves in new breeding habitats, they will be able to move quickly to nearby habitat and will not be affected at all. Therefore, displacement of Eiders from the relatively small (relative to the overall habitat availability) footprint and zones of influence, to nearby areas will have little to no effect on their migratory behavior and nesting success during all three phases of the Project.

A habitat suitability map for Common and King Eider nesting and foraging habitat was developed for the RSA based on Ecological Land Classification Modeling (see the Bird Baseline report in Appendix 6E). Based on an effects assessment of this data, there could be a loss of 426 km^2 of high quality habitat within the RSA (Table 6-4.9). This is equivalent to 1.4 % of the total RSA or 2.1 % of the total amount of high value habitat within the RSA. Since habitat effectiveness is reduced as a result of direct loss to the project footprint, and reduced effectiveness within a zone of influence due to sensory disturbances, there is a concomitant increase in lower quality habitats.

The habitat suitability model created for eiders combined the habitat preferences of King Eider which typically nest inland from the Arctic coastline, on Arctic tundra, often along freshwater lakes and ponds

(Suydam 2000) with the habitat preferences of Common Eider which are usually closely tied to marine habitats and tend to nest on coastal islands or islets (Goudie *et al* 2000). This resulted in a significant portion of the RSA being identified as high value habitat for Eiders. The model may somewhat overestimate the amount of high value habitat present within the RSA, however, the percent of the Eider habitat within RSA affected by the project is still expected to be relatively low in comparison to the available habitat.

Table 6-4.9 Change in Effectiveness of Eider Habitat within the Terrestrial RSA

Habitat Rating	Baseline Conditions		Change due to PDA and ZOI (km^2)		Post-development Conditions	
	Area (km^2)[1]	% RSA	Area (km^2)	% RSA	Area (km^2)	% RSA
High	20,284	66.4 %	-426	-1.39 %	19,858	65.0 %
Medium	920	3.0 %	+189	+0.62 %	1,109	3.6 %
Low	9,263	30.3 %	+127	+0.41 %	9,390	30.7 %
Nil	94	0.3 %	+110	+0.36 %	203	0.7 %

NOTE(S):
TOTAL AREA IN RSA = 30,711 KM^2. 151 KM^2 WAS NOT INCLUDED IN THE ELC MODELING EXERCISE.
HABITAT SUITABILITY VALUES WERE CLASSED AS: NIL (0-5), LOW (5.1 – 25), MODERATE (25.1-75), AND HIGH (75.1-100).

In addition to impacts within the terrestrial RSA, documented colonies are present in parts of the marine RSA including Turton Island and Southampton Island in Foxe Basin, and Fraser Island (just off Nottingham Island) and Markham Bay within Hudson Strait (Latour *et al.* 2008). However, ship routing will ensure that shipping traffic is kept a minimum of 2 km from breeding colonies, and the shipping route is expected to be more than 5 km from each of the above-listed colonies.

Issue 2 — Mortality

Potential influences on mortality for Eider within the terrestrial RSA will be similar to those described above for Snow Goose. Within the marine RSA, the main threat relating to Eider mortality comes from the potential for chronic and/or catastrophic release of contaminants which could cause direct and indirect mortality of Eiders. The probability of Eiders being hit by ships within the shipping corridor is very low.

Issue 3 — Health

Construction, operation, closure and post-closure activities may result in the release of contaminants that could be taken up in water or vegetation by birds such as Eider. Potential sources of contaminants that may be introduced into the environment include those from accidental spills of oil, gas or chemical products, emissions from diesel generators and other equipment, and the generation of dust along roads, at the ore stockpiles, and at other port facilities. Bird KIs may be exposed to contaminants through ingestion of plants, accidental soil ingestion while foraging, ingestion of water, epidermal contact with contaminated plants, soils or water, or direct inhalation of air and dust.

The construction and operation of the Project components will include procedures to control emissions and discharges from Project activities, as well as measures to avoid uncontrolled releases. Spill contingency plans, emission reduction measures, water treatment protocols and dust control measures will help to guard against unacceptable contaminant levels in the surrounding environment, and therefore effluent, dust and air emissions are expected to have minor to no effect on the health of Eider.

Mitigation

Within the terrestrial RSA, the potential effects on Eider are expected to be low and localized to areas immediately adjacent to the Project footprint. Baseline surveys indicated that there is an abundant supply of nearby suitable habitat for these species to move to. However, very few birds are expected to be disturbed enough to abandon their traditional breeding sites. If eiders nests are found, a 150m no-disturbance buffer will be applied for construction and industrial activities. If a 150m no-disturbance buffer is not feasible, the nest will be dealt with as per the Nest Management Plan (see section 4.12.2).

Within the marine RSA, chronic release of contaminants from the ore carriers is mitigated through regulatory compliance and state-of-the-are design. The Canada Shipping Act, 2001 (CSA 2001) came in force in 2007. It applies to Canadian vessels operating in all waters and to all vessels operating in Canadian waters. The section on environmental protection clearly describes the responsibilities of large vessel operators in terms of waste management requirements and potential discharge of toxic/chronic substances. These are regulatory requirements for any ship navigating in Canadian Waters. Baffinland expects partner shipping companies to meet or exceed these standards.

Environmental Protection included in the new regulations related to mitigation of potential pollutants in marine habitats include:

- Limits to sewage discharges.
- Ship-board oil pollution plans on certain non-oil barges carrying oil trucks or tanks.
- International Sewage Pollution Prevention Certificates for non-Canadian ships travelling to a Canadian port.
- Garbage management plans and up-to-date Garbage Record Books for certain ships (as specified in the Regulations).
- Limits to the sulphur content of any fuel oil used on a ship, set at 4.5 per cent.
- Quality standards for fuel oil used for combustion.
- International or Canadian Air Pollution Prevention Certificates for certain ships.
- International Anti-fouling System Certificates or self-declarations for certain ships.
- Paint containing tributyl tin removed or encapsulated from the coating of ships by January 1, 2008.

In addition to the updated environmental protection regulations that are part of the *Canada Shipping Act*, shipping activities will be conducted in accordance with the Project Shipping and Marine Wildlife Management Plan (Appendix 10D-10).

Although release of contaminants is regulated, there is a small probability that ships related to the Project can accidentally release contaminants (oils) into the marine environment used by foraging or migrating Eiders.

4.7.2 Assessment of Residual Effects

For Eiders residual effects within the terrestrial RSA could include;

- The unavoidable loss of coastal and terrestrial habitat for staging, nesting, foraging, and brood-rearing,
- Aspects of disturbance to these habitats adjacent to the footprints, and
- Aspects of disturbance to foraging habitat and behavior.

Table 6-4.10 presents a summary of the residual effects of the Project on Eider and assesses their significance. For each of the three key issues, the potential residual effect to Eiders is not significant.

Table 6-4.10 Residual Effects Assessment Summary (Terrestrial RSA): Common and King Eider

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints and LSA	**Level 1:** effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1:** habitat losses/disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortalities (collisions, increased harvests)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently or occasionally (if at all) during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 1:** direct mortality is unlikely, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1:** disturbance will be limited to Project component footprints	**Level 1:** effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while major increase in contaminant levels may persist or be irreversible	**Level 1:** changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High

Within the marine RSA, no residual effects are predicted. Colonies are being avoided through ship routing and ship passage through foraging habitat, while frequent (once/week), will be of short duration. Based on expected compliance with the environmental protection regulations associated with the *Canada Shipping Act* (2001), implementation of the Shipping and Marine Wildlife Management Plan (Appendix 10D-10) and state-of-the-art design of the yet to be built ore carriers, no residual effects of chronic contaminant release are expected.

4.7.3 Prediction Confidence

High — Within the terrestrial RSA, three years is a of baseline studies have been conducted within the marine and terrestrial environments, and there high degree of survey coverage over suitable terrestrial and freshwater habitats and the coastal marine waters in Milne and Steensby Inlet that may be used for nearshore foraging and raising young. The area expected to be affected is relatively low in relation to available habitats for Eider.

Within the marine RSA, ship routing will avoid known nesting colonies. The new ore carriers will comply with the *Canada Shipping Act*, and therefore, there is a high probability that the chronic release of contaminants in Eider migrating and foraging habitat will not occur. There is a very low probability of a catastrophic event resulting in the release of contaminants.

4.7.4 Follow-up

Nest searches will be conducted at the port sites in 2012 prior to any clearing of land. Nest site mitigation (no disturbance buffers as suggested by EC-CWS) will be implemented if active nests are found. Additionally, Baffinland will support EC-CWS research efforts to better determine seabird distribution in the eastern Arctic along the shipping route. The follow-up is further summarized in the monitoring program in Volume 10.

4.8 RED-THROATED LOON

4.8.1 Potential Effects and Proposed Mitigation

Issue 1 — Habitat

Red-throated Loon nests were found near marine coastlines in the Milne and Steensby Port areas as well as on freshwater bodies throughout the LSA that will be affected by the construction of Project facilities. Loons were also seen foraging and raising young throughout the RSA. During baseline studies, a habitat suitability map for Red-throated Loon nesting and foraging habitat was developed for the RSA based on Ecological Land Classification Modeling (See Appendix 6E).

Loons may be displaced by port construction and/or disrupted by noise disturbances during construction, operation, and closure activities. The potential effects of sensory disturbance may be the abandonment of traditional nesting and foraging areas within the zone of influence and may persist during the construction, operation, and closure phases, then decline shortly into post-closure. Based on 2006–2008 baseline studies around the Mary River exploration camp, loons will likely move only 300–500 m to less disruptive habitat. Baseline surveys also indicated that there is an abundant supply of nearby suitable habitat for this species to move to with the RSA. Therefore, displacement of loons from the zones of influence to nearby areas should have little to no effect on their nesting success during all three phases of the Project.

Within the RSA there could be a loss of 109 km^2 of high quality habitat (Table 6-4.11). This equates to only 0.36 % of the total RSA or 1.85 % of the total amount of high value habitat within the RSA. Based on the fact that the habitat effectiveness is reduced as a result of direct loss to the project footprint, and reduced effectiveness within a zone of influence due to sensory disturbances, there is a concomitant increase in nil, low and medium quality habitat.

Table 6-4.11 Change in Effectiveness of Red-throated Loon Habitat within the Terrestrial RSA

Habitat Rating	Baseline Conditions		Change due to PDA and ZOI (km^2)		Post-development Conditions	
	Area (km^2)[1]	% RSA	Area (km^2)	% RSA	Area (km^2)	% RSA
High	5,893	19.3 %	-109	-0.36 %	5,784	18.9 %
Medium	1,546	5.1 %	+23	+0.08 %	1,569	5.1 %
Low	9,187	30.1 %	+24	+0.08 %	9,211	30.1 %
Nil	13,935	73.6 %	+61	+0.20 %	13,996	45.8 %

NOTE(S):
TOTAL AREA IN RSA = 30,711 KM^2. 151 KM^2 WAS NOT INCLUDED IN THE ELC MODELING EXERCISE.
HABITAT SUITABILITY VALUES WERE CLASSED AS: NIL (0-5), LOW (5.1 – 25), MODERATE (25.1-75), AND HIGH (75.1-100).

Milne Port and Milne Inlet Tote Road — Noise from ongoing vehicle traffic during operations may disturb loons in this area; however, the birds were identified in relatively low densities, and high value habitats here are limited. Displacement of this small amount of habitat relative to the total available habitat is assessed as not significant along the road corridor. In 2008, six pairs of loons successfully raised young in water bodies within 300 m of the Tote Road.

Mine Site — Noise from mining activities, aircraft and vehicle traffic are likely to result in sensory disturbance that will result in decreased use of loon habitats adjacent to the Project footprint. Monitoring during the bulk sampling program suggests that the distance over which this disturbance takes place is generally limited to within 300 m from the development footprint. Disturbance could cause loons to abandon the areas directly adjacent to the mine and force them to move to other areas, such as suitable habitat areas nearby to the west. A pair of Red-throated Loons and a pair of Yellow-billed Loons nested on Sheardown Lake, which is 500 m from the current runway at the Mary River Camp and approximately 3 km from Deposit No. 1 (although their nests were found to be depredated by gulls in each year of survey), and therefore the sensory disturbance effects to loons are expected to be low.

Steensby Port — Baseline surveys indicated that there is an abundant supply of nearby suitable habitat for loons to move to in the Steensby Inlet area, but very few birds will be disturbed enough to abandon their traditional foraging and breeding sites.

Issue 2 — Mortality

The Project is not expected to cause direct mortalities to loons. Loons are in low enough densities (they do not form flocks) that collisions with aircraft are unlikely and they are capable of avoiding the relatively slow moving ships, even when accompanied by flightless young. The Project is not expected to result in increased harvesting of loons as they are not a species typically harvested by the Inuit and the Project will have a no-hunting policy for all mine workers. Also, workers will not be permitted to disturb wildlife under any circumstances.

Issue 3 — Health

Potential influences on health for Red-throated Loons will be similar to those described above for Peregrine Falcon, Snow Goose and Eiders.

Mitigation

The potential effects on Red-throated Loons are expected to be low and localized to only water bodies found directly adjacent to the Project footprint, and therefore, no specific additional mitigation measures are proposed. Baseline surveys indicated that there is an abundant supply of nearby suitable habitat for these species to move to but very few birds will likely be disturbed enough to abandon their traditional breeding sites. If individual loon nests are found, a 750 m no-disturbance buffer will be applied for construction and industrial activities. If a 750 m no-disturbance buffer is not feasible, the nest will be dealt with as per the Nest Management Plan (see section 4.12.2).

4.8.2 Assessment of Residual Effects

Residual effects on Red-throated Loons could include;

- The unavoidable loss of coastal and terrestrial habitat for staging, nesting, foraging, and brood-rearing from the port footprints,
- Aspects of disturbance to these habitats adjacent to the project footprint, and
- Aspects of disturbance to foraging habitat and behavior.

Table 6-4.12 summarizes the residual effects of the Project on Red-throated Loons and assesses their significance. For each of the three key issues, the potential residual effect to loons is not significant. This assessment has determined that while some individual-level disturbance and displacement is expected to occur within a zone of influence during all of the Project phases, no changes to the overall loon population are expected. Direct mortality of any individual loons due to Project activities is not expected nor is any increase in contaminants levels expected that would adversely affect any individuals' health. All effects will eventually be eliminated after carefully planned closure and post-closure procedures.

4.8.3 Prediction Confidence

High - Confidence is based on;

- Three years of baseline studies within the marine and terrestrial environments, and a high degree of survey coverage over suitable terrestrial and freshwater habitats and the coastal marine waters in Milne and Steensby Inlet that may be used for nearshore foraging and raising young; and
- A high degree of confidence in the data analyses, consistent with other bird studies.

4.8.4 Follow-Up

No follow-up monitoring is required for Red-throated Loon.

Table 6-4.12 Residual Effects Assessment Summary: Red-throated Loon

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints and LSA	**Level 1**: effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1**: habitat losses/ disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortalities (collisions, increased harvests)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently or occasionally (if at all) during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 1**: direct mortality is unlikely, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while an increase in contaminant levels may persist or be irreversible	**Level 1**: changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High

4.9 THICK-BILLED MURRE

4.9.1 Potential Effects and Proposed Mitigations

Issue 1 — Disturbance to Colonies and Migration

No Thick-billed Murre colonies or large feeding flocks were identified around the shoreline and waters of Milne Inlet or Steensby Inlet during field surveys, nor are any identified within this area in the regional literature. Therefore, no effects to seabirds are expected in Milne or Steensby Inlet during Project construction, operation, and closure.

Several Thick-billed Murre colonies were identified within the marine RSA, but the closest that shipping traffic will come to a colony is where the route passes 15 km south of Resolution Island when traversing through Key Marine Habitat #28 – Frobisher Bay (Figure 6-4.4). The shipping route described in the original submission of the DEIS showed that it approached Resolution Island within 5 km. The nominal shipping route described within this Final Environmental Impact Statement is approximately15 km from Resolution Island. There is no information to suggest that ships passing at distances > 5 km will disturb nesting Thick-billed Murres.

Ships will pass through waters that are on the migration route of Thick-billed Murres travelling south form colonies off the islands of southeast Baffin Island. The adult and young birds are flightless and may not be able to avoid oncoming ship traffic.

Issue 2 — Chronic Contaminant Release

Chronic wastage of oils and other contaminants can cause direct and indirect mortality to Thick-billed Murres. Chronic release of contaminants from the ore carriers is mitigated through regulatory compliance and state-of-the-are design. Shipping activities will be conducted in accordance with the Shipping and Marine Wildlife Management Plan (Appendix 10D-10). The Canada Shipping Act, 2001 (CSA 2001), which came in force in 2007, applies to Canadian vessels operating in all waters and to all vessels operating in Canadian waters. The section on environmental protection clearly describes the responsibilities of large vessel operators in terms of waste management requirements and potential discharge of toxic/chronic substances. These are regulatory requirements for any ship navigating in Canadian Waters. Baffinland expects partner shipping companies to meet or exceed these standards.

Environmental Protection included in the new regulations related to mitigation potential pollutants in Thick-billed Murre habitat include:

- Limits to sewage discharges.
- Ship-board oil pollution plans on certain non-oil barges carrying oil trucks or tanks.
- International Sewage Pollution Prevention Certificates for non-Canadian ships travelling to a Canadian port.
- Garbage management plans and up-to-date Garbage Record Books for certain ships (as specified in the Regulations).
- Limits to the sulphur content of any fuel oil used on a ship, set at 4.5 per cent.
- Quality standards for fuel oil used for combustion.
- International or Canadian Air Pollution Prevention Certificates for certain ships.
- International Anti-fouling System Certificates or self-declarations for certain ships.
- Paint containing tributyl tin removed or encapsulated from the coating of ships by January 1, 2008.

In addition to the updated environmental protection regulations that are part of the Canada Shipping Act, ore carriers (not yet built) will incorporate what is considered best technology to limit operational oil leakage.

All ore vessels will be equipped with seage treatment plants and incinerators for solid and liquid wastes. No seage effluent or untreated sewage will be discharged from vessels. The stern tube seal for the ore carriers will use a Biodegradable lubricant such as Vickers Hydrox 68 (http://www.vickers-oil.com/marine_v2/HYDROXOBIO68_MoreInformation.php). The nature of this substance, and the minimal quantities that could be released to the environment, result in a non-measurable effect on receiving water quality.

Although release of contaminants is regulated, there is a low probability that ships related to the Project can accidentally release contaminants (oils) into the marine environment used by foraging or overwintering Thick-billed Murres.

4.9.2 Assessment of Residual Effects

Issue 1 — Disturbance to Colonies and Migration

No residual effects expected. Colonies are being avoided by tens of kilometers. Ship passage through foraging habitat, while frequent (once/week), will be of short duration. Due to relatively quick migration (i.e., up to 40 km/day) individual Thick-billed Murre are expected to encounter ship passage infrequently (< three times) in any given year.

Issue 2 — Chronic Contaminant Release

Based on expected compliance with the environmental protection regulations associated with the *Canada Shipping Act* (2001), implementation of the Project Shipping and Marine Wildlife Management Plan and state-of-the-art design of the yet to be built ore carriers, no residual effects of chronic or catastrophic contaminant release and potential

4.9.3 Prediction Confidence

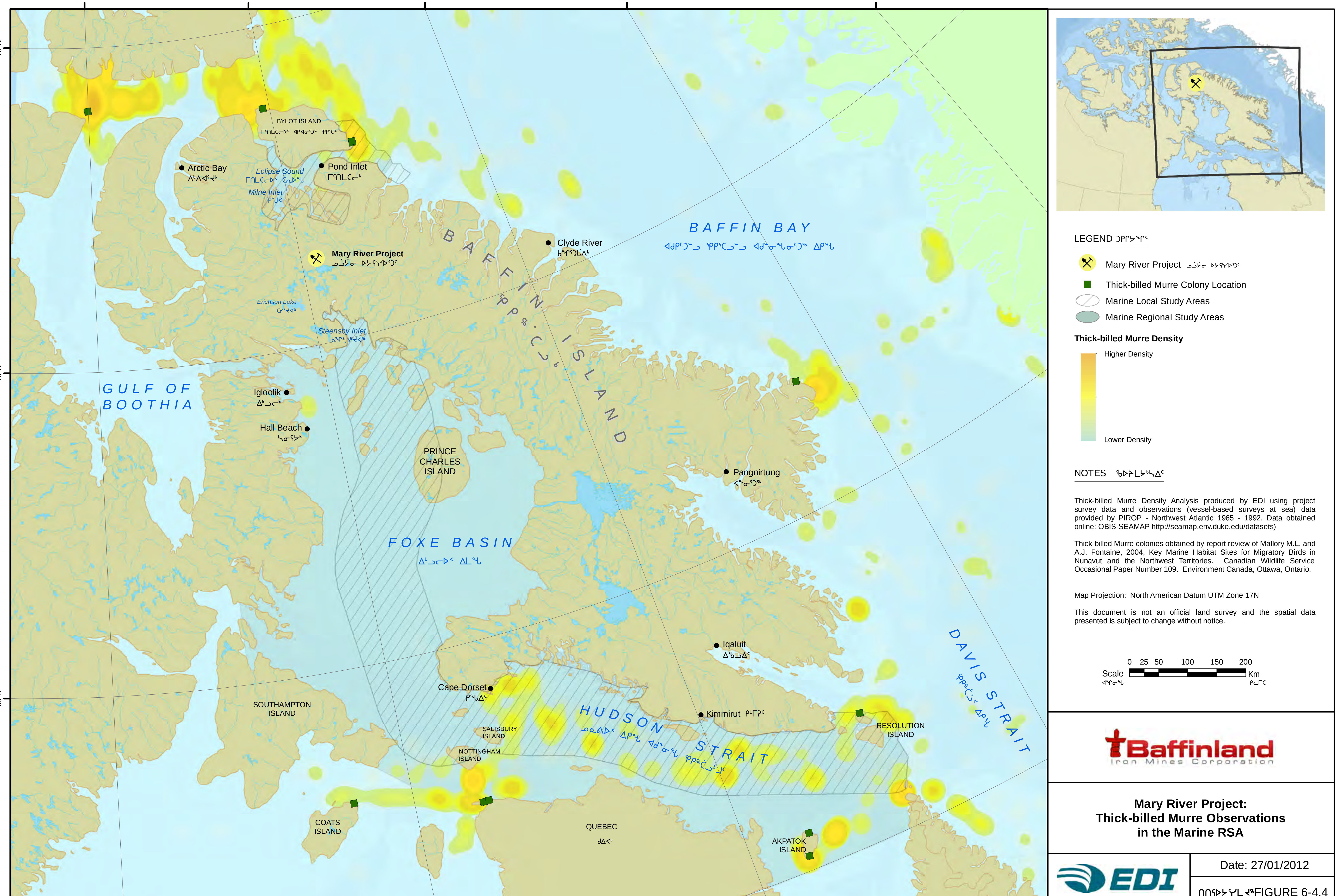
High — Although Thick-billed Murre migration routes are not completely understood, it seems that the migration itself occurs fairly rapidly, and expected encounters along the shipping corridor should be infrequent. The new ore carriers will comply with the Canada Shipping Act, and therefore, there is a high probability that the release of contaminants in Thick-billed Murre migrating and foraging habitat will not occur. There is a very low probability of a catastrophic event resulting in the release of contaminants. The assessment for residual effects is presented in Table 6-4.13.

4.9.4 Follow-up

Follow-up monitoring for seabirds will include studies looking at the winter distributions and migration routes of Thick-billed Murre. These are described in Volume 10.

Table 6-4.13 Residual Effects Assessment Summary: Thick-billed Murre

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints and LSA	**Level 1**: effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1**: habitat losses/ disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortalities (collisions, increased harvests)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently or occasionally (if at all) during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 1**: direct mortality is unlikely, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while an increase in contaminant levels may persist or be irreversible	**Level 1**: changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High



Mary River Project: Thick-billed Murre Observations in the Marine RSA

FIGURE 6-4.4

4.10 LAPLAND LONGSPUR

4.10.1 Potential Effects and Proposed Mitigation

The Project will increase exposure to metals from dust generated during crushing and hauling of mined materials. The introduction of contaminants such as metals released from ore dust could reduce species' health. Effects can occur through direct contact with the contaminant or indirectly through the food chain.

Effects on songbirds and shorebirds could potentially be reduced by:

- Decreasing the project footprint that will minimize habitat loss;
- Minimizing activity along the access roads which will reduce the functional loss of habitat due to disturbance; and
- Applying dust suppression along roads and at the mine site when required during summers. This will limit the deposition of dust on adjacent vegetation that could expose birds to elevated minerals and impact their health.

Issue 1 — Habitat Loss

The Project has the potential to adversely affect Lapland Longspur populations by reducing the availability of habitat due to the Project footprint and disturbance effects in adjacent habitats. Loss of habitat during migration, breeding/nesting and brood-rearing may occur throughout the construction, operation and closure phases of the Mary River Project. The assessment of habitat effects for Lapland Longspur was based on Density Mapping completed for the baseline. It estimated that 148 km² of high density Lapland Longspur habitat and 122 km^2 of moderate density Lapland Longspur habitat will see a decrease in value to low or nil density habitat (see Table 6-4.14). For each of the density classes the total change in less than 1 % of the RSA. The loss of 148 km² high density habitat equates to 0.48 % of the total RSA or 2.2 % of the available high density habitat. The loss of 122 km² of moderate density habitat is equivalent to 0.40 % of the total RSA and 1.3 % of the available moderate density habitat. The duration of this loss is long-term; however, once mine decommissioning commences the effects may be reversible over time.

Table 6-4.14 Predicted Change in Lapland Longspur Densities within the Terrestrial RSA

Habitat Rating	Baseline Conditions		Change due to PDA and ZOI (km^2)		Post-development Conditions	
	Area (km^2)[1]	% RSA	Area (km^2)	% RSA	Area (km^2)	% RSA
High	6,679	21.70 %	-148	-0.48 %	6,531	21.27 %
Moderate	9,649	31.40 %	-122	-0.40 %	9,527	31.02 %
Low	7,218	23.50 %	+164	+0.53 %	7,382	24.04 %
Nil	7,165	23.30 %	+106	+0.35 %	7,271	23.67 %

NOTE(S):
TOTAL AREA IN RSA = 30,711 KM^2.
LAPLAND LONGSPUR DENSITIES WERE CLASSED BASED ON NUMBER OF INDIVIDUALS /KM^2: NIL (<1), LOW (1 – 10), MODERATE (11 – 30), AND HIGH (>30).

Issue 2 — Mortality

Direct mortality of Lapland Longspur due to collisions with road traffic, rail or aircraft is possible; however, this is expected to affect only a few individuals. Given that the birds are abundant and well distributed throughout the study area, a few individual mortalities would represent a very low percentage of the population. Direct mortalities due to collisions with permanent structures on land are also possible but are not expected.

Indirect mortality (of adult birds and/or eggs and young) because of increased predator abundance could occur, however, Baffinland is taking several steps to prevent this through measures to reduce the potential for project infrastructure to provide additional nesting, roosting and denning habitats, and by using appropriate waste management, and a ban on staff feeding wildlife that permanently or temporally occur within the Project site. For further information see section 4.12.5.

Issue 3 — Health

Potential influences on health for Lapland Longspur will be similar to those described above for Snow Goose.

Mitigation

The potential effects on Lapland Longspur are expected to be low and localized to areas directly adjacent to the Project footprint, and therefore, no specific additional mitigation measures are proposed for this species. Baseline surveys indicated that there is an abundant supply of nearby suitable habitat for these species to move to. If individual nests of Lapland Longspur are found, a 100m no-disturbance buffer will be applied for construction and industrial activities. If a 100m no-disturbance buffer is not feasible, the nest will be dealt with as per the Nest Management Plan (see section 4.12.2).

4.10.2 Assessment of Residual Effects

Residual effects on Lapland Longspurs could include;

- The unavoidable loss of nesting and foraging habitats within the Project footprint,
- Disturbance to these habitats adjacent to the Project footprint, and
- Direct mortality of a few individuals due to collisions with road, rail and aircraft traffic.

Table 6-4.15 provides a summary of the residual effects on Lapland Longspurs as a result of the Project and assesses their significance. For each of the three key issues, the potential residual effect is not significant. This assessment has determined that while some individual-level disturbance and displacement is expected to occur within a zone of influence during all of the Project phases, no changes to the overall population of Lapland Longspurs are expected. Direct mortality of a few individuals due to Project activities is possible; however, numbers are expected to be very low in relation to population size. No increase in contaminants levels is expected that would adversely affect any individuals' health. All effects will eventually be eliminated after carefully planned closure and post-closure procedures.

4.10.3 Prediction Confidence

High – Baseline data collection could have been more systematic, standardized and a greater number of points sampled by habitat type, however, comparative densities from other Arctic studies illustrate that the bird populations and densities observed in the Mary River Project area are generally comparable to other Arctic tundra habitats.

Table 6-4.15 Residual Effects Assessment Summary: Lapland Longspur

Issue	Magnitude / Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints and LSA	**Level 1**: effect expected to occur primarily during construction	**Level 2:** effect will continue through operations phase	**Level 1**: habitat losses/ disturbance are comparatively low as alternative sites are available in close proximity	**Level 2:** direct loss and/or disturbance of some habitat is likely due to their proximity to some project components	Not Significant	High
Issue 2 Mortalities (collisions, increased harvests)	**Level 1**: local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently or occasionally during construction and operations	**Level 2:** effect will continue through operations phase	**Level 3:** effect is not reversible	**Level 2**: direct mortality of a few individuals is possible, mitigation measures regarding collisions and wildlife protection are addressed in the Mitigation and Monitoring Plan	Not Significant	High
Issue 3 Health (spills and introduced contaminants)	**Level 1:** local disturbance relative to the extent of the features	**Level 1**: disturbance will be limited to Project component footprints	**Level 1**: effect could occur infrequently during construction and operations	**Level 2:** effect will continue through operations phase	**Level 2:** effect of minor levels of contaminants likely to be reversible while an increase in contaminant levels may persist or be irreversible	**Level 1**: changes to health are unlikely, mitigation measures for spills, effluent, dust, and air emission controls are addressed in the Mitigation and Monitoring Plan	Not Significant	High

4.10.4 Follow-Up

No monitoring is necessary since no significant adverse effects are expected.

Although regular monitoring is not required for songbirds and shorebirds, Baffinland will work with Environment Canada to conduct periodic PRISM surveys to contribute to regional baseline data. See Volume 10 for more details.

4.11 SPECIES AT RISK

Harlequin Duck, Ross's Gull, Ivory Gull and Short-eared Owl were all detected during baseline surveys at Mary River; Figure 6-4.5 shows the location of each of these observations. Additionally, Red Knot was not detected during field surveys but might potentially to be found within the Project Area.

4.11.1 Harlequin Duck

Project interactions with Harlequin Duck behavior and distribution and potential effects were determined qualitatively through a review of Project-observations, known distribution, and expected future occurrences in the terrestrial and marine RSA. The Terrestrial RSA is not considered breeding habitat; however, the southern third of Baffin Island is within the breeding range of the eastern population of Harlequin Duck. It is expected that individuals breeding on Baffin Island will migrate to Greenland in the winter, as do Common Eiders that breed in this area (Mallory *et al*. 2008), and will likely migrate along portions of the southern shipping route.

4.11.1.1 Potential Effects and Proposed Mitigation

There are no predicted Project-related effects to breeding Harlequin Ducks. Their use of fast flowing streams within the terrestrial RSA for breeding is not expected based on known distribution. There were no observations of the species in typical breeding habitat.

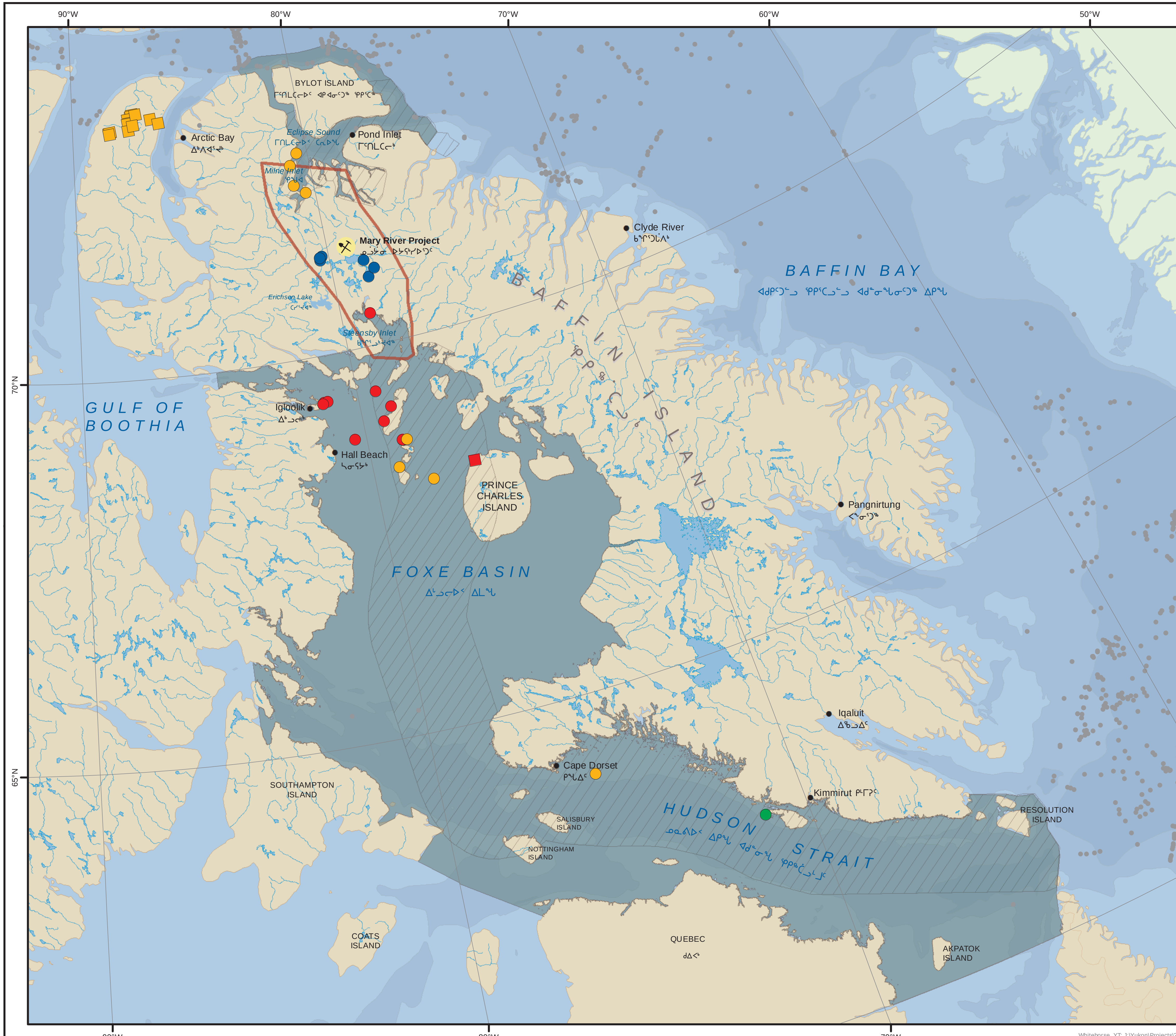
There is the potential for interaction with migrating birds or non-breeding Harlequin Ducks foraging in Hudson Strait. However, the number of birds that may be encountered is expected to be very low. The potential effects of a chronic or catastrophic contaminated released within marine waters is expected to be similar to those described above for Thick-billed Murre.

4.11.1.2 Assessment of Residual Effects

There are no expected residual Project-related effects on Harlequin Duck behaviour or distribution. There will be no residual effects of contamination because chronic leaking is not expected to occur, and a catastrophic event is not foreseeable. Collision at sea is unlikely.

4.11.1.3 Prediction Confidence

High — Harlequin Duck is easily identified and none were found in the terrestrial LSA where the bulk of potentially disturbing activities to any breeding pairs would occur. The terrestrial RSA is outside of the expected breeding range (northern extent is southern Baffin Island). Given the very low number of Harlequin Ducks expected to be observed in either the terrestrial or marine RSA through the life of the Project, it is unlikely that an effect will ever be reliably observed.



LEGEND

- Mary River Project
- Ivory Gull Observation (PIROP - Northwest Atlantic 1965-1992)
- Ivory Gull Nesting Site (COSEWIC, 2006)
- Ivory Gull Observation (Mary River Project Observation)
- Ross's Gull Nesting Site (COSEWIC, 2007)
- Ross's Gull Observation (Mary River Project)
- Harlequin Duck Observation (April 28, 2008)
- Short-eared Owl Observation (Mary River Project Observation)
- Terrestrial Regional Study Area
- Marine Local Study Areas
- Marine Regional Study Areas

NOTES

Ivory Gull Observations (vessel-based surveys at sea) data provided by PIROP - Northwest Atlantic 1965 - 1992. Data obtained online: OBIS-SEAMAP http://seamap.env.duke.edu/datasets).

Ivory Gull Nesting Sites: Assessment and Status Report on the Ivory Gull (COSEWIC, 2006). Ross's Gull Nesting Site: Assessment and Status Report on the Ross's Gull (COSEWIC, 2007).

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 25 50 100 150 200 Km

Baffinland Iron Mines Corporation

Mary River Project
Species at Risk Observations,
Mary River Marine RSA

EDI

Date: 1/9/2012

FIGURE 6-4.5

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_4_5_MarineRSA_SpeciesAtRisk.mxd

4.11.1.4 Follow-up

Incidental sightings of Harlequin Duck will be noted by onsite monitors and during follow-up within the marine environment. Scientific surveys are not cost effective for this species in the Baffin region (Gilchrist et al 2005).

4.11.2 Ross's and Ivory Gulls

The assessment of Ross's and Ivory Gull is combined because project interactions and potential effects are considered identical. Observations were rare, but the Project's observations do include the largest known observation of Ross's Gull numbers in Canada (22 individuals in west Foxe Basin in October 2008).

4.11.2.1 Potential Effects and Proposed Mitigations

Issue 1 — Disturbance to Colonies and Migration

The Project's shipping lane passes within 50 km of only one known breeding site of Ross's Gull on the northwest corner of Prince Charles Island in eastern Foxe Basin (Bechet *et al*. 2000; Figure 6-4.5), although it was not considered a "stable" colony. The additional Project survey observations of Ross's Gull in August, September and October 2008 suggest the continued presence of the species in the region. The observations of Ivory Gull were more widespread, but those in Milne Inlet, Eclipse Sound, and Hudson Strait were within the range of previous observations from earlier marine bird surveys (e.g., Programme intégré de recherches sur les oiseaux pélagiques — PIROP Northwest Atlantic database with observations from 1966–1992). Ivory Gull is not known to breed in the study area, but may migrate through it to reach breeding colonies on Brodeur Peninsula, northern Baffin Island, or the eastern Lancaster-Jones Sounds regions close to Bylot Island.

The ships are not expected to travel through shore leads or polynyas during the winter season where Ivory Gulls may be foraging. The shipping route does approach a known shore lead east of Cape Dorset in Hudson Strait, but it is unlikely that the ice-breaking ships will divert their course in this region. Although their habits are poorly understood, Ross's Gull are expected to winter in the pack ice in the northern Bering Sea and the Sea of Okhotsk in the western Arctic (COSEWIC 2007c), entirely outside of the marine RSA and shipping route.

Research conducted in the 1980s was required by Canadian regulatory agencies for granting permits for offshore oil exploration in Hudson and Davis Straits (Orr and Ward, 1982). To date, none of the guidelines that may have been produced by Environment Canada at the time of that exploration activity can be located (C. Callaghan, Environment Canada, pers. comm.). If guidelines do become available they will be reviewed for their relevance to the Project's shipping activities.

Issue 2 — Chronic Contaminant Release

The effect of and proposed mitigation for a Chronic and Catastrophic Contaminant Release on Ross's and Ivory Gull is expected to be similar to what is described for Thick-billed Murre. See Section 4.5.1.

4.11.2.2 Assessment of Residual Effects

There will be no residual effects to Ross's or Ivory gull nest sites or nesting colonies, migration, or foraging areas. There will be no residual effects of contamination because chronic leaking is not expected to occur, and a catastrophic event is not foreseeable.

4.11.2.3 Prediction Confidence

High — Although the birds are rarely observed, they are observed at sea during marine surveys. Birds are very unlikely to be encountered at nest sites. There will be no residual effects of contamination because chronic leaking is not expected to occur, and a catastrophic event is not foreseeable. Collision at sea is unlikely.

4.11.2.4 Follow-up

Ross's and Ivory gulls are fairly distinctive and readily observed when present. Nesting will be mitigated with a no-disturbance buffer (see Section 3.8.2) if nests are found in the terrestrial RSA. Follow-up monitoring for seabirds may include studies looking at the winter distributions and migration routes of Ivory Gull. These are described Volume 10 of the FEIS.

4.11.3 Red Knot

Project interactions with Red Knot are unknown. Field studies have not documented the species within the terrestrial RSA; however, specific surveys for Red Knot were not conducted and the species could have been missed. If present, they are expected to nest in barren areas such as windswept ridges, slopes or plateaus within approximately 50 m of the marine coastline. Observations at Bylot Island (n=4) indicated that the species may be selecting gravelly habitats for nesting (LePage *et al*. 1998).

4.11.3.1 Potential Effects and Proposed Mitigation

Nest sites may be disturbed by project activities such as port construction and ship wake. Nest searches will be conducted along shorelines expected to be most heavily impacted by ship wake in 2012, and at the port sites prior to any clearing of land and construction. If nests are found, a 300 m no-disturbance buffer will be implemented around the nest until fledging occurs (see Section 4.8.2) and if necessary, efforts will be made to protect the nest from wake effects (e.g., creation of a rock wall between the nest and the coastline).

4.11.3.2 Assessment of Residual Effects

There are no expected residual effects on Red Knot.

4.11.3.3 Prediction Confidence

Moderate — Breeding has not been confirmed in the area, but may have been missed during the baseline surveys.

4.11.3.4 Follow-up

Nest searches will be conducted along shorelines in 2012 and at the port sites prior to any clearing of land. Nest site mitigation will be implemented if active nests are found as per EC-CWS guidelines for no-disturbance buffers.

4.11.4 Short-eared Owl

Project interactions with Short-eared Owl are unknown. Although three individuals were observed in 2007 and 2008, no nesting was confirmed or suspected. Habitat preference beyond the known northern extent of their distribution is not known, but is expected to be similar to habitat preferences in more southerly regions. Habitat availability is not expected to be a limiting factor within the study area.

4.11.4.1 Potential Effects and Proposed Mitigations

Nest sites may be disturbed by project activities, although no nests have been located after three years of intensive ground and aerial surveys. If a nest is located during construction, a 400 m no-disturbance buffer (Cooper and Beauchesne 2004) can be established until nesting is complete. If a nest is discovered during operations, a similar 400 m buffer will be established permanently.

4.11.5 Assessment of Residual Effects

There are no expected residual effects on Short-eared Owl habitat use and distribution.

4.11.5.1 Prediction Confidence

High — Short-eared Owls are readily observed and nest sites are generally easily located when observers are in the vicinity of a nest. Breeding has not been confirmed in the area.

4.11.5.2 Follow-up

In the event that an active Short-eared Owl nest is discovered, nest-site mitigation will be implemented (e.g., a 400 m no disturbance buffer).

4.12 ADDITIONAL SUBJECTS OF NOTE

This section addresses additional issues identified during Project scoping and/or the Technical Review process.

4.12.1 General Mitigation Measures for all Bird Species

Although the FEIS focuses on the impacts to specific key indicators, Canada's *Migratory Birds Convention Act* (1917, 1994) regulates the protection and conservation of all migratory bird species identified in the Act (including waterfowl, seabirds and other aquatic birds, shorebirds and songbirds) and prevents the disturbance or destruction of these birds, their nests and eggs, while other birds such as falcons and other raptors, ptarmigan and ravens are protected by territorial legislation. Therefore, all bird species present within the Mary River Project Area warrant special consideration and protection during Project construction, operation and closure; this relates particularly to any activities conducted between mid-May and October when migratory bird species are present.

General mitigation measures that will be applied to all bird species within the Project Area will include:

- Minimizing the project footprint to the extent possible, thus minimizing the direct loss of habitat and the reduction of habitat effectiveness (indirect habitat loss);
- Conducting nest searches in areas which will be disturbed during the nesting season (late May through late August), prior to any clearing of land;
- Implementing a nest management plan which will apply to any nest sites located within 750 m of Project activity (see below);
- Minimizing potential effects to breeding birds by limiting Project activity and noise emissions to the extent possible, to non-nesting and non-migration periods (November–April);
- Avoidance of areas of large concentrations of foraging or moulting birds by Project personnel and equipment to the extent possible;

- To the extent possible, preventing air traffic below 610 m above ground level (agl) over known nesting areas during the nesting period, and over any large concentrations of birds;
- Developing appropriate aircraft approach and departure flight paths, to the extent possible, for the airstrips at the Milne and Steensby Inlet port sites with consideration for nearby bird populations to avoid disturbance and to minimize the likelihood of bird strikes;
- Routing ships to maximize distances between the ships and shorelines, and to remain at least 2 km from seabird colonies to the extent possible;
- Handling ship discharges in a way that conforms with the *Canada Shipping Act* and the *Arctic Waters Pollution Prevention Act*;
- Developing effective oil spill emergency response plans in accordance with the *Arctic Waters Pollution Prevention Act*;
- Minimizing dust production by implementing dust suppression methods, and thereby minimizing the Project's zone of influence; and
- Employee training to ensure workers do not disturb, harass, or feed wildlife (including birds).

4.12.2 Nest Management Plan

If nests are found within 750 m of a work area, environmental staff will be contacted and mitigation plans such as closure of the area within a specific buffer of the nest until fledging occurs (typically late July) will be implemented. The following table outlines the setback distances recommended by Environment Canada for tundra-nesting species that will be applied within the Mary River Project.

If any Species at Risk nests are encountered within 2 km project activities, appropriate setback buffers will be applied, and the nests will be monitored by environmental staff to confirm that project activities are not affecting the nest.

Table 6-4.16 Recommended Setback Distances for Activity near Bird Nests

Species Group	Recommended Setback Distances (m)	
	Pedestrians/ATVs	Roads/Construction/Industrial Activities
Songbirds	30	100
Shorebirds	50	100
Terns/Gulls	200	300
Ducks	100	150
Geese	300	500
Swans/Loons/Cranes	500	750

In some cases it may not be feasible to maintain the recommended buffer between known nests and Project activities. In such cases, nest-specific guidelines and procedures will be developed and issued to all employees to ensure the duration of the activity and the magnitude of the disturbance to that nest is minimized. Project biologists will monitor each individual case as often as possible and in a manner that does not cause added disturbance to the nest, to assess the effectiveness of the nest-specific management plans. To prevent thermoregulatory stress to eggs, incubating adults should not be disturbed/flushed from their nests during inclement weather (rain, snow, cold temperatures) in June and July.

4.12.3 Important Habitat Areas

There are no habitat areas within the terrestrial RSA that have been federally or territorially designated as important habitat areas, or conservation areas. However, as described in Appendix 6E (Bird Baseline Report), Sirmilik National Park and the Bylot Island Bird Sanctuary lie along the northern tip of the marine RSA and there are various Key Marine Habitat Sites (Mallory and Fontaine 2004), Key Terrestrial Habitat Sites (Alexander et al. 1991, and Latour et al. 2008), and Important Bird Areas (CEC 1999, Bird Studies Canada 2010) scattered along the edges of the shipping lanes, particularly in Foxe Basin and Hudson Strait. No effects are expected within these important habitat areas as ships routes will be planned to maximize distances between the ships and the shorelines, remain at least 2 km from seabird colonies, and to the extent possible, will avoid Key Marine Habitat Sites. See Figure 6-4.6 for the location of Parks, important habitat areas and other conservation areas along the RSA.

4.12.4 Seabirds and Seabird Colonies

No large seabird colonies or large feeding flocks were identified around the shoreline and waters of Milne Inlet or in Steensby Inlet. Ships travelling in and out of Eclipse Sound must by necessity pass within close proximity of Canada's largest Greater Snow Goose colony on Bylot Island, as well as large seabird colonies at Cape Graham Moore. Ships travelling through Foxe Basin and Hudson Strait will also pass several large colonies; however, ship routing will maximize the distance between the ships and shorelines, and will remain at least 2 km distant. As a result, ship passage is unlikely to disturb nesting birds at their colonies. It is possible that these birds could come into contact with the ships when foraging in marine waters. However, it is thought that ship movements along shipping lanes will have inconsequential effects on foraging marine birds as bird collisions with ships are unlikely and the periodic requirement to move out of a ship's path will not be a significant energetic stress to birds. Sealift, Navy, and cruise ships have long been entering into Pond Inlet, Eclipse Sound, Navy Board Inlet, Foxe Basin and Hudson Strait and there have been no reports of noticeable long-term effects to seabird and goose colonies in these areas.

The likelihood of a large-scale catastrophic fuel spill is low, but nonetheless remains a potential threat during any shipping operation. The potential for smaller fuel spills or chronic leakage from ships is higher, but also remains low overall. Regardless, all marine birds, and seabirds in particular, are vulnerable to even minor exposure to fuel through contamination of their plumage and through the ingestion of fuel contaminated food. Oiled feathers can result in the loss of insulation and water-proofing, leading to hypothermia. Ingestion of oil can lead to changes in physiology, internal tissue damage, and death. Birds that feed at the water surface, along the shoreline, or dive under the surface to feed are all highly vulnerable to exposure in the event of even a minor spill. Colonial nesting species and species that form large concentrated feeding aggregations are also highly vulnerable to spills of any size. Therefore, the effect of oil spills in Eclipse Sound, Pond Inlet, Foxe Basin, and Hudson Strait have the potential to be significant. This effect is assessed in the Accidents and Malfunctions section of Volume 9.

4.12.5 Potential Increase in Predation Due to Project Development

Predation, particularly nest predation, is a key factor limiting the productivity of many bird species. Artificial increases in avian (e.g., ravens and gulls) and terrestrial (e.g., foxes) predator populations as a result of human activities can alter the existing balance between nesting birds and predators, and lead to population declines. Previous projects in other northern settings have been associated with increased predation on local prey species (Canadian Wildlife Service 2007). However, increased mortality of birds because of increased predator abundance is not expected to occur.

Waste management is the primary mitigation to reduce the risk of increased predator abundance within the Project footprint (see Section 5.3). Baffinland is confident that operational standards and management plans (Volume 10), and, where practical, the incorporation of the recommendations in the guidelines for Preventing Wildlife Attraction to Northern Industrial Sites (Canadian Wildlife Service 2007) will mitigate the potential for increased predator abundance in the area. Appendix 10B and 10D-4 describe the Project's waste management infrastructure, systems, and policies.

The Project will also reduce the potential for project infrastructure to provide additional nesting, roosting or denning sites for predators by implementing guidelines from Preventing Wildlife Attraction to Northern Industrial Sites (Canadian Wildlife Service 2007). For example, bird spikes will be installed on horizontal surfaces, particularly near heat sources, and buildings will reduce the number of sheltered surfaces where nests could be established. Terrestrial predators will be deterred from using the site by reducing their ability to den underneath buildings, appropriate waste management, and a ban on staff feeding wildlife that permanently or temporally occur within the Project site.

4.12.6 Bird Collision Risk with Communication Towers, Tall Structure and Overhead Wires

The proposed Mary River Project is currently planning to install 12 permanent communication towers, all of which will be located along the rail right-of-way (see Volume 3: Project Description). These towers are expected to be 30 m high and will be free-standing (unguyed). They will have shelters at the bottom containing diesel generators and a diesel tank, plus backup batteries and possibly alternate power supply (solar or wind). Temporary two-way radio towers are also planned along the Tote Road for the construction phase only (approximately five years), these are expected to be guyed masts.

The communication towers do present some risk of collision for local bird species, particularly during migration, when large flocks of birds may be passing through. However, the lack of guy wires on all permanent towers limits this risk. Any temporary communication towers which do require guy wires will be fitted with bird diverters to help minimize the risk of bird collisions. During most of the migration and breeding seasons in the Mary River Project Area, the area will be experiencing 24 hour sunlight. Therefore, any lights associated with the communication towers are not expected to present a risk to birds.

4.12.7 Impact of Aircraft Disturbance on Staging, Nesting and Moulting Birds

Baffinland is proposing three airstrips for the Mary River Project — one each at Milne Port, Steensby Port, and the mine site. To assess the impact of these airstrips and, in particular, to account for the auditory and visual disturbance generated by large aircraft upon takeoff and landing, a Zone of Influence (ZOI) buffer was mapped for each airstrip. Based on recommendations from Environment Canada, these buffers extended 3 km on either side and 5.4 km from the ends (5.4 km is the estimated distance that it would take for a Boeing 737 aircraft to reach a height of 650 m upon takeoff, the 3 km buffer on either side of the airstrip was based on a literature review by Environment Canada).

Field surveys identified no large seabird colonies or large feeding flocks around the shoreline and waters of Milne Inlet or in Steensby Inlet. A breeding colony of Snow Geese was identified on the southwest coast of Steensby Inlet, and two Glaucous Gull colonies were located on cliff habitats in the northern and mid-sections of Milne Inlet. None of these colonies overlap the airstrip ZOI buffers. Baseline surveys also observed thousands of Snow Geese using the terrestrial RSA as a migratory stop-over and moulting location. Some of these observations were located with the ZOI buffer for the airstrip at Steensby Inlet;

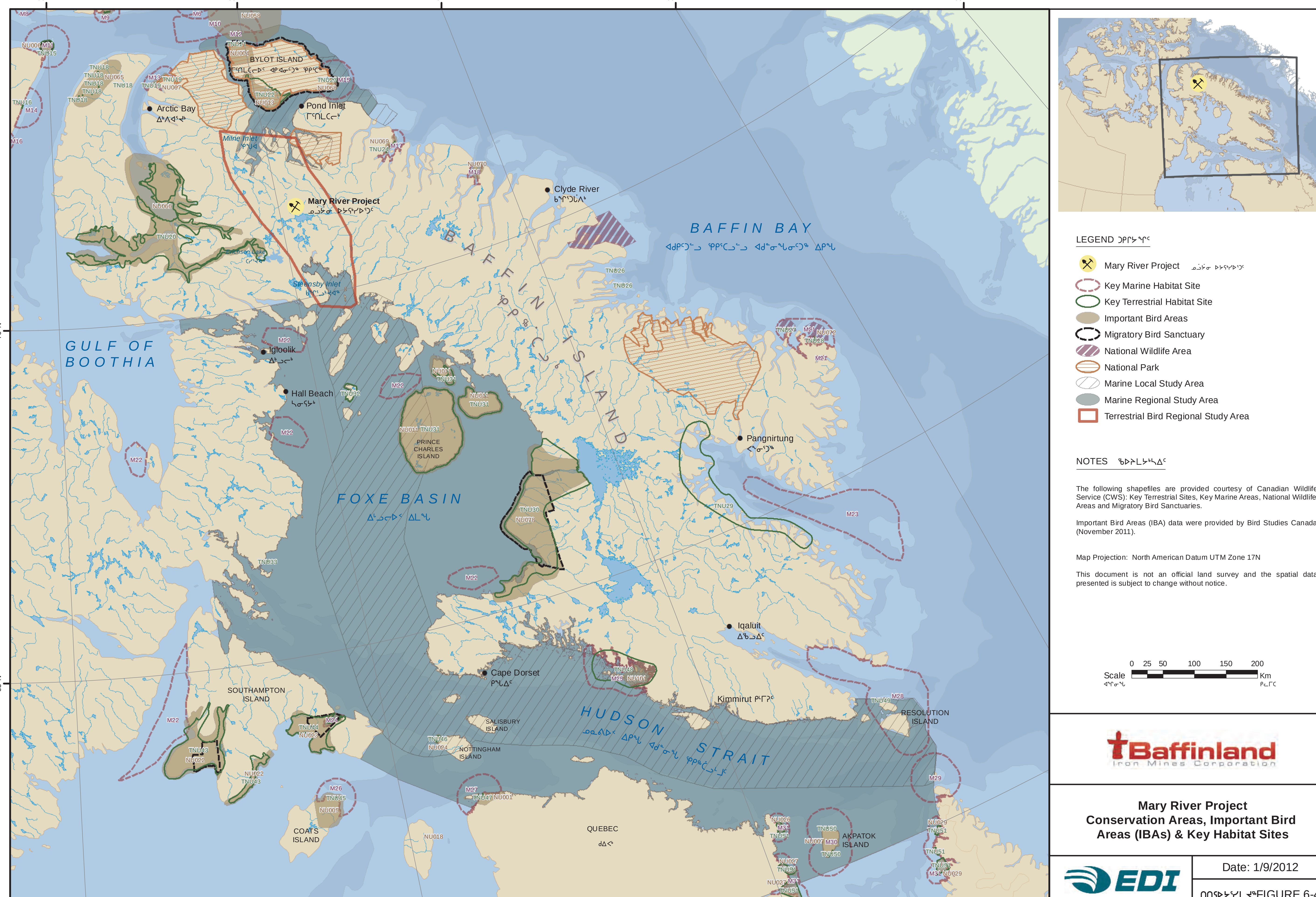
however, as assessed in Section 4.2.1, there is abundant habitat available for migratory stop-overs located on either side of Steensby Port and the bulk of the moulting activity occurs within a proposed Special Management Area which is located outside of the ZOI buffer. Figure 6-4.7 shows the location of the airstrip ZOIs in relation to the breeding colony and moulting areas.

4.12.8 Impact of Wake on Coastal Foraging and Nesting Habitat

An analysis of the effects of ship wake on Project shorelines was completed by Coastal and Ocean Resources Inc. and is available in Appendix 8D-2. According to this report, most wakes reaching the shoreline are likely to be very small, especially where speeds of less than 15 knots occur. Significant wakes are expected to occur only within Steensby Inlet and a small part of northwest Foxe Basin (outside of these areas, ships will be routed far enough away from islands and coastlines that will avoid predicted wake effects), and with a few exceptions ship wakes along the shore in this area are expected to be less than 0.5 m high and to last only a few minutes per transit. By comparison, typical fall storms in the Foxe Basin area can easily produce a wave 0.7 m or more in height. The exceptions to this are the shoreline and islets immediately adjacent to Steensby Port, and a small island near the mouth of Steensby Inlet; wakes in these two areas may exceed 0.5 m.

Given the expected size and duration, the wake generated by project shipping is not expected to have a significant impact on foraging birds or foraging habitats. There is potential for some impacts to nesting birds (e.g., temporary swamping of ground nests); however, this is expected to be rare since ground nests will be located beyond the reach of the local tides and in most cases (other than during high tide) any wake reaching the shore will likely dissipate within the tidal zone. Wake will only have an effect during high tide, if ground-nesting species are nesting in close proximity to the tidal zone.

Nest searches will be conducted in 2012 along the Project shorelines expected to see the highest wakes. If necessary, mitigation will be developed to limit the impact of wake on nesting birds.



LEGEND ᑐᑭᑦᓯᕐᑦ

- Mary River Project ᓇᓗᔾᓂ ᐅᔭᕐᓯᐅᕐᑦ
- Key Marine Habitat Site
- Key Terrestrial Habitat Site
- Important Bird Areas
- Migratory Bird Sanctuary
- National Wildlife Area
- National Park
- Marine Local Study Area
- Marine Regional Study Area
- Terrestrial Bird Regional Study Area

NOTES ᖃᐅᔨᒪᔭᒃᓴᐃᑦ

The following shapefiles are provided courtesy of Canadian Wildlife Service (CWS): Key Terrestrial Sites, Key Marine Areas, National Wildlife Areas and Migratory Bird Sanctuaries.

Important Bird Areas (IBA) data were provided by Bird Studies Canada (November 2011).

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Baffinland Iron Mines Corporation

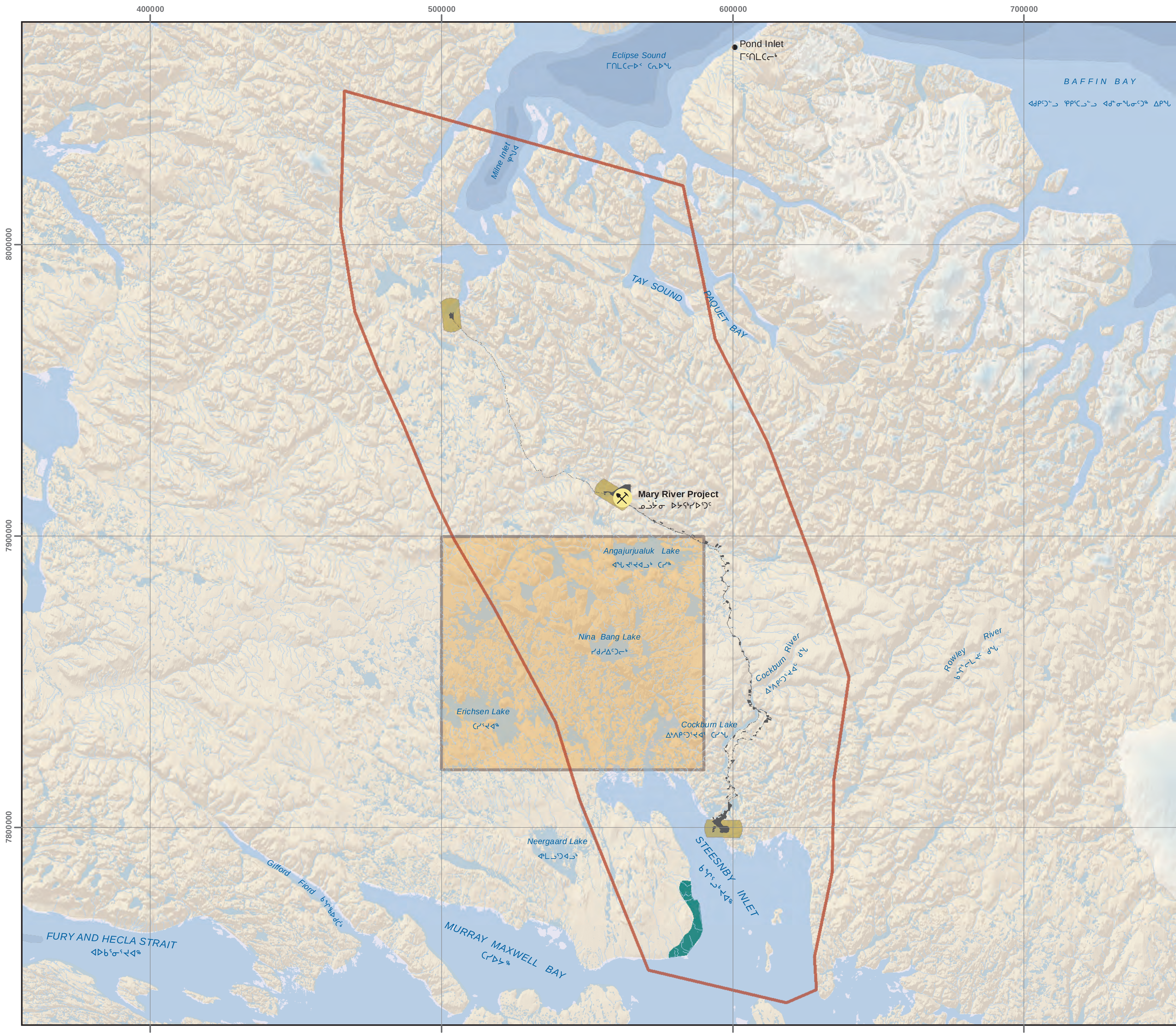
Mary River Project
Conservation Areas, Important Bird Areas (IBAs) & Key Habitat Sites

EDI

Date: 1/9/2012

ᑎᑎᖅᐅᔭᑦᓯᒪᔪᖅFIGURE 6-4.6

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_4_6_KeyHabSites_IBAs.mxd



LEGEND

- Mary River Project
- Potential Development Area
- Terrestrial Regional Study Area
- Airstrip Zone of Influence
- Snow Goose Colony
- Proposed Management Area (Environment Canada)

NOTES

The proposed Special Management Area was digitized by EDI using study area description by Canadian Wildlife Service (CWS), Reed et al 1993.

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 5 10 20 30 40 50 Km

Baffinland Iron Mines Corporation

**Mary River Project:
Airstrip Zone of Influence with Snow Goose Breeding Colony & Moulting Area**

EDI

Date: 1/9/2012

FIGURE 6-4.7

Path: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_4_7_SNGO_BirdZOI.mxd

4.13 IMPACT STATEMENTS

Project-related activities could potentially alter bird behavior and cause displacement during all three phases but will be confined to the Project footprint, relatively small in relation to the availability of suitable habitat nearby. Densities of bird KIs are expected to decline within the footprint, and possibly within adjacent zones of influence. However, these changes are expected to be a result of displacement out of the affected areas and not a result of mortalities to the birds or their offspring. Because of the vast amount of available suitable habitat nearby, the overall effect of the Project to the KIs specifically, and to all bird species in general, is expected to be minimal.

In summary, the residual effects of Project activities on bird KIs include habitat changes such as localized direct habitat loss and chronic disturbance; however, overall effects are not likely to have serious implications for any species' regional populations. Species abundance and habitat use will almost certainly be altered within the port footprints, and to some extent within a certain zone of influence around them as some individuals are forced out to less-disturbed neighboring areas. Mitigation measures will need to be used to ensure that birds are not directly affected by accidents, collisions, increased harvesting, or exposure to contaminants as a result of the Project. An environmental effects monitoring plan to assess the accuracy of effects predictions and the effectiveness of proposed mitigation plans is described in Appendix 10D-11.

4.13.1 Peregrine Falcon

The Project will have a not significant residual effect on Peregrine Falcon population dynamics and habitat. Although minor changes in falcon density may occur within the Project footprint as birds move to less disturbed habitat nearby, the overall effect on these birds is expected to be minimal. No cumulative effects are expected.

4.13.2 Snow Goose

The Project will have a not significant residual effect on Snow Goose population dynamics and habitat. Although minor changes in goose densities may occur within the Project footprint as birds move to less disturbed habitat nearby, the overall effect on these birds is expected to be minimal. No cumulative effects are expected.

4.13.3 Common and King Eider

The Project will have a not significant residual effect on Common and King Eider population dynamics and habitat. Although minor changes in Eider population densities may occur within the Project footprint as birds move to less disturbed habitat nearby, the overall effect on these birds is expected to be minimal. No cumulative effects are expected.

4.13.4 Red-throated Loon

The Project will have a not significant residual effect on Red-throated Loon population dynamics and habitat. Although minor changes in loon population densities may occur within the Project footprint as birds move to less disturbed habitat nearby, the overall effect on these birds is expected to be minimal. No cumulative effects are expected.

4.13.5 Thick-billed Murres

The Project will have a not significant residual effect on Thick-billed Murres. Their migration appears to occur fairly rapidly, and expected encounters along the shipping corridor should be infrequent. The ore carriers will comply with the Canada Shipping Act, and therefore, there is a high probability that the chronic release of contaminants in their migrating and foraging habitat will not occur. There is a very low probability of a catastrophic event resulting in the release of contaminants that will harm a population of Thick-billed Murres.

4.13.6 Lapland Longspur

The Project will have a not significant residual effect on Lapland Longspur populations and habitats. Minor changes in bird densities may occur within the Project footprint as birds move to less disturbed habitat nearby, however, the overall effect on these birds is expected to be minimal. No cumulative effects are expected.

4.14 AUTHORS

This report was prepared by Anne MacLeod (EDI Environmental Dynamics Inc.) with contributions from Kelsey Russell and mapping by Matthew Power (EDI Environmental Dynamics Inc.). It was based on an earlier version by Dr. Matthew Evans (AMEC Earth and Environmental) with contributions from Richard Cook (Knight Piésold). Final technical editing was completed by Michael Setterington (EDI Environmental Dynamics Inc.).

SECTION 5.0 - TERRESTRIAL WILDLIFE AND HABITAT

Terrestrial wildlife on north Baffin Island, described in the terrestrial wildlife baseline report (Appendix 6F), includes caribou, wolves, foxes, Arctic hares, ermine, and small mammals. Terrestrial wildlife, caribou in particular, are an important part of the Inuit culture and are an important component of a subsistence lifestyle. Occurrence of most wildlife species on north Baffin Island is relatively sparse. Regardless of current numbers, the proposed Project could potentially affect wildlife by removing habitat within the project footprint, increasing the degree of sensory disturbances such as that created by noise and traffic, possibly changing movement patterns of some caribou as they perceive physical and sensory barriers to movement, and possibly reducing the health of local animals. This section of the EIS assesses the degree of those potential effects on the key terrestrial wildlife species (to both humans and within the broader ecology) — caribou.

North Baffin Island caribou currently occur at low densities and their abundance seems to be cyclical — harvest data and Inuit Qaujimajatuqangit (IQ) suggests that there is roughly a 70-year cycle of abundance. The cyclical pattern of caribou abundance is similar to patterns described on Greenland and south Baffin Island. The cause of these changes in abundance is currently unknown. The last period of caribou abundance in the RSA was approximately from 1980 to 2000. Caribou numbers are expected to gradually increase in the Project area, but may not recover to a historical high until the 2050s. There is evidence that, although in low density, caribou occur throughout the entire region and therefore use most of the area as some form of habitat. The most used habitat is in the southern and central portion of the Regional Study Area (RSA), as indicated by caribou sign (bones, antlers, tracks and trails), IQ and recent collar data. Analyses of habitat use show a greater probability of caribou occurrence for some habitats during the calving, growing and winter seasons, but the probability of occurrence of caribou is relatively equal in many areas throughout the Project area.

Wolves and foxes are the dominant carnivores in the study area and exist at low densities. Limited information was collected on carnivores because they were so rarely observed. Carnivores are discussed as issues of note.

5.1 ISSUES SCOPING

Baffinland conducted a number of public consultation meetings and personal interviews to receive information on baseline data and to scope potential issues of perceived project effects (Volume 2). The key issues that are addressed for the Project's effects on terrestrial wildlife were identified through several consultation processes that included the following elements:

- Community scoping meetings;
- Terrestrial wildlife focused working groups;
- An environmental assessment workshop with the Qikiqtani Inuit Association and their community representatives;
- Professional experience from other northern mining projects; and
- Guidance provided by the Nunavut Impact Review Board's (NIRB) project EIS guidelines.

The community comments, personal interviews and IQ were used in combination with the information gained from the above sources to develop the baseline report and formed the basis of this assessment. The interpretation of knowledge about specific issues and project interactions with terrestrial wildlife as it relates to the process used to predict effects and determine their significance are described below.

Terrestrial wildlife Valued Ecosystem Components (VECs) were identified based on ecological and social importance and relevance to the potential interactions with the Project. Caribou were consistently identified as an important species to the communities. They are abundant during population cycle highs and may interact with the proposed Project. When present, caribou are harvested and consumed by local people and hunters from communities surrounding the Project. Harvest records back to the 1920s indicate that caribou certainly remain a key component of Inuit diet and culture. Caribou also appear to be a keystone species in the north Baffin Island ecosystem as the abundance of many other animals, particularly carnivores, seem to be related to their abundance and distribution. Additionally, many studies have been conducted on caribou responses to industrial activities throughout the species range. For these reasons, caribou were identified as a VEC and are in part representative of a north Baffin Island terrestrial wildlife response to the Project.

Baffinland conducted a number of workshops, interviews, radio call-in shows and written requests to collect baseline information and determine public perceptions and concerns with the project's interaction with terrestrial wildlife (Volume 2). Concerns were varied, but generally focused on the project's potential to affect caribou behaviour, movement patterns, and the potential for increased mortality.

> "*Helicopters are a mean machine to a caribou. We have seen this in Igloolik and Hall Beach. In an area where we go caribou hunting, the helicopters scared them away*." Louis, Arctic Bay

> "*When helicopters fly around Hall Beach, the caribou scatter. Last summer, there were not too many helicopters and the caribou seemed to be happier. Because of this there are more of them now.*" Percy, Arctic Bay

> "*With the helicopter study, I have seen helicopters scare caribou when I have been out hunting by ATV.*" Public comment, Arctic Bay

> "*Will the company get fined if the train kills caribou? I get fined if I kill a caribou and leave the carcass on the land. Will we be compensated?*" Arctic Bay

> "*Based on my understanding of train speed and weight, it would be impossible to stop. My question is, will there be a spotter up front, or something to chase caribou away, or will we be compensated for dead and dying caribou* [those hit by the train]*?*" James, Pond Inlet

> "*Will I be compensated if I can't catch caribou anymore?*" Radio question, Pond Inlet

> "*The company should be prepared to take us caribou hunting if they disrupt them* [caribou]*.*" Arctic Bay

> "*So, if a train doesn't notice if it hits an animal, what would you do about it? I think the train driver should be taken to court.*" Pond Inlet

> "*Back to transportation, I am concerned about the rail line on an embankment, and wonder if the rail line will prevent the caribou from migrating through. I think the caribou might turn around. Will the embankment prevent the caribou from crossing over?*" Koonoo, Arctic Bay

> "*Caribou follow their food. In winter, they change their location; they do not stay in one area. The railway will not hinder the caribou unless there is a fence. You need to know this. If you tell us there are no caribou at Mary River now, we will tell you that there will be at some time in the future.*" Percy, Arctic Bay

"*When caribou are in a herd, they are not afraid of people, skidoos or even helicopters. Now, they are scattered in smaller populations. Now, they are afraid of any people. The rail line might frighten them if they are in smaller groups. I have even seen caribou in smaller groups that seem afraid to cross a skidoo track. Maybe it's the smell or the noise? But, bigger herds are not afraid to cross track, and I don't think they will be afraid of the rail line. When they are afraid, they tend to run towards the mountain tops. I want you to be aware of our experience.*" Koonoo, Arctic Bay

"*I think the route being proposed will happen no matter what, and maybe we can use it to travel on as well. When the train is operating, I am concerned that animals will be hit by the train. The train can't stop and caribou are stubborn, so they won't stop. This will be a problem.*" Samuelie, Pond Inlet

"*Caribou are important for north Baffin communities. We thought the railway was going to block the caribou. But now we are hearing that the railway might be the best option for the environment. If they use trucks, there would be constant traffic and dust, so I believe the train is the best option to haul material.*" Arctic Bay

At the caribou focus working group meetings in Arctic Bay, Baffinland summarized some of the key current concerns about exploration activities, key notes on caribou behaviour as it may relate to assessment and mitigation, and concerns about the potential effect of a railway on migrating caribou. Some of the key summary notes included the following:

- The number one concern is that helicopters scare caribou and they never get used to it.
- Let the first animals (the leaders) pass. Avoid scaring lead caribou during surveys and transportation of ore.
- When caribou decide to move, nothing will stop them - including trains.
- Large caribou movements on north Baffin Island are east/west.
- Females are more sensitive than males; smaller groups are more sensitive than larger groups.
- Cows and calves will stay in the high grounds/mountains.
- Caribou move - they will come back to the area.
- Look at the tracks on the land to see how they move.
- Don't know what a caribou will look like after it's been hit by a train.
- Communication back to the communities - how will Baffinland communicate?

While preparing the EIS guidelines for the Mary River project, the Nunavut Impact Review Board (NIRB) also conducted a number of additional community meetings to scope key issues to be considered in the assessment of the Project. The NIRB guidelines generally seem to reflect many of the concerns identified during Baffinland's consultations where there are concerns about disturbance to caribou behaviour and movement, and a desire to predict the overall effects on animal health and distribution. The NIRB guidelines related to terrestrial wildlife effects (8.1.10.2) are summarized below:

i) *Potential general impacts on terrestrial wildlife in the LSA* [Local Study Area]*, including: interference with migratory routes; alienation from important habitat (e.g., denning sites, calving and post-calving areas); and general disturbance or disruption caused by Project activities.*

ii) Potential impacts on population size, abundance, distribution and behaviour of wildlife VECs from:

a) Direct and indirect loss of habitat from the presence of and use of infrastructure, the conduct of project activities and associated sensory disturbances;

b) Direct and indirect impacts from potential degraded water quality and ground contamination, as well as airborne contaminants resulting from project facilities and associated activities;

c) Direct and indirect impact from dust fall and accumulation on forage resulting from anthropogenic sources, and natural sources influenced by anthropogenic activities;

d) Direct and indirect impacts from ice-breaking associated with shipping and ice management at seaport (with special attention to caribou migration, if applicable).

iii) Potential impacts on wildlife from ground traffic and air traffic disturbance, particularly low level flights (i.e., lower than 610 metres) during critical periods (caribou calving and post-calving). For this impact assessment, a delineated Flight Impact Zone could be useful in determining the potential impact of flights on wildlife, with a particular focus on critical life cycle periods and planned air traffic volume and routes.

iv) Potential impacts on wildlife from injury or mortality caused by Project activities, particularly the use of the Milne Inlet tote Road, railway line, mine hauling roads and other access roads, as well as intentional killing of wildlife to defend human life or property by mine personnel.

v) Potential impacts on wildlife from increased hunting pressure resulting from improved access due to Project infrastructure.

vi) Potential impacts of noise and vibration on wildlife from drilling, blasting and other activities as results of Project construction and operation. In particular, consideration should be given to potential impacts on caribou and other wildlife VECs from frequent noise and vibration associated with railway operations, with a focus on disturbance/disruption to caribou calving and migration.

vi) Assessment of the potential for Project activities to act as an attractant to wildlife species, and associated effect/changes to behaviour and condition.

vii) Evaluation of the potential for contaminants to be released to the environment as a result of the Project and be taken up by VEC species.

5.2 CARIBOU

Construction, operation and closure activities have the potential to effect distribution and abundance of wildlife VECs in the RSA. The key indicator of the Project's effects on the VEC "Terrestrial Wildlife" is caribou. Four measurable parameters that allow us to predict the effects of the project on caribou are habitat, movement, mortality and health. A review of the potential interaction of the project with the four measurable parameters is described below. The Project's potential effect on caribou health with respect to metals deposited on soils is assessed in Appendix 6G-2; however, a summary is provided within each of the following sections. The residual project effects, those effects that remain after implementation of mitigations, are incorporated into an energetics model that estimates the overall Project effects on caribou productivity using various impact scenarios (Appendix 6H). The models results are conservative estimates of overall Project effects as each model scenario assumes the worst case for each potential impact.

Habitat

Habitat can be affected through direct loss within the footprint of the project that is either temporary or permanent, or through indirect loss from project activities that create sensory disturbances and temporarily reduce the effectiveness (usefulness) of adjacent habitats.

Loss of caribou foraging habitat will occur because of the infrastructure footprint, or PDA. The presence of infrastructure is considered a negative effect on caribou as they have been reported to generally avoid infrastructure. The responses were sex-specific during spring and summer, and females showed a greater response to human infrastructure (Whitten and Cameron, 1983; Dau and Cameron, 1986). Alternatively, caribou have also been reported using industrial infrastructure (e.g., well pads, roads) in northern Alaska as features that allow them to get relief from insect harassment (Vistnes and Nellemann, 2007). Direct loss of habitat is readily assessed by determining the spatial extent of the project footprint, and the methods used to define both are described below.

Indirect or functional loss of habitat includes reduction of habitat effectiveness due to project activities. Sensory disturbances can result in behavioural responses such as flight responses or avoidance of particularly disturbing areas. These behavioural responses can ultimately affect the energetic benefits of particular habitats. Sensory disturbances associated with the project can be categorized by the senses they stimulate: sight (vision), hearing (audition), smell (olfaction), touch (tactition) and taste (gustation). Human caused visual stimuli that cause behavioural responses can include pedestrians, off-road vehicles, automobiles, trains, aircraft and ships travelling across a landscape/seascape. Aural stimuli include noises associated with motors, generators, automobiles, aircraft, blasting, etc. Olfactory stimuli include scents associated with human presence (cooking), motors (exhaust) or dust. Tactile disturbances may be related to an animal's response to vibration. A taste response may be elicited by dust deposition on forage that affects palatability. A number of project activities can be associated with several sensory disturbances; for example, caribou could see, smell, hear and feel blasting around the mine and a resulting behaviour could be to avoid some areas of otherwise useable habitat.

The effectiveness of habitat is reduced in proximity to developments even if the habitat is unaltered, and the extent of that effect can sometimes be at the scale of kilometres (Wolfe *et al*. 2000; Mayor *et al*. 2009). The variability of the ecosystems caribou have adapted to means that precise and accurate predictions of how caribou respond to specific human developments within their range are difficult to estimate because behavioural responses can be regionally specific. Recent advances in the application of analytical techniques to caribou collar data have provided further insight into an understanding of which habitat features caribou select and how caribou perceive their environment. Woodland caribou have been reported responding to human caused changes in habitat at distances up to 15 km (Mayor *et al*. 2009).

Sensory disturbances are the ultimate cause that explains why caribou may avoid areas closer to disturbing stimuli (Stankowich, 2008). For caribou, visual stimuli, as opposed to aural stimuli, cause a greater change in activity, possibly because caribou tend to live in windy and, therefore, noisy environments. Olfactory and taste stimuli have not been studied, but anecdotal information suggests that smell can elicit a flight response in the absence of visual or aural stimuli. The Reimers and Colman (2006) literature review of caribou response to human activities concluded:

- Cows and calves are more sensitive to disturbances than bulls.
- Humans moving on foot elicit a greater response than moving vehicles. The assumption is that the response has a genetic basis as caribou evolved with humans, and human sized animals as a predator. Habituation is possible.
- Off-road vehicles (ORVs) can cause increased flight responses if caribou are hunted from the machines. If the ORVs are seen frequently and consistently by caribou along fixed and predictable trails, caribou are able to habituate to the activity.
- Traffic activity along the transportation corridor causes the disturbance, not the infrastructure itself.
- Some degree of habituation to traffic is possible if it is not associated with direct mortality or other disturbances (e.g., harassment by humans or dogs).
- Responses to aircraft disturbance are variable. Caribou show no change in behaviour when aircraft travel at high altitudes (>900 m agl); however, studies of caribou responses to aircraft and helicopters at low altitudes have reported variable results. Multiple studies of fighter jets flying 30 m to 610 m above ground in caribou range resulted in small short-term changes in caribou behaviour. Caribou during calving and immediately post-calving seem to be the most sensitive to aerial disturbances.

Numerous studies have reported the effects of industrial activity on migratory caribou range use. Most studies describe the presence/absence and abundance of caribou with distance from industrial infrastructure (e.g., pipelines, power lines, roadways, mine sites, drilling sites). Other studies rely on observations of caribou behaviour during disturbances, either controlled or uncontrolled. The conclusions from the studies are varied, and the differences are likely due to factors which are herd or even location specific. Consequently, while using general study results to predict effects of new disturbances on other caribou herds is possible, the ecosystem the caribou herds have adapted within are unique among herds so the predictive power may be limited (Klein, 2000).

Caribou distribution in relation to oil and gas development within calving grounds in northern Alaska is the most well studied industrial interaction between caribou and humans. Caribou habitat use around oil field developments during calving and post-calving suggests that there is a reduction in habitat use (measured as number of animals observed) within 1 km of industrial developments (Cameron *et al.*, 1992) and the reduction might continue up to a distance of 4 km (Cameron *et al*. 2005). Decreases in caribou abundance near industrial developments are correlated with increases in habitat use beyond 4 km (Cameron *et al*. 2005; Joly *et al*. 2006; Vistnes *et al*., 2008).

Although the overall caribou responses to human activity along roads in previous studies are negative, caribou may seasonally choose to be near roads. First, caribou may select gravel roads as an important feature during times of high insect abundance because a road tends to be elevated and exposed to greater wind speed, thus reducing insect harassment (Hanson, 1981). Second, a ‘dust shadow’ effect was observed along roads in oilfield development areas of Alaska (Cronin *et al*. 1994, cited in Klein, 2000). Increased dust levels from vehicle traffic may result in earlier snowmelt and growth of vegetation in spring, facilitating access to higher quality vegetation prior to parturition; conversely, intense dust deposition can change the vegetation cover and reduce overall availability to forage (Klein, 2000), or a change in palatability (taste).

Dust from mining activities could be the primary mechanism that reduces the abundance of caribou within the area around a mine site. At the EKATI™ mine in the Northwest Territories, monitoring showed that caribou were four times more likely to be found >14 km away from mine activities than adjacent to activities (Boulanger *et al*. 2009). The mechanism of the reduction at EKATI™ is unclear, but is probably a combination of dust deposition and other sensory disturbances. Dust will be produced from blasting, crushing and traffic, and while it is not expected to be toxic to animals, it will settle on vegetation and could make the vegetation less palatable. This would change habitat use by reducing habitat effectiveness within an area surrounding the mine and transportation facilities. Dust dispersion and its effects on forage palatability may also be a factor in determining a zone of influence of a mine.

Movement

Traditional movement patterns can be altered by project related infrastructure or activities that act as a barrier or filter (i.e., limiting some but not all) to movement.

Infrastructure could change, restrict or stop the movement of caribou. Barriers that limit or change caribou movement may cause changes in their distribution and abundance by limiting access to important parts of their traditional range. Changes to the traditional movement pattern of caribou could have unpredictable effects on a population. Effects are dependent on the scale of an animal's environment. For example, migratory caribou require access to distant ranges that are used for portions of their seasonal life cycles, including calving grounds, post calving range, rutting areas and winter range. Non-migratory caribou select habitat at a more local scale and the distance travelled between seasonal habitats is much smaller.

Point source disturbances that are discrete and separated by large distances (e.g., mine site and ports) are unlikely to cause changes to movement because caribou can use adjacent habitat to get to their target habitats. Linear infrastructure, however, could block movement or cause caribou to change routes. Ensuring the permeability of these linear disturbances is important for maintaining migratory routes when caribou return to the RSA.

During the construction phase it is expected that few caribou will occur within the RSA; currently, they are thought to be in the trough of a 70-year population cycle. The caribou that currently occupy the RSA are not migratory. The local caribou on average move less than 4 km per day during all seasons. There were very few focused directional movements and all movements were at the scale of tens of kilometres — most caribou remained within the areas they were collared.

In the long-term, the local caribou population is expected to return to highs observed during the 1980–2000 period, and migratory caribou will return to the region. If this is the case, abundance and density in the RSA will significantly increase and caribou will start to make the long distance movements observed during the last population high. According to IQ, and trail orientation and abundance, movement will predominantly be east-west and will occur within the southern half of the RSA.

Mortality

Caribou mortality may increase as a direct result of the project through collisions, or indirectly through increased harvesting access. Project related activities could directly cause wildlife mortality through collisions with vehicles (trains, planes, and automobiles) or through problem animal kills; and indirectly cause higher mortality through increased hunter harvest because of easier access into hunting areas or greater knowledge about caribou in the area. Increased mortality because of project infrastructure or activities would result in reduced caribou abundance in the RSA.

The abundance and density of caribou within the RSA is currently low, so any mortality could cause changes in the abundance of caribou that might be large relative to populations of animals in the RSA. Therefore, avoiding higher caribou mortality due to project related activities is important. Baffinland implemented a wildlife policy that resulted in no direct mortality of local caribou. Mine related activities will increase in the short-term and medium-term compared to current conditions. Closure activities will likely be less intense and even less of a mortality risk.

Health

Effluent, dust and air emissions released into the environment have the potential to be absorbed, ingested or inhaled by wildlife; this may have an effect on the health of individual animals and, consequently, on wildlife abundance. Emissions from diesel generators and other equipment, and dust along transportation corridors and near project facilities are the project's most likely contributors to contaminants within the RSA. The potential effect of dustfall on caribou health is assessed in Appendix 6G-2.

5.2.1 Assessment Methods

The assessment of the Project's effects on caribou was based on four measurable parameters: habitat, movement, mortality and health. Habitat and movement effects were predicted using a quantifiable procedure. Mortality and health effects were assessed qualitatively. Assessment methods are described for individual measurable parameters below.

The magnitudes of the effects were determined relative to the scale of occurrence within either the RSA or within the range of the north Baffin Island caribou herd. The RSA was identified to ensure that the range of direct and indirect potential disturbances as a result of the Project's activities could be examined and potential effects could be spatially quantified. The RSA was chosen to represent wildlife and habitat at an ecologically relevant scale and to reflect regional habitat use and seasonal movement patterns on north Baffin Island. The RSA also had to be a reasonable size so that surveys and information could be gathered in an economical fashion and provide information that is directly relevant to project management and mitigation. The 21,053 km² RSA was described in the terrestrial wildlife baseline report (Appendix 6F). The range of the north Baffin Island caribou herd encompasses an area from south of the Barnes Ice cap, extending north along the southern coast to the southern Brodeur Peninsula, and inland to east of Pond Inlet. Caribou are known to exist throughout this region, and effects on caribou as a result of the project are assessed within the entire range. The maximum extent of the north Baffin Island caribou range is estimated at 134,308 km² (Figure 6-5.1). Residual effects assessments and the overall effects summary are described in the context of the North Baffin herd — the caribou population that interacts with the Project.

Habitat

To assess the predicted effects of the Project on caribou habitat, studies were reviewed of the effects of industrial activities on the use of habitat by caribou. The findings of the review were used to predict changes in the probability of caribou using habitat within the RSA and as a range-wide comparison for the north Baffin Island caribou range. For comparisons within the RSA, changes to the resource selection probability function (RSPF) that was developed for the terrestrial wildlife baseline report (Appendix 6F) was used. The model was used to quantify the probability of caribou using habitats within the RSA during the winter and growing seasons. The model was used to predict the direct and indirect effects of mine activity on caribou habitat effectiveness. The RSPF did not include the northern one-fifth (~20 %) of the RSA because caribou were not collared nor moved into the area. For the purposes of this assessment the measurement of effects on habitat were limited to the extent of the RSPF analysis (16,664 km²) within the RSA.

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.......Mary River Project

.......Regional Study Area

Major Herd Distribution (Ferguson 1989)

North Baffin Island Caribou Herd

Data Sources:

Major Herd Distributions:
Ferguson, M. 1989. Baffin caribou. Pp. 142 in Hall, E. (ed). People and caribou in the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. Yellowknife, NT. 190 pp.

Scale 0 25 50 75 100 Km

Regional Study Area and Range of North Baffin Caribou Herd

07 December 2010

FIGURE 6-5.1

WHITEHORSE, YT SAVED: J:\Yukon\Projects\2010\10_YC_0025\Mapping\Fig6_5_1_RSAandCaribouRange.mxd

Direct habitat effects were quantified by assuming that the habitat within the footprint of the mine will become unavailable to caribou (i.e., the probability of finding caribou within the PDA are reduced to 0). Indirect effects were more difficult to predict because the zone of influence (ZOI) from the project infrastructure and activities is often specific to the type of activity (e.g., oil and gas compared to mining) and location of the activity (e.g., forest compared to tundra).

The ZOI for the tote road, rail and port sites were determined to be smaller than the ZOI of the Mine Site. The reason for the difference is a recent article that documents a 14 km ZOI around the EKATI™ and Diavik mine sites in the Northwest Territories (Boulanger *et al*., 2009). The authors suspect that one of the main mechanisms causing the observed ZOI is dust deposition. Dust may be generated from mining activity at the Mine Site; however, the train will not generate significant dust and the port facility will generate minimal dust. Transport of equipment from Milne Inlet port along on tote road will produce dust, but the road will mostly be used during construction, and only intermittently during operation. Consequently, dust generation along the road will be reduced compared to the mine site. Therefore, the mechanism reducing caribou use around the Railway, tote road, and ports sites will be sensory disturbance from human activities as opposed to dust. Reduced caribou use of areas near industrial sites from has generally been documented at distances ranging from 1-4 km (Table 6-5.1).

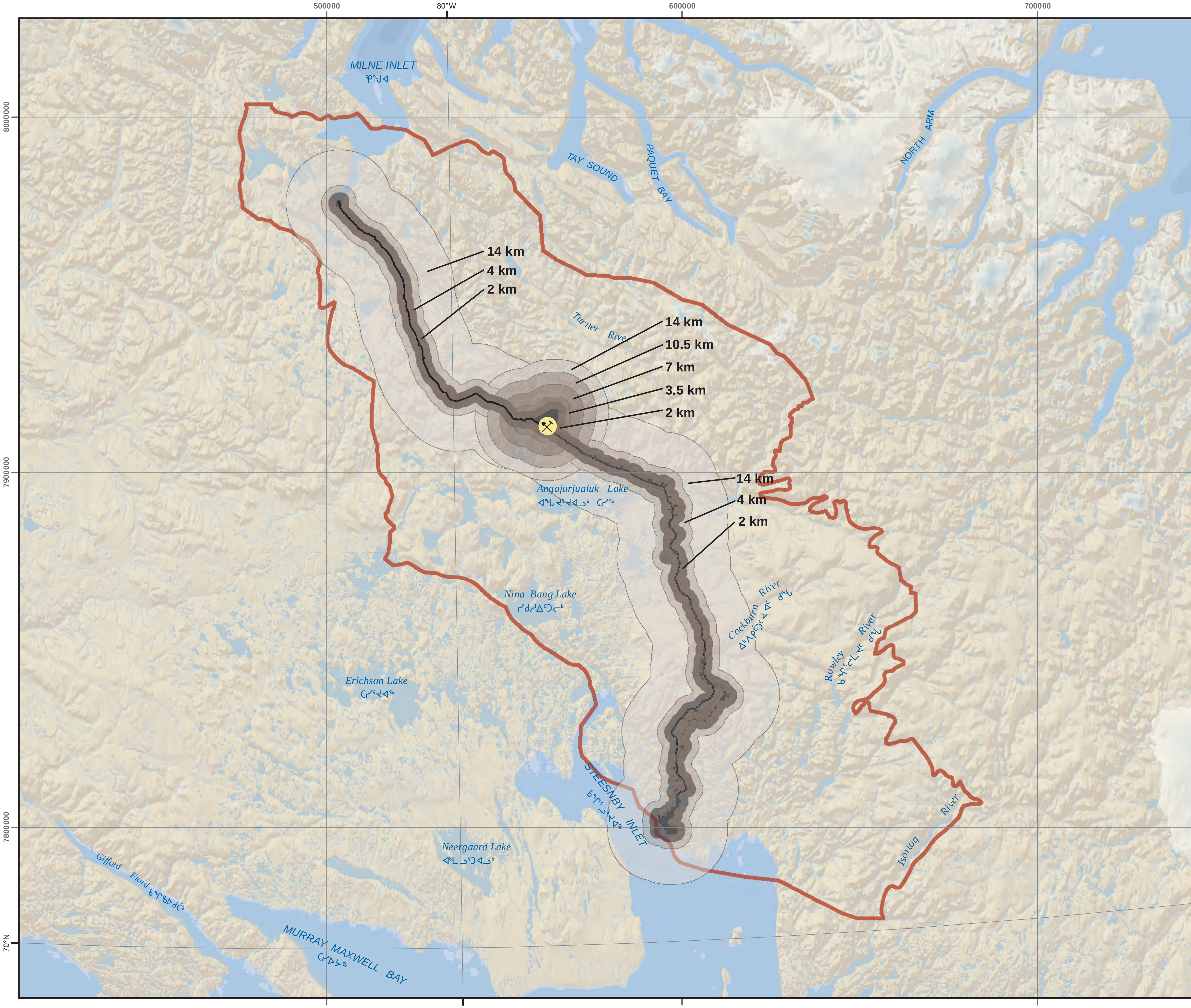
Predicted indirect habitat effects using the RSPF habitat model were qualified by reducing the probability of observing caribou within each of the pixels. Indirect effects of the Mine Site were predicted by multiplying RSPF values within 0–3.5 km, 3.5–7.0 km, 7.0–10.5 km, and 10.5–14 km by 0.30, 0.40, 0.60, and 0.80, respectively (Table 6-5.1). Indirect effects of the tote road, Railway, and Milne and Steensby Ports were predicted by multiplying RSPF values within 0–2 km, 2–4 km, and 4–14 km from the PDA by 0.25, 0.75, and 0.90, respectively (Table 6-5.1, Figure 6-5.2). The RSPF values beyond 14 km of the PDA were assumed to be unaffected, so RSPF values remained unchanged. The combined area of the ZOI (including waterbodies) of the project is 7,696 km² (37 % of the 21,053 km2 RSA, and 5.7 % of the 134,308 km² north Baffin Island caribou range).

To determine the magnitude of effect, summed RSPF values within the RSA pre-disturbance and post-disturbance were compared. The overall magnitude of effect was determined at the scale of the north Baffin Island caribou range - calculated as a scaled proportion of the effects within the RSA (i.e., % difference in values in RSA multiplied by the proportional representation of the RSA to the total north Baffin Island caribou range).

Cows and calves during and after the calving period are most sensitive to human disturbances. Collared North Baffin cow caribou show high fidelity to calving sites (Appendix 6F). The effect of the Project on calving caribou is assessed by determining the proportion of collared cows that calved in the ZOI and, therefore, would potentially be affected by disturbance associated with the Mine. Collared caribou are assumed to be representative of the North Baffin caribou; therefore, the proportion of known calving sites within and outside the ZOI is representative of North Baffin caribou.

Table 6-5.1 Summary of the Factor used to Reduce RSPF Values and Calving Site Effectiveness with Distances from the Project

Project Area	Zone of Influence (ZOI)	Habitat Selection Multiplier	Subspecies or Herd	Source of Information	Calving Site Multiplier
All	PDA	0.00	na	na	0.00
Steensby Port, Milne Port, Railway	>PDA–2.0 km	0.25	Central Arctic herd (Alaska), woodland (Alberta)	Cameron et al. 1992, Dyer *et al.* 2001	0.125
	>2.0–4.0 km	0.75	Woodland (Newfoundland), central Arctic herd, reindeer (Norway)	Weir *et al.* 2007, Cameron *et al.* 2005, Vistnes *et al.,* 2001	0.375
	>4.0–14.0 km	0.90	Woodland (Ontario)	Vors *et al.* 2007, mayor *et al.* 2007, 2009	0.45
Milne Inlet Tote Road, Mine Site	>PDA–3.5 km	0.30	Bathurst herd	Boulanger *et al.* 2009	0.15
	>3.5–7.0 km	0.40	Bathurst herd	Boulanger *et al.* 2009	0.2
	>7.0–10.5 km	0.60	Bathurst herd	Boulanger *et al.* 2009	0.3
	>10.5–14 km	0.80	Bathurst herd	Boulanger *et al.* 2009	0.4
All	>14.0 km	1.00	na	Vors *et al.* 2007, Mayor *et al.* 2007, 2009, Boulanger *et al.* 2009	1.00



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Mary River Project Study Specifics

Mary River Project

Regional Study Area

Potential Development Area

Potential Disturbance Area (multiplier)

0.25
0.30
0.40
0.60
0.75
0.80
0.90

NOTES:

Proposed Rail Alignment provided by Canarail January 2010.

Projection: North American Datum 1983 UTM Zone 17N

Scale 0 10 20 30 40 50 Km

Baffinland Iron Mines Corporation

The Zones of Influence of the Project on Caribou Habitat.

EDI ENVIRONMENTAL DYNAMICS INC.

07 December 2010

FIGURE 6-5.2

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Movement

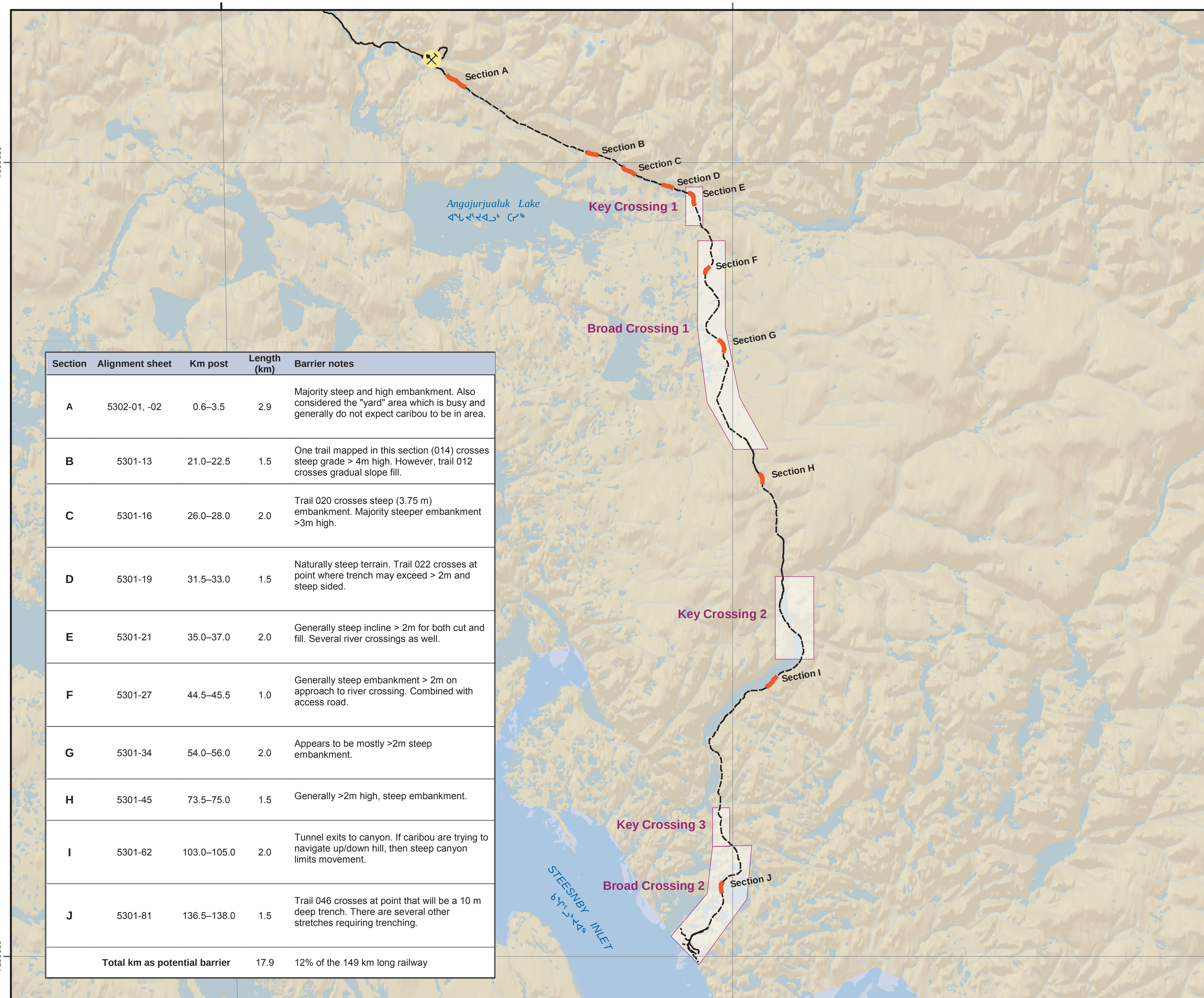
The effect of mining infrastructure, the Railway, the Milne Inlet Tote Road, and ore shipping during the ice season on caribou movement was qualitatively assessed through information from a literature search, professional opinion, or self-evident effects.

The effects of the Railway at broad and fine scales, and specifically within three key and two broad crossing areas identified by IQ surveys and preliminary aerial surveys of the rail route that was used to locate caribou trails (Figure 6-5.3) were qualitatively and quantitatively assessed. The broad scale assessment was conducted by visually inspecting each of the Railway alignment map sheets while looking for specific attributes that could cause reduced movement of caribou. The fine scale assessment involved mapping 52 trails located during the 2010 ground surveys, mapping them on individual rail alignment sheets (illustrating embankment and other engineering details) and determining if caribou travelling along those trails could experience a physical barrier to movement. The three key and two broad crossing areas were evaluated individually for potential barriers to movement within the area as a whole.

The criteria used to predict whether the Railway infrastructure could be a physical barrier included a combination of professional opinion and a relative assessment based on surrounding landscapes in the RSA. Conservative criteria for identifying areas that could be barriers to caribou movement were developed. Four types of infrastructure are associated with the Railway: cuts, fills, tunnels, and bridges. It is assumed that caribou will easily pass over tunnels and under bridges. It is assumed that cuts (embankment below grade) and fills (embankment above grade) will act as similar barriers. The characteristics of the cuts and fills will determine the permeability of the Railway for caribou. Based on professional opinion it was determined that steep and tall embankments will act as the greatest barrier to caribou movement. Criteria for determining if a segment of rail will be a barrier to caribou movement was to visually estimate cuts or fills that have embankments slope ratios that are greater than 1 in 2 (e.g., 1:2, 50 %, 26.6° slope) and the height or depth of the embankment is greater than 2 m (Flowchart 1). Two metres was chosen as a reasonable height, slightly higher than caribou, which stand about 1.5 m at full alert. Lower embankments would encourage animals to cross the track for forage. The Railway alignment was stratified into 4 km segments because that was approximately the average distance travelled by caribou in one day — determined by the caribou collar data (see the terrestrial wildlife baseline report in Appendix 6F).

In order to assess Project effects on caribou movement, assumptions related to movement are as follows:

- The Railway will act as a partial barrier or filter to caribou during train set passes, and where embankments have been identified as potential barriers.
- North Baffin caribou will not use the rail line as a travel corridor during winter, largely due to the nature of the surrounding landscape (thin, hard-packed, wind-swept snow cover that does not greatly impede movement).
- The permeability of the RSA will not be significantly impacted by the Railway if a number of crossing sites are maintained along the Railway infrastructure and adaptive management of other crossing areas is employed.
- The accessibility of the RSA will not change, as crossing sites and Railway embankment design will provide adequate accessibility to either side of the Railway.



Section	Alignment sheet	Km post	Length (km)	Barrier notes
A	5302-01, -02	0.6–3.5	2.9	Majority steep and high embankment. Also considered the "yard" area which is busy and generally do not expect caribou to be in area.
B	5301-13	21.0–22.5	1.5	One trail mapped in this section (014) crosses steep grade > 4m high. However, trail 012 crosses gradual slope fill.
C	5301-16	26.0–28.0	2.0	Trail 020 crosses steep (3.75 m) embankment. Majority steeper embankment >3m high.
D	5301-19	31.5–33.0	1.5	Naturally steep terrain. Trail 022 crosses at point where trench may exceed > 2m and steep sided.
E	5301-21	35.0–37.0	2.0	Generally steep incline > 2m for both cut and fill. Several river crossings as well.
F	5301-27	44.5–45.5	1.0	Generally steep embankment > 2m on approach to river crossing. Combined with access road.
G	5301-34	54.0–56.0	2.0	Appears to be mostly >2m steep embankment.
H	5301-45	73.5–75.0	1.5	Generally >2m high, steep embankment.
I	5301-62	103.0–105.0	2.0	Tunnel exits to canyon. If caribou are trying to navigate up/down hill, then steep canyon limits movement.
J	5301-81	136.5–138.0	1.5	Trail 046 crosses at point that will be a 10 m deep trench. There are several other stretches requiring trenching.
	Total km as potential barrier		17.9	12% of the 149 km long railway

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Mary River Project Study Specifics

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.......Proposed Rail Alignment ᓄᓇᓯᐅᑎᑯᑕᒃ ᐊᕐᑯᑎᒋᓂᐊᕐᑕᖓ
.......Milne Inlet Tote Road ᕿᖑᐊᓂ ᐊᕐᖁᑎ ᐅᓯᒃᑲᕐᑕᕕᒃ
.......Key caribou movement area along railway alignment
.......Potential caribou barrier section along railway alignment

NOTES: ᖃᐅᔨᒪᔭᖅᐃᑦ

Proposed Rail Alignment provided by Canarail January 2010.

Projection: North American Datum 1983 UTM Zone 17N

Scale 0 5 10 15 20 Km

Baffinland Iron Mines Corporation

Key Caribou Movements from IQ and Aerial Surveys

EDI Environmental Dynamics Inc.

07 December 2010

ᑎᑎᕋᐅᔭᕐᓯᒪᔪᖅ FIGURE 6-5.3

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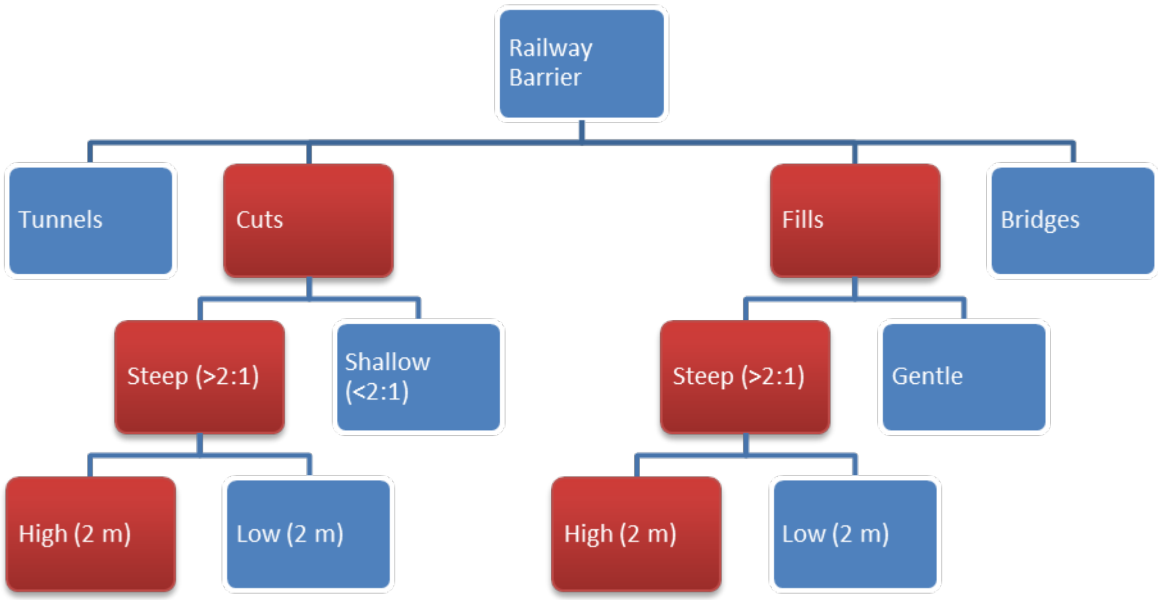

Flowchart 1. Flow chart for determining the potential of the Railway embankment as a physical barrier to caribou movement.

NOTE(S):

1. RED BOXES (STEEP AND HIGH) REPRESENT A BARRIER TO MOVEMENT.

Mortality

The Project's effect on caribou direct mortality was assessed as the probability of increased risk of activities killing caribou: collisions with caribou on the Milne Inlet Tote Road and Railway, and the potential interaction with project infrastructure (e.g., falling into an open pit). The assessment is considered within the framework of Baffinland's wildlife policy of wildlife having the right-of-way for travel and a no-hunting policy for on-site staff.

The Project's effect on caribou indirect mortality was assessed as the potential for increased harvest of the regional caribou herd through increased access (e.g., roads and accommodation) and improved knowledge of the region that could increase harvester success.

Health

The Project's effects on caribou health are considered as it relates to potential contamination of forage as a result of dust and emissions from the project. The potential effect of sensory disturbances on caribou health (e.g., noise) is accommodated within the assessment of habitat effectiveness as noted above (e.g., caribou avoiding suitable habitat and resulting negative effects on health from reduced foraging).

The potential for dust containing metals to settle on forage to the point where that forage may become unhealthy for caribou is assessed in Appendix 6G-2. The report includes an evaluation of the potential for exposure to ore dust to affect caribou health. An assessment of the potential effects of increased metals in caribou meat as a result of Project related deposition of metals which in turn could affect the health of humans in assessed in Appendix 6G-1.

To assess the caribou exposure to metals in forage relative to the ZOI, caribou collar data collected from 2008–2011 (assumed to be representative of the current habitat use of north Baffin caribou), was used to examine the percent of the home range area that intersects with the ZOI. Some caribou are expected to be exposed to dustfall within the Mine Site and Steensby Port ZOIs. To make a conservative estimate of caribou exposure to metals, it was assumed the distribution of north Baffin caribou will not change. Using minimum convex polygons, caribou home range polygons were generated and those that intersected the Mine Site or Steensby Port ZOI were selected for further analysis. Percent of each caribou's home range that was within the ZOI was further defined by a threshold of annual dust deposition (TSP). Home range area (km^2) within a TSP threshold (low, moderate, high) was calculated, along with the area that lay within the ZOI (i.e., beyond a detectable threshold TSP level).

Overall Project Effect

A caribou energetics model was used to assess the overall effect of the Project on caribou under different impact scenarios (Appendix 6H). The model assessed potential Project effects of the current population of caribou in the area, as well as Project effects on a future caribou population that is expected to grow, expand range use, and begin to re-use existing trail systems.

The Energy-Protein Model simulated food intake based on the seasonal quantity and quality of forage available, followed energy and protein kinetics through the rumen, and allocated the resultant metabolizable energy intake and metabolizable nitrogen intake into maintenance, activity, growth, lactation, and gestation. The model did not assess the role of climate in exacerbating or ameliorating the projected impacts of devleopment.

Model inputs were obtained to best reflect the conditions in the north Baffin region. Distribution of cover types were compiled separately for the north Baffin caribou range, the Regional Study Area (RSA), and the Zone of Influence (ZOI). Five scenarios were developed to be tested in the model. All five scenarios are considered conservative predictions of potential Project effects. The scenarios are as follows:

Scenario 1. The baseline condition, with no development but with an expanding and thus increasingly dense caribou population.

Scenario 2. The impact of caribou abandoning the ZOI completely. The negative effect of caribou abandoning the ZOI was an increased density on the rest of the range, thus reducing the effective biomass per individual.

Scenario 3. The impact of the potential for caribou to be unable to cross the Railway in key places, thus abandoning a portion of the RSA over and above the ZOI. In this scenario it is assumed that caribou would abandon 35 % of the RSA, which includes all of the ZOI (representing about 25 % of the RSA) and an additional 25 % of the RSA north and west of the development. The same source of impact was modeled: increased density outside the abandoned zone with a proportional decrease in biomass per individual.

Scenario 4. The same as Scenario 3, except it is assumed caribou would abandon the entire RSA north and west of the infrastructure, including the ZOI on the south and east side of the Mine and Railway (65 % of the RSA).

Scenario 5. The impact of caribou being in the Zone of Influence (ZOI) for the whole year. Impacts were modeled based on a reduction in foraging time and eating intensity (the proportion of foraging time actually spent eating) and an increase in walking and running time.

5.2.2 Potential Effects and Proposed Mitigation

Habitat

Caribou habitat effectiveness can be reduced by 1.72 %, 1.67 % and 1.83 % across the north Baffin Island caribou range during the calving, growing and winter seasons, respectively (Table 6-5.2; Figures 6-5.4 to 6-5.6). Most North Baffin caribou yearly ranges are generally relatively small and all caribou exhibit movement patterns more similar to sedentary caribou (Appendix 6F, Figure 14). Caribou do not show predictable long distance movements during any season.

Project mitigations to reduce effects on habitat loss include reclamation of disturbed areas post-construction and operation to reduce the direct loss of habitat; dust suppression around the mine site during dry summers; and limiting potential sensory disturbances to only those reasonably required for mining activities. Furthermore, transportation of ore to Steensby Port using the railway is also a mitigation that reduces habitat loss. The frequency of travel between the Mine Site and Steensby Port will much reduced compared to a trucking option reducing disturbance, and the train will not generate as much dust as trucks.

Table 6-5.2 Change in Effectiveness of Caribou Habitat within the RSA and the North Baffin herd range

Season	Baseline Sum of Probabilities – North Baffin	Baseline Sum of Probabilities – RSA	Loss to ZOI	% Diff. in RSA	% Diff. in North Baffin
Calving	2,310,306	387,006	-39,793	-10.28 %	-1.72
Growing	6,372,250	1,042,060	-106,688	-10.24 %	-1.67
Winter	4,741,184	828,562	-86,654	-10.46 %	-1.83

NOTE(S):
1. VALUES SHOWN ARE THE SUM OF ALL PIXEL VALUES (PROBABILITY OF CARIBOU USING THE HABITAT) WITHIN THE RSA FOR EACH SEASON.

Calving dates were identified by visually estimating plots of caribou movement looking for reduced movements associated with calving (Appendix 6F). Calving sites were defined by creating minimum convex polygons from calving caribou collar data using the estimated calving dates plus ten days post-calving. None of the identified calving sites overlap with the PDA. Ten of 39 collared caribou calves were born within the 14 km ZOI (Table 6-5.3, Figure 6-5.7). Assuming that collared caribou are representative of North Baffin caribou, 25.6 % of the caribou calves were born within the ZOI.

The variation in calving locations shown by some caribou suggests that alternative and suitable calving sites exist in the throughout most of the area and the low abundance of caribou means there is limited competition of calving habitat; therefore, caribou that calved within the ZOI could use alternative calving locations if these areas become less desirable because of human activity. There is a strong indication that North Baffin collared caribou use the same calving sites in consecutive years — 67 % of collared caribou calved in the same location. While the collar data is the best available data for North Baffin caribou and is assumed to be representative of the North Baffin Caribou, it does not show all caribou calving sites. North Baffin caribou are assumed to calve in other areas that contain suitable habitat throughout the region. The calving sites identified using the collar data identify those where monitoring effort can initially be focused.

The DIAND Caribou Protection Measures are intended to mitigate human impacts on the large migratory caribou herds. The Caribou Protection Measures identify known calving grounds as “Caribou Protection Areas” and provide protection of these areas from human disturbance during the 15 May – 15 July calving period. No designated Caribou Protection Areas exist within the Terrestrial Wildlife RSA. There are no known caribou calving grounds where caribou form large calving groups currently used within the North Baffin caribou herd range. The 2008–2011 caribou collar data clearly show that caribou are dispersed across suitable habitat within the herd’s range, and that individual caribou generally return to calve in similar sites each year. Given that calving caribou are dispersed throughout the RSA and no Caribou Protection Areas exist within the terrestrial wildlife RSA, the DIAND Caribou Protection Measures do not directly apply to the Project area. Although the DIAND Caribou Protection Measures do not apply to the terrestrial wildlife RSA, Baffinland will mitigate effects by minimizing disturbance to calving caribou during the calving period identified in the DIAND Caribou Protection measures. Calving caribou are predicted to avoid calving near disturbance, so disturbances that occur prior to the calving season should cause caribou to avoid calving near those disturbances; consequently, caribou will choose to calve in alternate calving habitat. Based on the collar data and the habitat model there appears to be an abundance of alternative calving areas. Potential project effects on calving caribou will be mitigated through planning construction locations and activities prior to the calving season and maintaining those disturbances through the calving season. No large changes to location or magnitude of construction and operation will occur during 15 May – 15 July, unless the change is to reduce disturbance for the remainder of the calving period.

The greatest disturbance to calving caribou will be associated with railway construction. Baffinland will partially mitigate railway construction disturbance to calving caribou by planning construction activities to minimize disturbance around the Cockburn Lake area — the location of most calving sites. Activities at the mine site and Steensby port facility will be continuous, and few mitigations are available at these sites to limit disturbance during the calving season. Only one known calving site occurs within the ZOI of the mine site, and no known calving sites occur within the ZOI of the port. To partially mitigate the impact of mining activity on the known caribou calving area within the mine site ZOI, Baffinland will not increase mine construction or operational activity during the 15 May – 15 July calving season identified in the Caribou Protection Measures.

After mitigation, the Project is expected to have a not significant effect on calving caribou because of human disturbance at calving sites. Collar data and IQ indicates that cow caribou calve in more rugged areas north and east of the mine site, and the area around Cockburn Lake. The documented calving sites in the vicinity of Cockburn Lake are the mostly likely to be affected by construction and operation activity.

Table 6-5.3 Yearly location of known calving sites relative to PDA and ZOI for each collared female caribou

Year	Caribou ID	Distance from PDA (km)	Within ZOI		Year	Caribou ID	Distance from PDA (km)	Within ZOI
2009	36835	20	No		2009	37030	23	No
2009	36836	18	No		2009	37035	18	No
2009	36837	31	No		2009	37048	28	No
2010	36837	7	Yes		2009	37050	2	Yes
2009	36838	76	No		2009	37052	2	Yes
2010	36838	76	No		2010	37052	16	No
2009	36840	10	Yes		2009	37054	32	No
2010	36840	10	Yes		2009	37055	13	Yes
2009	36841	81	No		2010	37055	13	Yes
2010	36841	81	No		2009	37123	36	No
2009	36842	6	Yes		2009	37407	24	No
2010	36842	<1	Yes		2009	37408	31	No
2009	36843	34	No		2010	37408	31	No
2010	36843	34	No		2009	37490	32	No
2009	36844	16	No		2010	37490	32	No
2009	36846	63	No		2009	37492	14	No
2010	36846	49	No		2010	37492	16	No
2009	36847	9	Yes		2009	37493	70	No
2010	36851	39	No					
2009	37025	37	No					
2010	37025	37	No					

LEGEND

- Mary River Project
- Potential Development Area

Caribou Calving Habitat Selection Probability	Project Zone of Influence
High Probability	0.25
	0.30
	0.40
	0.60
	0.75
	0.80
Low Probability	0.90

NOTES

Map Projection: North American Datum UTM Zone 17N

Ferguson, M. 1989. Baffin caribou. Pp. 142 in Hall, E. (ed). People and caribou in the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. Yellowknife, NT. 190 pp.

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale: 0 10 20 40 60 80 100 Km

Baffinland Iron Mines Corporation

Mary River Project: Caribou Habitat Selection Probability During the Calving Season.

EDI

Date: 1/9/2012

FIGURE 6-5.4

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_5_4_Caribou_HSP_Calving.mxd

LEGEND

Mary River Project

Potential Development Area

Caribou Summer Habitat Selection Probability

High Probability

Low Probability

Project Disturbance Area

0.25
0.30
0.40
0.60
0.75
0.80
0.90

NOTES

Map Projection: North American Datum UTM Zone 17N

Ferguson, M. 1989. Baffin caribou. Pp. 142 in Hall, E. (ed). People and caribou in the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. Yellowknife, NT. 190 pp.

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Scale: 0 10 20 40 60 80 100 Km

Baffinland Iron Mines Corporation

Mary River Project:
Caribou Habitat Selection Probability During the Summer Season.

EDI

Date: 1/9/2012

FIGURE 6-5.5

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_5_5_Caribou_Growing_02.mxd

LEGEND

Mary River Project

Potential Development Area

Caribou Winter Habitat Selection Probability

High Probability

Low Probability

Project Disturbance Area

0.25
0.30
0.40
0.60
0.75
0.80
0.90

NOTES

Map Projection: North American Datum UTM Zone 17N

Ferguson, M. 1989. Baffin caribou. Pp. 142 in Hall, E. (ed). People and caribou in the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. Yellowknife, NT. 190 pp.

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Scale 0 10 20 40 60 80 100 Km

Baffinland Iron Mines Corporation

Mary River Project: Caribou Habitat Selection Probability During the Winter Season.

EDI

Date: 1/9/2012

FIGURE 6-5.6

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_5_6_Caribou_Winter_02.mxd

LEGEND

Mary River Project

Potential Development Area

Zone of Influence

Calving Sites (2009)

Calving Sites (2010)

NOTES

Map Projection: North American Datum UTM Zone 17N

This document is not an official land survey and the spatial data presented is subject to change without notice.

Scale 0 2.5 5 10 15 20 25 30 35 Km

Baffinland Iron Mines Corporation

Mary River Project: Caribou Calving Sites

EDI

Date: 1/9/2012

FIGURE 6-5.7

Whitehorse, YT: J:\Yukon\Projects\2011\11_Y_0128_Baffinland_PostEIS\Mapping\Mapping_Finals_15Dec2011\Fig6_5_7_Caribou_Calving_Sites.mxd

Movement

Literature regarding caribou movement (e.g., permeability, accessibility, barrier effect, etc.) is discussed in the context of roads or pipelines, and to a lesser extent, railways, but provides additional insight into transportation infrastructure effects on wildlife. Bergerud *et al*. (1984) looked at behaviour in eight different caribou herds that were exposed to industrial development or transportation corridors and found that caribou are very resilient to human disturbance, and seasonal movements and range habitation are a function of population size as opposed to anthropogenic disturbance.

The mine and ports will not be significant barriers to caribou movement. Migrations have persisted across constructed railways or roads in Newfoundland, Yukon, British Columbia, and Alaska, but one example from Norway found migrations between summer and winter ranges ceased (Wolfe *et al*. 2000). Currently, the caribou within the region are non-migratory and it is not expected that migratory caribou will return to the area until the population begins to increase, perhaps first becoming apparent in the 2030s. The density of caribou in the region is low compared to the caribou numbers observed during the end of the twentieth century, so few caribou will come in contact with the mine infrastructure and these caribou are not expected to be migratory. If caribou start moving through the area again, the Project will be in the closure stage or in the final years of extraction. Effects on the movement of migratory caribou is possible; however, they will not simply appear in the area, there will likely be a gradual increase in the number of caribou during two or three decades, so monitoring of the non-migratory caribou and early migratory caribou during operation of the mine will provide some insight into potential mitigation requirements.

Although many caribou herds benefit from increasing their range by traveling to nearby islands, the need for Baffin Island caribou to use more than one island for seasonal ranges may be reduced by the island's large size and varied terrain (Miller *et al.* 2005). Ore shipping during the winter (ice) season may present a partial barrier to caribou movement to and from the islands south in Steensby Inlet, although during IQ interviews and in wildlife logs it was not noted that caribou move across the shipping lane. Caribou are able to swim across shipping tracks, although it adds difficulty, especially for young, smaller-bodied individuals (Miller *et al.* 2005). Igloolik residents indicated that the use of islands was less at low caribou numbers, but will increase when numbers rebound. Caribou are suspected to travel between the mainland and Baffin Island by crossing Fury and Hecla Strait, and among the islands surrounding Baffin Island, but long movements across Foxe Basin are unlikely to occur. Consequently, ore shipping using ice-breakers will not cause a barrier to caribou movement.

The broad scale assessment of the railway as a barrier to caribou movement indicates that 12 % of the railway may form some kind of barrier to caribou movement because of embankment characteristics being too steep and high (or deep when encountering trenches; (Table 6-5.4). The length of the sections that may be a barrier range from 1.0–2.9 km, less than the 4 km threshold of an average daily movement of caribou on north Baffin Island (based on daily caribou movements described in the terrestrial wildlife baseline report, Appendix 6F). On the broad scale, the sections of the rail that may be a barrier to movement are located throughout the length of the rail route. To further determine specific areas of crossings based on current trail locations, each of 52 known trails located along the Railway alignment were reviewed. The fine scale assessment of the Railway as a barrier to caribou movement indicates that caribou using five of 52 known trails (~10 %) along the route may find the Railway structure a barrier (Table 6-5.5).

The height of embankments is a widely discussed aspect of caribou movement across transportation corridors due to the visual barrier they present to caribou. Barrier threshold heights of 1.2 m, 1.43 m, and 1.0–1.5 m have been reported for Arctic caribou herds, but it is generally believed that caribou move with their learned directional orientation (Miller 1995) and simply look for crossings with the least energetic cost (Bergerud *et al*. 1984), as opposed to responding to barriers of a certain threshold height. Deflection from transportation-related berms or embankments is believed to be a response to other sensory disturbances rather than the height of the barrier (Bergerud *et al*. 1984). Miller (1995) found caribou would cross 19 m high embankments in open terrain on the Dempster Highway. In the absence of traffic, caribou may be influenced by stimuli associated with roads, such as gas, oil, and rubber odours and the visual appearance of the plowed road (Miller 1995); which will be largely absent stimuli on the Railway.

Trails that cross or approach the Railway will have modified embankments (if necessary) to ensure the height and slope do not present a barrier to caribou moving through the landscape (i.e., > 2 m high and > 1V:2H). If the regional caribou population increases and caribou start to move through the RSA more frequently, as expected based on IQ, these areas will become more heavily used and monitoring of caribou movement will become increasingly important. Operation of the railway will incorporate IQ into activity planning, particularly in movement areas, and future monitoring. Operators will be made aware of the crossing areas, and will be required to report any caribou sighting along the railway. Furthermore, different configurations on a limited number of potential crossings will be considered to see if caribou behaviour indicates the need to alter the engineering of the embankment. The fill material used for all Railway embankments will be a fine mixture of gravel and sand, preventing possible caribou leg entrapment, and will be of sufficient width to facilitate caribou movement across broad sections of the Railway. Other crossing structures (underpasses, overpasses, fencing, etc.) were investigated for effectiveness in the Project landscape; however, it was determined that these structures are not feasible in this environment and will not be effective to facilitate caribou movement.

When considering the permeability of the landscape, Cramer and Bissonette (2006) provide an excellent summary of the effectiveness of crossings:

> *"A sufficient number of crossings would allow almost free daily movement so that members of most species would be able to find and use crossings within their home ranges. By facilitating daily movement, at least some measure of permeability is achieved. True permeability may not be achievable in practice on the roaded landscape; however, to the extent that barriers can be made less impermeable, then the benefits can be measured in sustainable and less isolated populations."*

Of the three "key" and two "broad" crossing areas identified through a combination of IQ and preliminary aerial surveys, none of them seem to contain sufficient lengths of embankments/cuts to pose a barrier to caribou movement (Table 6-5.6). While most of the areas do contain small sections that may be barriers to caribou movement, overall caribou movement in the key and broad crossing areas will not be affected by physical barriers. Collar data from 2008–2011 displaying locations of female caribou was correlated with the identified higher use crossing sites; however, the collar data were collected at 11 hour intervals, so they are not detailed enough to delineate any additional trails near or crossing the Railway alignment.

IQ knowledge of caribou movement and crossing areas was incorporated indirectly into the design and directly into the operation of the Railway. Caribou crossings are located at various points along the Railway based on the identification of trails. IQ holders were specifically asked to identify areas used by caribou during migrations/movements. The information was used to determine areas where baseline trail information collection was focused and to identify the areas important for monitoring caribou movement.

Fourteen water caribou crossings were identified during a 2007 trail survey (Appendix 6F). General water crossings were identified based on IQ interviews and aerial surveys confirmed the location of the crossings based on concentrations of trails observed near lake and river narrows. Of the 14 identified crossings, the Cockburn Lake crossing is the only water crossing that will be directly impacted by project infrastructure. A large railway bridge at this crossing will allow continued use of the use of the crossing by caribou travelling east and west. The bridge will be tall enough (10 m agl) to allow caribou to pass underneath. The railway embankment is made of fine enough fill material that caribou will be able to cross at any point along the railway alignment. The slopes of the railway embankments will be widened where trails cross the railway.

Table 6-5.4 Sections of the Railway that May Impede Caribou Movement

Section	Alignment Sheet	Km Post	Length (km)	Barrier Notes
A	5302-01, -02	0.6–3.5	2.9	Majority steep and high embankment. Also considered the "yard" area which is busy and generally do not expect caribou to be in area.
B	5301-13	21.0–22.5	1.5	One trail mapped in this section (014) crosses steep grade > 4m high. However, trial 012 crosses gradual slope fill.
C	5301-16	26.0–28.0	2.0	Trail 020 crosses steep (3.75 m) embankment. Majority steeper embankment >3m high.
D	5301-19	31.5–33.0	1.5	Naturally steep terrain. Trail 022 crosses at point where trench may exceed > 2m and steep sided.
E	5301-21	35.0–37.0	2.0	Generally steep incline > 2m for both cut and fill. Several river crossings as well.
F	5301-27	44.5–45.5	1.0	Generally steep embankment > 2m on approach to river crossing. Combined with access road.
G	5301-34	54.0–56.0	2.0	Appears to be mostly >2m steep embankment.
H	5301-45	73.5–75.0	1.5	Generally >2m high, steep embankment.
I	5301-62	103.0–105.0	2.0	Tunnel exits to canyon. If caribou are trying to navigate up/down hill, then steep canyon limits movement.
J	5301-81	136.5–138.0	1.5	Trail 046 crosses at point that will be a 10 m deep trench. There are several other stretches requiring trenching.
	Total km as potential barrier		17.9	(12 % of the 149 km long Railway).

NOTE(S):
1. SEE FIGURE 6-5.3 FOR LOCATIONS OF SECTIONS.

Table 6-5.5 Trail-Specific Assessment of Potential Barriers to Movement along the Railway

Trail ID	Alignment Sheet	Km Post	Barrier Notes	Mitigation Required?	Barrier following Mitigation?
002	5301-08	13.2	Trail parallel and off of embankment	No	No
003	5301-09	15.2	Trail crosses gradual embankment.	Yes – grading of embankment	No
004	5301-09	15.3	Trail crosses gradual embankment.	Yes - grading of embankment	No
005	5301-10	16.0–16.5	Trail follows proposed maintenance road.	Yes - grading of embankment	No
006–007	5301-10	17.0–17.5	Steep but low embankment.	Yes - grading of embankment	No
008	5301-11	18.3	Trail generally following creek valley.	Yes - grading of embankment	No
009	5301-11; -12	19.3	Trail perpendicular and off of embankment.	No	No
010	5301-12	19.8	Trail parallel and above cut	No	No
011	5301-12	19.8	Trail crosses through gradual slope cut	No	No
012	5301-13	21.2	Parallels Railway along gradual slope fill.	Yes - grading of embankment	No
013	5301-13	21.2	Below embankment. Crosses maintenance road.	No	No
014	5301-13	22.4	Crosses Railway on potentially steep and high grade.	Yes - grading of embankment	Possible
015	5301-14	23.3	Parallel to Railway, off of embankment	No	No
016	5301-15	24.6	Cross rail at steep but low embankment.	Yes - grading of embankment	No
017	5301-15	24.8	Crosses rail along gradual fill between hills.	Yes - grading of embankment	No
018	5301-15	24.9	Crosses rail at west end of bridge, crossing high but gradual fill	Yes - grading of embankment	No
019	5301-15	24.9	Crosses rail at west end of bridge, crossing high but gradual fill	Yes - grading of embankment. Site-specific investigation post-construction	Possible
020	5301-16	26.9	Crosses rail on high but gradual embankment in naturally steep terrain.	Yes - grading of embankment	No
021	5301-18	31.4	Crosses at intersection of cut and fill in naturally steep terrain.	Yes - grading of embankment	No
022	5301-19	31.7	Crosses cut in naturally steep terrain. Cut <2m	No	No

Table 6-5.5 Trail-Specific Assessment of Potential Barriers to Movement along the Railway (Cont'd)

Trail ID	Alignment Sheet	Km Post	Barrier Notes	Mitigation Required?	Barrier following Mitigation?
023	5301-25	43.7	Parallel rail below embankment.	No	No
024	5301-30	47.9	Crosses rail on steep but low embankment	Yes - grading of embankment	No
025	5301-30	47.4	Crosses low (almost no) cut	No	No
026	5301-30	48.7	Crosses low fill	Yes - grading of embankment	No
027	5301-31	48.8	Parallel rail beneath embankment	No	No
028	5301-31	49.2	Crosses rail on low fill	Yes - grading of embankment	No
029	5301-31	49.4	Crosses rail on gradual low fill	Yes - grading of embankment	No
030	5301-32	79.8	Crosses access road	Yes - grading of embankment	No
031	5301-32	51.2	Crosses on low fill	Yes - grading of embankment	No
032	5301-32	51.4	Parallel rail below embankment	No	No
033–034	5301-32	51.8–52.1	Crosses and parallels on low slope	Yes - grading of embankment	No
035	5301-33	53.2	Crosses high but gradual embankment	Yes - grading of embankment	No
036	5301-32	86.6	Crosses rail along steep and high cut	Yes - gradual slope cut	Possible
037	5301-57	94.6	Parallel Railway in naturally steep terrain.	Cut in this area may make terrain conducive to animal movement.	No
038	5301-74	125.4	Parallel to rail, along high gradual slope in naturally rugged terrain	Yes - grading of embankment	No
039	5301-75	126.1	Parallel to rail along gradual embankment.	Yes - grading of embankment	No
040	5301-76	127.8	Parallels rail along base of natural slope, crosses at steep but relatively gradual embankment.	Yes - grading of embankment	No
041	5301-76	128.6	Crosses rail 3m slope, but relatively gradual	Yes - grading of embankment	No
042	5301-77	129.8–130.7	Parallels rail and eventually crosses on 4m gradual embankment.	Yes - grading of embankment	No
043	5301-77	131.3	Parallels rail below embankment.	Yes - grading of embankment	No
044	5301-78	132.4	Crosses near cut and fill location - low embankment	Yes - grading of embankment	No

Table 6-5.5 Trail-Specific Assessment of Potential Barriers to Movement along the Railway (Cont'd)

Trail ID	Alignment Sheet	Km Post	Barrier Notes	Mitigation Required?	Barrier following Mitigation?
045	5301-80	136.4	Crosses rail at low embankment	Yes - grading of embankment	No
046	5301-81	136.7	Crosses rail at steep high cut in naturally rugged terrain	Yes - gradual slope cut	Possible
047	5301-82	138.5	Crosses rail through gradual slope cut into ~ 700m long trough. Makes slope more gradual for travelling caribou	No	No
048	5301-82	139.3	Along shoreline of pond below embankment.	No	No
049	5301-82	139.6	Parallel below embankment, at edge of maintenance road	No	No
050	5301-83	144.3–144.5	Crosses at steep but very low grade in naturally rugged terrain	No	No
051–052	5300-01	143.8–144.1	Possible workshop area, multiple tracks. Crossing location low slope and gradual	No - active train area due to workshop	Possible
053	5300-01	144.5	Parallel Railway near base of hill in naturally rugged terrain	No	No

Table 6-5.6 Key and Broad Movement Areas and Railway Barrier Assessment

Area	Km Posts	Alignment Sheets	Barrier notes	Overall Barrier to Movement >4 km Long
Key area 1	34.7-39.7	5301-20–23	No trails observed during ground surveys in 2010. 5301-21 is considered a potential barrier.	No
Key area 2	87.6-99.2	5301-53–59	No sections are considered a barrier to movement. Trail 037 only one mapped in this area (no barrier).	No
Key area 3	124.7-129.8	5301-74–77	No sections are considered a barrier to caribou movement. Trail 038–043 mapped in this area, and none are considered to encounter barriers.	No
Broad area 1	42.1-70.2	5301-25–43	There are potential barriers to movement along sections 44.5–45.5 and 54.0–56.0 (alignment sheets 5301-27 and 5301-34). Trail 023–036 mapped in area. Only caribou travelling along trail 036 may encounter barrier.	No
Broad area 2	130.3-149.0	5301-77–84	There are potential barriers to movement along section 136.5–138.0 (alignment sheet 5301-81). Trail 043–50 are mapped in area. Only caribou travelling along trail 046 may encounter barrier.	No

NOTE(S):
1. SEE FIGURE 6-5.3 FOR LOCATIONS OF AREAS.

Infrequently traveled transportation corridors act as semi-permeable barriers to caribou, and result in fewer collisions, less deterrence of road crossings, and no observable effects on migration routes, annual distribution, or energetic costs (Dyer *et al*. 2002; Wolfe *et al*. 2000). Caribou have been found to successfully cross roads with 15 vehicles per hour (Curatolo and Murphy 1986).

Although the Project traffic is considered infrequent, traffic along the roadway and Railway will result in barriers to caribou movement while the vehicles are travelling along the corridor. It is difficult to quantify a "moving" barrier to caribou movement, so it was determined the quantity of the effect by considering a caribou standing on one side of a transportation corridor and estimating the quantity of time that they will be unable to cross the road or rail because of traffic. Estimating barrier effects in this way underestimates the actual barrier effect because caribou are very unlikely to cross immediately before or after a truck or train passes.

Traffic along the Railway during a normal day of mine operation will include three ore trains making six round trips. Depending on their load and location, these trains travel between 22 and 60 km/h and are approximately 1200 m long. An additional freight train and a fuel train will operate once a week and make two passes each. Both trains are 500 m long and travel between 55 and 60 km/h. On days when all these trains are operating (although it is unlikely the freight and fuel trains will operate on the same day), and at a point where the trains are traveling the slowest, caribou would be prevented from crossing for a total of 29 minutes and 39 seconds throughout the day (Table 6-5.7). This corresponds to 2.06 % of a normal mine operation day that caribou are unable to cross the tracks because of trains. If caribou will not cross the Railway 100 m before and after a train passes, then the barrier effect increases to 3.01 % of a normal mine operation day. The range of variation in time that a caribou standing beside the tracks will be physically blocked from crossing by a single moving train is 30 seconds to 3 minutes and 16 seconds. Other track maintenance and snow removal vehicles will also travel the rail route during some days, and during the construction phase of the Project, a grinder will be required three times a year. These will not substantially increase the barrier as they are much smaller vehicles and will disrupt the operation of the larger ore trains. If weather or other operational delays occur, it is not expected that the frequency of Railway passes will increase to compensate for delivery losses.

Table 6-5.7 Estimate of time that Railway traffic presents a barrier to a single point along the rail line

Traffic type	Length (m)	# of passes	Max. speed (km/h)	Min. speed (km/h)	Max. barrier time (per pass)	Max. barrier time (per day)	Min. barrier time (per day)
Loaded ore train	1200	6/day	60	22	3 mins 16 s	19 mins 38 s	7 mins 12 s
Empty ore train	1200	6/day	60	55	1 min 19 s	7 mins 51 s	7 mins 12 s
Freight train	500	2/week	60	55	33 s	1 min 5 s	1 min 0 s
Fuel train	500	2/week	60	55	33 s	1 min 5 s	1 min 0 s
TOTAL						**29 mins 39 s**	**20 mins 24 s**

The tote road will be used primarily during construction. After construction the road will be used only intermittently to move oversized equipment to the mine (equipment that will not fit through the Railway tunnels). Given that there are currently few caribou occupying habitat north of the mine site and that the road will be used primarily during the construction phase, caribou will have limited interactions with project related human activities along the tote road after the construction phase.

No significant adverse effect to caribou movement across the railway is anticipated due to trains causing a barrier to movement. Truck traffic has the potential to cause a barrier to caribou movement across the roadway; however, currently there are very few caribou in the region, specifically the roadway is in an area where caribou numbers are particularly low, and the road will be used primarily during construction and only intermittently during mine operation. No significant adverse effect to caribou movement across the roadway is anticipated due to traffic causing a barrier to movement.

It is assumed caribou will easily pass over the tunnels; however, there have been instances where caribou (in northeastern Norway) have entered tunnels to escape insect harassment in the summer (Klein 1971). Trail locations in relation to the tunnels were examined to determine the likelihood of caribou using areas close to the tunnels. The closest identified trail to either tunnel was 7.5 km away, suggesting caribou typically do not move across the Railway in this area. Caribou collar locations from 2008–2011 were also examined in relation to the tunnels, and were found approximately 8 km to the west of the Railway, and more than 10 km away from the east side of the Railway. It appears that the areas around the tunnels are currently not frequented by caribou, thus the tunnels will not negatively impact caribou movement through the region.

In years with poor snow conditions (e.g., deep snow and fall icing), caribou may use the Railway as a travel corridor to decrease energy costs, especially if they are already in poor physical condition (Klein 1971). An analysis of climatic data for the North Baffin Island region produced a range of possible snow depths throughout the year (Figure 6-5.8). The months with the greatest snow depths are April and May, with a maximum annual snow depth of 0.68 m and a maximum average annual depth of 0.46 m; both of which occur in April. Rain-on-snow events, characterized as days during fall months when there was recorded rainfall and more than 10 cm of snow on the ground, were also examined from 1979 to 2009 (Figure 6-5.9). The highest (64 days) and lowest (23 days) number of rain-on-snow events occurred in 1996 and 2007, respectively, with an average number of 41 days with rain-on-snow events. Freezing rain, characterized as rainfall recorded when temperatures were below 0°C (i.e., when total precipitation exceeded precipitation of snow) during fall months from 1979 to 2009, occurred considerably less often than rain-on-snow events. Both a range of snow depths and fall icing events are expected in the North Baffin region throughout the duration of the Project. There is little that can be done to prevent caribou from traveling on the Railway; however, Baffinland's Caribou Protection Measures (Volume 10, Appendix 10D-11, Section 3.3.3) aim to prevent Railway-related collisions.

Current snow conditions in winter are hard packed snow cover. These snow conditions allow easy movement across the landscape.

Elevating the railway reduces snow accumulation on the tracks by exposing them to a wind flow. To avoid snow drifting on roads Baffinland smoothes the snow piles on the edges of the roadways. Similar snow management will be required along the Railway, reducing the possibility of caribou encountering large artificial snow drifts. This will be achieved using the locomotive at the front of the trains. Snow accumulation along the Railway will likely facilitate caribou movement across the landscape and reduce any barrier that was potentially caused by the embankment (e.g., snow will fill voids and slopes will become more gradual). Snow management along the Railway will not result in a barrier to caribou movement during the winters. Some crossings that are in embankment cuts will be cleared during operations which should enable caribou to easily move off the tracks (i.e., an escape route) if a train is approaching.

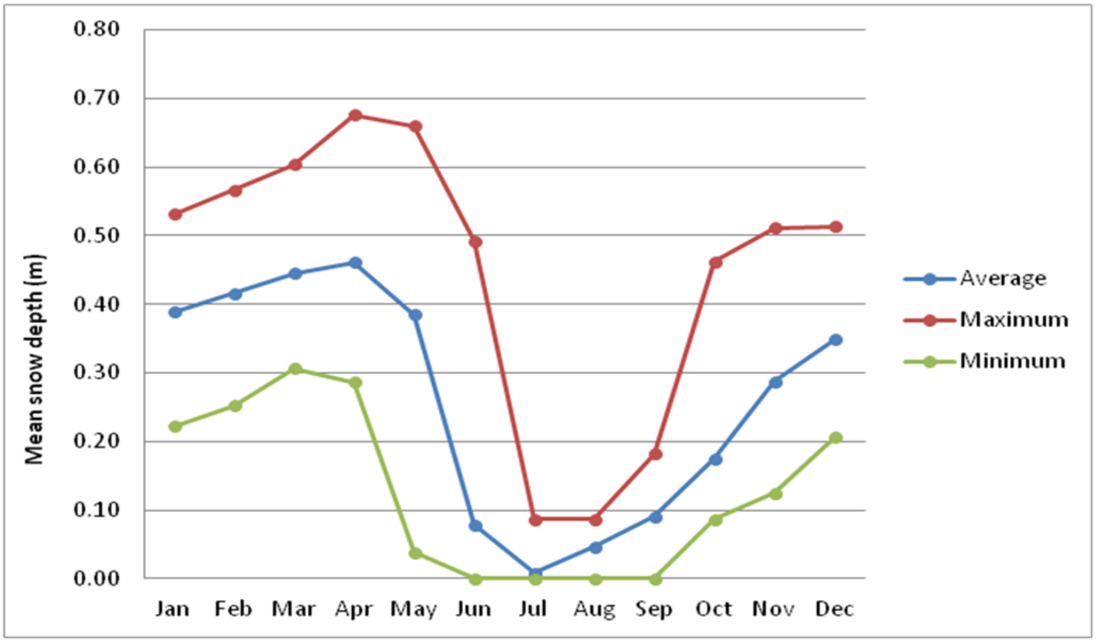

Figure 6-5.8 **Average, maximum and minimum mean monthly snow depth in the north Baffin region (MERRA climate data, 1979–2011).**

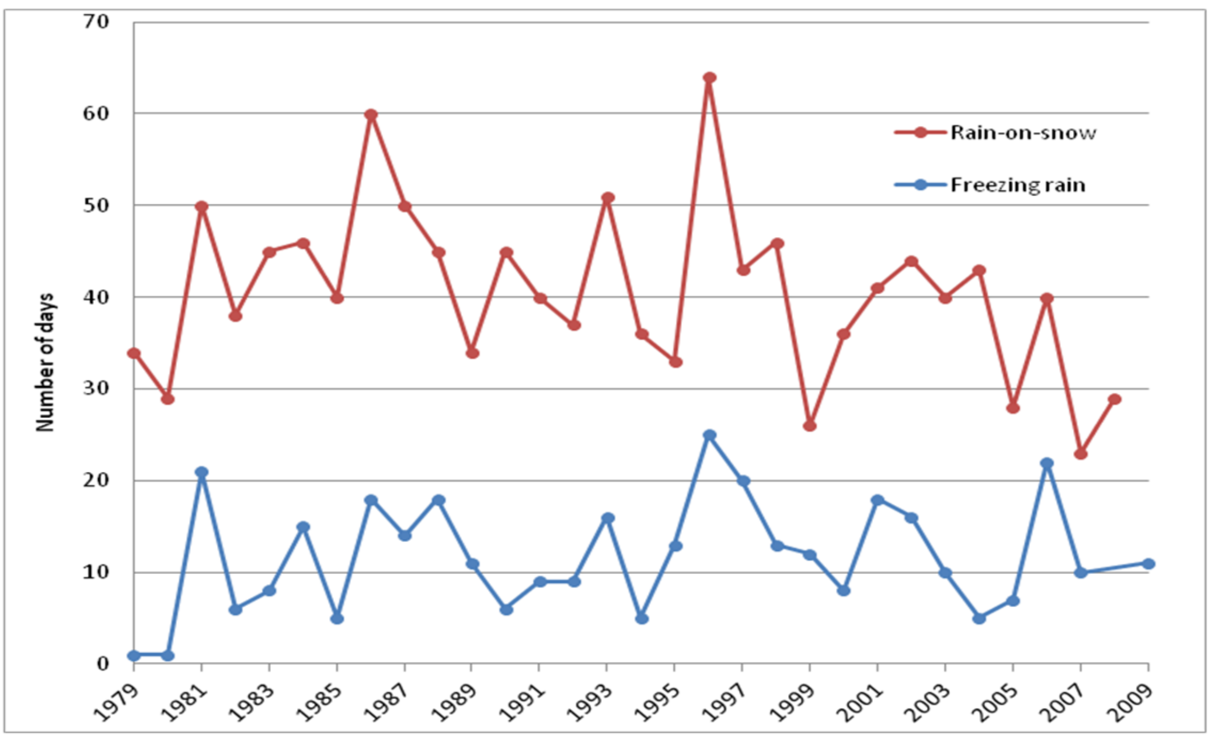

Figure 6-5.9 **Number of days a rain-on-snow event or freezing rain occurred during fall months in the north Baffin region from 1979 to 2009 (MERRA climate data, 1979–2011).**

Insects also play a role in caribou movement across transportation infrastructure. Caribou tend to move across roads/railways more frequently when insect harassment is high, essentially reducing the behavioural effect of the disturbance (Murphy and Curatolo 1987, Wolfe *et al*. 2000). Effects on movement are also most pronounced in females and calves, suggesting further consideration for movement needs to be taken during times of calving and post-calving (Nellemann and Cameron 1996 and 1998; Murphy and Curatolo 1987; Wolfe *et al*. 2000; Klein 1971).

The pertinent literature suggests that a range of caribou responses to the Railway are possible. By applying a precautionary approach and employing an adaptive management strategy, any negative impacts of the Railway to caribou movement can be mitigated (Volume 10, Section 2.0).

<u>Mortality</u>

During the previous four years of exploration, there was no caribou mortality caused by Baffinland personnel or from project activities. Wildlife are given the right-of-way, thus traffic controls are in place should caribou be observed on or near the road. On-site staff are restricted from harvesting wildlife. Garbage (as a potential attractant to scavengers) is incinerated and not stored on site.

In caribou ranges where railway infrastructure exists, the risk of mortality is greatest in the winter months when there is decreased light and visibility for the train conductor, the caribou are using the tracks for easier travel, or they are concentrated in groups on the rail line (Klein 1971, van der Grift 2001). Similarly, railway collisions with moose tend to increase with increasing snow depth and colder ambient temperatures (Gundersen *et al.* 1998).

Smaller and younger caribou (i.e., calves, yearlings, and two year olds) moving to and from islands south of Steensby Inlet could have an increased risk of mortality from shipping traffic creating 'ice debris' making it more difficult to swim (Miller *et al.* 2005); however, there is currently little to no use of these areas and mortality is expected to be negligible.

Caribou abundance is expected to remain low and migratory caribou are not expected to return to the area in the short-term. Currently, the caribou are in the trough (bottom) of a population cycle. Consequently, a very low probability of direct project-related mortality is expected.

If caribou mortality were to increase as a direct result of the project, the effects can be readily mitigated by increasing traffic controls including seasonal traffic limitations of both the tote road and rail. The timing and duration can only be determined by repeated on-site observations of caribou behaviour along the transportation corridors as the project proceeds through construction and operation. All mortalities will be reported and carcasses promptly removed from the railway to prevent possible collisions with scavengers.

The projects transportation infrastructure will not provide improved access to the RSA. Caribou harvest of the area is primarily a winter activity using snowmachines. Snowmachines will not benefit from roads and railway infrastructure. The ability of snowmachines to access the RSA is dependent on snow cover, ice, and topography. Employment with Baffinland will improve local people's knowledge of the area. Most employees will be working at the Mine Site or the Steensby Port facility where most of the mining and shipping activity will occur, so increased knowledge of the RSA will be primarily within these areas. Hunter access and knowledge of the RSA will not significantly change from baselines conditions, so no mitigations are required to mitigate indirect caribou mortality due to the project.

Health

Metals in soils and vegetation from aerial deposition potentially effecting caribou health is assessed in Appendix 6G-2.

In summary, caribou exposure to metals in soil and vegetation is expected to be low due to the relatively small area outside the various PDAs where dust deposition is predicted to be elevated. As a result of this, the likelihood of significant increases in metals loadings to caribou (and hence, to local people eating caribou), is predicted to be low.

A total of 12 different collared caribou currently have part of their home range within either the Mine Site or Steensby Port ZOI. Of those 12, four individuals have their home range within a detectable dustfall gradient; however, all four fell within the low (0–7.5 g/m²/year) threshold (Table 6-5.8). A total of 23.680 km² and 1.746 km² of caribou forage food (e.g., lichens) within the Mine Site and Steensby Port PDAs, respectively, will be exposed to dustfall.

Mitigation of dust effects on forage food will be addressed by those measures used to mitigate effects on air quality as described in Volume 5, Section 2. Potential effects of dustfall within the PDA are not considered further since vegetation removal is predicted for the entire PDA and is encompassed within the expected area of caribou habitat loss.

Table 6-5.8 Summary of predicted caribou exposure to annual dust deposition (TSP) within the ZOI

Collar ID	Location	Home/collar range			Home Range affected by annual dust deposition (TSP)			
		Total (km²)	Area in ZOI (km²)	% in ZOI	Low (0–7.5 g/m²/yr)	Moderate (7.5–55 g/m²/yr)	High (> 55 g/m²/yr)	% in TSP zone
36835	Mine site	3,312	233	7	10.0	-	-	0.3
36840	Mine site	477	172	36	13.5	-	-	2.8
37030	Mine site	6,693	214	3	0.2	-	-	0.0
37035	Mine site	1669	31	2	-	-	-	-
37492	Mine site	5087	78	2	-	-	-	-
36837	Steensby Port	4420	717	16	-	-	-	-
36841	Steensby Port	3,302	6	0	-	-	-	-
36842	Steensby Port	981	30	3	-	-	-	-
36847	Steensby Port	565	64	11	-	-	-	-
37050	Steensby Port	3375	21	6	-	-	-	-
37408	Steensby Port	1,004	171	17	-	-	-	-
37490	Steensby Port	1623	490	30	1.7	-	-	0.1
				Total	25.4	-	-	3.2

5.2.3 Assessment of Residual Effects

The following text describes the residual effects that will remain after mitigations have been applied for each measurable parameter. After a discussion/description of the residual effects, the predictions are tabled and summarized for each measurable parameter using the language and evaluation criteria described in Volume 2, Section 3.

Habitat

Loss of habitat within the PDA (footprint) of the project is a residual effect - Baffinland does not expect that habitat will be reclaimed (re-vegetated) within a generation of caribou. Sensory disturbances that reduce habitat effectiveness within a zone of influence can only be partially mitigated. Caribou will find some project activities disturbing. It is uncertain to what degree caribou will adapt to those disturbances. However, over the entire range of the north Baffin Island caribou, habitat effectiveness is predicted to be reduced by 1.72 % during the calving season, 1.67 % during the growing (summer) season, and by 1.83 % during the winter season. This effect will last for the duration of the project's activities or until caribou adapt to the disturbances.

The loss of calving habitat will be entirely from disturbance associated with the mine, and therefore is reversible. The greatest disturbance to calving caribou will be associated with railway construction. Railway construction will not impact the entire railway route simultaneously; therefore, the largest magnitude effect will be reduced simply because of the small spatial extent and shorter duration. Given the broad distribution of calving sites within the RSA, the assumed availability of alternative calving areas, and the minimal competition for calving areas, Baffinland is moderately confident that after mitigation the Project will have a not significant effect on calving caribou.

The predicted levels of habitat effects based on the evaluation criteria are summarised in Table 6-5.9.

Movement

At the broad scale, there are 17.9 km of sections ranging from 1.0–2.9 km where caribou may experience a barrier to movement (Table 6-5.3). Mitigation on only two trails (014 and 046) that are known to exist in these areas may be insufficient to ensure that caribou do not encounter a barrier to movement during the growing season. At a finer scale, there are five of 52 trials (014, 019, 036, 046, 051/052, Table 6-5.5) where mitigation may not be sufficient to ensure that travelling caribou do not experience a barrier to movement. These trails cross particularly steep and high gradients, or in areas of expected high rail activity (e.g., near maintenance shops). On an area-by-area basis there are no barriers to movement for caribou travelling through the three key and two broad movement areas (Table 6-5.6, Figure 6-5.3).

Alterations to the landscape that will remain post-closure are consistent with the surrounding environment and will be immeasurable features on the landscape given the rough terrain in the RSA. Transportation embankments and building foundations do not exceed the characteristics of the current landscape. The caribou population is expected to rebound and large numbers of migratory caribou, relative to current levels, are expected to return to the area. Trails that were altered because of transportation infrastructure will be re-established as caribou return to and start to move through the region again.

The overall residual effect of the project on caribou movement may be that caribou travelling on five of 52 (9.6 %) known trails of may experience a barrier to their movement on those trails. This effect is expected to have a not significant effect on the movement of North Baffin caribou. The predicted levels of movement effects based on the evaluation criteria are summarised in Table 6-5.9.

Mortality

Project-related direct mortality on caribou is readily reduced by adjusting speed limits, seasonal traffic limits, regular monitoring of caribou numbers and proximity to transportation corridors, and a no-hunting policy for staff while on-site. There are no known features of the project that will reduce health to a level of increased mortality for the north Baffin Island caribou herd. An outstanding concern of communities related to mortality is how north Baffin Island caribou will react to the trains, and whether they will be aware of moving locomotives and be capable of getting off of the rail tracks. This is considered to be mitigable; caribou currently are in very low numbers and are seldom expected to be encountered along the rail route, and when the large numbers of caribou return, seasonal shut downs are possible to allow caribou to pass during migratory movements. The Project will not significantly increase caribou harvest in the RSA because of increased human access or improved knowledge of the area; no mitigations are required.

There are no expected residual effects of the project on caribou mortality. Mortality, if it occurs, will be limited to individuals within the PDA. The effect of the Project on North Baffin caribou mortality is not significant. The predicted levels of mortality effects based on the evaluation criteria are summarised in Table 6-5.9.

Health

The potential effect of dustfall on caribou health is assessed in Appendix 6G-2. No residual effects of the Project on caribou health are anticipated due to metal exposure from dustfall.

Overall Project Effect

The overall project effects are quantified and assessed using an existing energy-protein model updated to include protein dynamics. The objective ot the energetics model was to predict how varying potential impacts of the Project's affect the long-term productivity of the North Baffin caribou herd.

Model inputs were obtained to best reflect the conditions in the North Baffin region. The model assumes that the North Baffin caribou population is cyclical, so it incorporates the predicted caribou population increase during the life of the Project. The model simulated food intake based on the seasonal quantity and quality of forage available, followed energy and protein kinetics through the rumen and allocated the resultant metabolizable energy intake and metabolizable nitrogen intake into maintenance, activity, growth, lactation and gestation. Details of the model are included in Appendix 6H of Volume 6 of the Final EIS.

The model was developed to reflect one baseline and four impact scenarios. All four impact scenarios were considered *extremes* of the expected potential project effects if the Mine project were to proceed; however, it was determined to be important to test the extremes of each scenario and compare with baseline conditions.

To assess overall Project effects on an expanding north Baffin caribou population, scenarios were modeled over a 50 year time period (at 5 year intervals). The initial population was allowed to grow and thus with each iteration (time step) the biomass per individual was reduced as a response to increasing density and for Scenarios 2, 3, and 4 with increased density due to abandoning portions of the range. Output body condition variables that link directly to rates of herd productivity were used to compare the outcomes of the scenarios.

Table 6-5.9 Effects Assessment Summary: Caribou

Issue	Magnitude/ Complexity	Geographical Extent	Frequency	Duration	Reversibility	Likelihood	Overall Significance	Degree of Confidence
Issue 1 Habitat Loss (direct and indirect)	**Level 1**: Effect will be indistinguishable from natural variation in caribou distribution.	**Level 2**: The Zone of Influence occur within the RSA.	**Level 3**: The effect will be continuous through operation phase.	**Level 2**: The effect will occur through operation phase.	**Level 1**: The effect is fully reversible.	High	Not significant at the scale of the North Baffin caribou population	Moderate
Issue 2 Movement (reduced frequency of caribou crossing infrastructure)	**Level 3**: The effect will reduce caribou movement across project infrastructure.	**Level 1**: The effect will occur within the Project footprint.	**Level 3**: The effect will be continuous through operation phase.	**Level 2**: The effect will occur through operation phase.	**Level 1**: The effect is fully reversible.	High	Not significant at the scale of the North Baffin caribou population	Moderate
Issue 3 Mortality (collisions and harvest)	**Level 1**: minor to no effect, and undetectable at the population scale.	**Level 1**: The effect will occur within and near the Project footprint.	**Level 3**: The effect will be continuous through operation phase.	**Level 2**: The effect will occur through operation phase.	**Level 1**: The effect is fully reversible.	Moderate	Not significant at the scale of the North Baffin caribou population	High
Issue 4 Health (exposure to contaminants)	**Level 1**: minor to no effect, and undetectable at the population scale.	**Level 1**: The effect will occur within and near the Project footprint.	**Level 3**: The effect will be continuous through operation phase.	**Level 2**: The effect will occur through operation phase.	**Level 1**: The effect is fully reversible.	High	Not significant at the scale of the North Baffin caribou population	High

In all runs, cows did better with no development. With the Scenario 2, Scenario 3, and Scenario 4, cows did progressively worse in terms of the key variables. The least severe impact modeled, abandoning the entire ZOI (Scenario 2), reflects an unlikely impact of the Project, but is used to show the result of what would be considered a severe Project impact on the North Baffin caribou herd. Under Scenario 2 conditions, the changes to the key variables from baseline values at the highest caribou densities (largest population) when project impacts are expected act with natural stressors associated with an oversized population range from a -1.7 % to -6.4 % change in body condition variables.

This analysis allows us to better understand the impacts of human activity on the energy-protein relations of caribou. When new North Baffin specific data become available, more monitoring of impacts on activity and distribution is conducted, and a better understanding of the population dynamics of this population is achieved, we can use this modeling approach to re-assess impacts of this development and others that may occur in the future. This modeling did not assess the role of climate in exacerbating or ameliorating the projected impacts of development.

The Project is expected to result in *not significant* changes to factors that could act to influence caribou population dynamics. Population dynamics of caribou herd can be influenced if project activities that significantly change the numbers of births, deaths, emigration, or immigration. The Project is expected to cause *not significant* changes north Baffin Island caribou mortality, habitat loss, or reduced health; therefore, there is no pathway to an effect on caribou population dynamics from project effects. Consequently, changes to caribou population dynamics are not anticipated.

5.2.4 Prediction Confidence

Habitat

Moderate Confidence in Prediction. The zone of influence in based primarily on work from EKATI™ and Diavik mines in the Northwest Territories. Although that study has high quality empirical evidence, it is limited to an assessment of migratory caribou from the central Arctic from only mid-July to mid-October. The caribou in this Project's RSA use habitat year-round and are not migratory. Although there appears to be a 12 % reduction in habitat effectiveness within the RSA, this still represents a potential effect across 1.9 % of the entire north Baffin Island caribou range. Reduced effectiveness does not exclude caribou from using the habitat. The ZOI was based primarily on the findings from the EKATI™ and Diavik monitoring (Boulanger *et al.*, 2009). Although caribou in general were four times more likely to be found >14 km from the mine, there were still observations of large numbers of caribou within the 14 km ZOI. Habitat will still be available and it is possible that caribou will adapt to mine disturbances and forage in areas close to Project activities.

If caribou avoid habitat within the predicted ZOI, then a future RSPF model may show that there could be increased probabilities of caribou outside of the ZOI. A pre-development and post-development RSPF study in Wyoming found that mule deer response to well pad development resulted in increased probabilities of occurrence further away from the well pads (Sawyer et al 2006). This shift in the probabilities of caribou using habitat outside the ZOI would increase the sum of probabilities (the index used for this assessment) post-construction so that the difference pre and post-development may be more similar. The assumption is that overall there is no effect on caribou numbers, rather just an effect on the probability of finding them within the ZOI. However, it is not possible to quantitatively predict increased probabilities of habitat use outside of the ZOI. This prediction will require follow-up monitoring.

Movement

Moderate Confidence in Prediction. It was not possible to monitor caribou reaction to sensory disturbance in the Project area (densities were too low). The assessment of potential project impact relies on literature reporting impacts of transportation infrastructure, including railroads, on caribou movement and habitat use. It is unclear exactly what characteristics of the Railway embankment may be a physical barrier, and how behaviour of caribou in low numbers (current) differs from caribou at high numbers (future). During the construction and early stages of operation the caribou population is expected to remain low and the regional caribou are expected to remain sedentary. Therefore, there is moderate confidence in our prediction of effects in the near future. As the North Baffin caribou herd population increases, IQ and the abundance of trails suggests that caribou will start to move across the PDA. Caribou movement reaction to infrastructure could be readily monitored and assessed to ensure that the project has a not significant effect to caribou movement. Future mitigation options available to mitigate unforeseen effects on a larger caribou population (e.g., seasonal traffic limitations when caribou start moving through the RSA). This prediction will require follow-up monitoring.

Mortality

High Confidence in Prediction. There are few caribou in the area. Mitigation is readily enacted (e.g., speed limits, seasonal traffic limitations). No hunting is allowed by mine staff. General project activity monitoring will include a component tracking project-related animal mortality.

Health

High Confidence in Prediction: No significant effect on overall health of north Baffin Island caribou is expected. Most dustfall will be associated with the Mine Site and the primary metals are relatively innocuous to caribou. Standard operating protocols to minimize dust dispersal in ZOI will be implemented and transportation of ore and freight using Railway infrastructure will minimize dust deposition (compared to truck transport).

5.2.5 Follow-Up

Due to the low numbers of caribou that currently occur in the RSA, monitoring should focus on simple data at first and more intensive monitoring should be initiated only if certain indicators trigger further questions. The goal of the initial monitoring will be to collect data that tests predictions, where possible, and collect information that will trigger further monitoring if needed.

The four parameters addressed in the assessment — Habitat, Movement, Mortality, Health — will be monitored using several techniques as detailed in the Terrestrial Wildlife Management Plan (Appendix 10D-11).

5.3 SUBJECTS OF NOTE

5.3.1 Lighting

The current scientific knowledge of the effects of artificial lighting on wildlife primarily focuses on wildlife that live in highly urbanized areas of western countries where there is extensive lighting (Longcore and Rich 2004). Many studies focused on the effects of artificial lighting on relatively small sized aquatic and terrestrial animal species. Behavioural responses of animals to artificial light are orientation/disorientation and attraction/repulsion. These responses can result in ecosystem level effects which can include changes to predator-prey relationships and, consequently, changes to ecological communities. For example, sea turtles immediately after hatching on beaches use starlight to navigate toward the water (Longcore and Rich 2004).

Whether light will cause orientation/disorientation or attraction/repulsion in terrestrial wildlife is currently a technical limitation of the project. We were unable to find literature or case studies that addressed this issue which were related to the project VECs. Caribou, the terrestrial wildlife indicator, are expected to avoid the mine site and port facilities because of the multiple mine related sensory stimuli. Lighting, independent of other stimuli, should not affect the orientation/disorientation or attraction/repulsion of local caribou. Other terrestrial wildlife VECs are also expected to avoid mine infrastructures because of human activity.

Some diurnal animals (active during daylight hours) take advantage of the extended lighting hours because it allows increased foraging times, but animals are then exposed to greater predation risk or new predators (Longcore and Rich 2004). Also, the potential to affect daily activities of wildlife, such as foraging, can adversely affect the energy balance potentially reducing physical fitness and survival of individuals. Daily animal activity cycles are frequently based on physiologically controlled "internal clocks" that are caused by environmental lighting; these daily cycles are known as circadian rhythms. Artificial changes in lighting can affect the daily cycles of animals by extending their activity time.

In the Arctic, environmental conditions, including light, change considerably between seasons. The current scientific literature suggests that the daily activity of animals living in the Arctic is not governed by the daily natural light patterns possibly because there is too much variation in light conditions over the year. Studies of reindeer occurring at altitudes similar to the project area and further north show no clear pattern in daily cycles, suggesting that Arctic reindeer physiology is not governed by a 24 hour cycle (Oort *et al*. 2006; Lu *et al*. 2010; Paul and Schwartz 2010). Because reindeer, and by extension caribou, are not affected by changes in lighting, the artificial light associated with the project will not cause changes to caribou daily activity patterns in winter that could impact their survival.

All sensory disturbances associated with mine activities, including light, are expected to cause some loss of functional habitat through avoidance. Airstrip lighting, independent of other stimuli, is expected to have a not significant impact on caribou distribution or survival. Caribou are the indicator species for terrestrial wildlife; however, our prediction of the effect of lighting on caribou likely applies to other local wildlife species.

5.3.2 Carnivores

Wolves and foxes are the dominant predators within the RSA, but they occur at very low densities. Though they are rarely observed, they occur within the RSA during the entire year and there are likely active den sites every year. None of the local carnivores are designated as being of conservation concern. Interviews with local people suggest that few carnivores are harvested each year. Wolf numbers are mostly dependent on caribou abundance, so any effects from the mine or mining activity will likely be not significant compared to the main effect of carnivore response to caribou abundance. Mitigation will include:

- Garbage management (Appendix 10B and 10D-4) and
- Monitoring of den sites that may be disturbed by Project activities.

5.4 IMPACT STATEMENTS

5.4.1 Caribou Habitat

We are moderately confident that Project related activities will have a not significant loss of habitat and a not significant reduction in the effectiveness of caribou habitat within the North Baffin caribou range.

5.4.2 Caribou Movement

We are moderately confident that Project related activities will have a not significant effect on traditional caribou migration and daily movements on north Baffin Island.

5.4.3 Caribou Mortality

We are highly confident that the Project will have a not significant effect on overall north Baffin Island caribou mortality.

5.4.4 Caribou Health

We are highly confident that the Project will have a not significant effect on overall north Baffin Island caribou health.

A summary of the terrestrial wildlife impact statements is provided in Table 6-5.10.

Table 6-5.10 Terrestrial Wildlife Impact Statement Summary for the Mary River Project

Measurable Parameter	Significance of Residual Effect	Mitigation Measures	Level of Confidence
Habitat	No significant reduction in the effectiveness of caribou habitat within the north Baffin Island caribou range.	• No immediate measures • Collaring program triggered if abundance monitoring information points to caribou avoidance of RSA.	Moderate
Movement	No significant effect on traditional movement on north Baffin Island caribou.	• Wildlife monitoring on Railway and tote road • Wildlife monitoring by HTO • Wildlife monitoring by employees • Speed limits on roads • Seasonal traffic limitations if required	Moderate
Mortality	No significant effect on overall mortality of north Baffin Island caribou.	• Record of collision on Railway and tote road • Record of all observed wildlife mortality reported by personnel • Harvest study for pre and post construction period • Log of hunters passing through the camp • “no harvesting/hunting” camp policy • Speed limits on road • Seasonal traffic limitations	High
Health	No significant effect on overall health of north Baffin Island caribou.	• Standard operating protocols to minimize dust dispersal in ZOI • Transportation using Railway infrastructure	High

5.5 AUTHORS

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SECTION 7.0 - DEFINITIONS AND ABBREVIATIONS

7.1 DEFINITIONS

Abiotic (conditions)	The non-living physical and chemical components of the environment (e.g., temperature, moisture, wind, etc.).
Abundance	The total number of individuals, or the total amount of a resource (e.g., food, water, habitat) present in an area, population, or community. When abundance is described as a number within a defined area, the quantity is a density. 'Absolute abundance' refers to the exact number present and 'relative abundance' refers to the number in one area compared to another area and is usually a less accurate estimate (e.g., an index of high, medium, low).
Acid deposition	The transfer of atmospheric pollutants to the earth's surface either by wet or dry deposition. *Refer* to *Deposition*, *Dry deposition* and *Wet deposition*.
Acidic (soils)	Soils with a pH below 7. *Refer* to *pH*.
Acidification (of soil)	A process by which soil pH decreases over time. *Refer* to *pH*.
Acute (symptoms)	Sharp or severe in effect; intense (symptoms).
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.
Airborne pollutants	Amounts of artificial and/or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, and/or materials.
Albedo	The amount of light (radiation) reflected by a surface such as snow.
Ambient air	The air occurring at a particular time and place outside of structures. Often used interchangeably with "outdoor air".
Annual (plants)	A plant that germinates, flowers and dies within a year or a growing season. *Compare* to *Perennial (plants).*
Atmospheric chemistry	Chemical components of the air.
Barrens (vegetation type)	A stretch of unusually level land that is sparsely vegetated or barren [unable to support growth; unproductive land]. Described in detail in the vegetation baseline report.
Barrier (movement)	A structure or activity that restricts caribou movement.

Barrier (sensory)	An activity, such as an intense sensory disturbance (e.g., very loud noise), that will affect caribou movement.
Base cations	Include ions of calcium, magnesium, and potassium. Accumulation of base cations determines critical loads for soil acidity. Input of base cations counteracts the acidification effects in soils.
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.
Bioaccumulation	An increase in the concentration of a substance within an organism.
Bioavailable	The ease with which a material (e.g., a chemical) in the surrounding environment can be taken up by organisms.
Biomass	The mass of living matter present in a specific location (e.g., the weight of lichen in a one square metre plot).
Bryoid	Vegetation dominated by mosses, liverworts, or lichens.
Bryophyte	Mosses.
Chlorophyll	The molecule in green plants that absorbs sunlight and uses its energy to synthesise carbohydrates from carbon dioxide and water.
Chronic (symptoms)	A persistent and lasting symptom.
Colluvium	Surface soils and rocks that are loosened and transported down slopes by weathering and erosion processes.
Combustion emissions	Products of engine exhaust including carbon dioxide (CO_2), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2).
Community (ecological)	An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.
Competitive dynamics (re: plants)	The individual opportunity of a plant to survive and grow with other plants when they are all using a similar resource that may be limited (e.g., nutrients, light).
Compost	Plant matter that has been decomposed and recycled as a fertilizer and soil amendment.
Contaminant	A substance that is not naturally present in the environment or is present in unnatural concentrations and amounts in sufficient concentrations can adversely alter the environment.

Correlation	The numeric relationship between two variables; for example, caribou age and weight are positively correlated.
Critical levels	The concentration of pollutants in the atmosphere above which direct adverse effects on plants and ecosystems may occur.
Cryosolic soils	Soils affected by permafrost-related processes.
Cryptogam	A plant that bears no flowers or seeds but propagates (reproduces) by means of spores (e.g., algae, mosses, ferns, etc.).
Culturally valued vegetation	Plants previously and currently used by Inuit.
Cuticle (protective)	A protective waxy covering.
Cycle (population)	Predictable changes (fluctuations) in the size of a population over long periods of time.
Deciduous	Trees or shrubs that shed their leaves annually.
Deficiency zone	When concentrations of a particular nutrient are below a desirable range, plant health is compromised.
Density	The number of individual caribou in relation to the space in which they occur.
Deposition	The settlement of particulate material from air onto the land. *Refer* to *Acid Deposition*, *Dry deposition* and *Wet deposition*.
Direct habitat loss	The physical loss of habitat due to the Project footprint. Compare to *Indirect Habitat Loss*.
Discrete	Separate or distinct.
Dispersion	The gradual decrease in concentration of material as distance increase from the source of emission. Therefore, concentrations are likely to be higher, at or near, the source of emissions.
Dispersion modeling	Predicting the extent and amount of material spread from emission sources.
Distribution	The boundaries or ranges within which individuals of a particular species are found.
Distribution (of animals)	The arrangement of animals in an area.
Disturbance	A Project related process that influences the behaviour, abundance, or distribution of individuals and/or populations.
Diversity	*See species diversity and species richness.*
Dose-effect response	The relationship between the amount of exposure (dose) to a substance and the resulting changes in function or health.

Drought stress	Negative effects on a plant resulting from a lack of water.
Dry deposition	In arid areas like the Arctic, dry deposition of plays a significant role in soil and water acidification. *Refer* to *Acid Deposition*, *Deposition* and *Wet deposition*.
Dust deposition	Dust will be transported downwind and deposited according to the local atmospheric conditions and particle size.
Dwarf shrub	A plant with a woody stem that does not grow any taller than ~ 2 feet.
Ecology	A field of study that describes species abundance and distribution. It involves describing the interrelationships between and among organisms.
Ecoregion	Large units of land and water that: are smaller than an ecozone; contain a geographically distinct assemblage of natural communities and species; share similar environmental factors including climate, physiography and soils; and interact ecologically in ways that are critical for their long-term persistence. *Compare* to *Ecozone*.
Ecosystem	A community of interacting plants, animals and other living organisms and the physical surroundings in which they live. Describes the living and non-living parts of an environment that interact to function as a system.
Ecozone	Areas of the earth's surface representative of large and generalized ecological units that are characterized by interactive and adjusting abiotic and biotic factors.
Effectiveness (habitat)	A relative measure of the usability/usefulness of habitat.
Emissions	The release of contaminants in the environment (air/water).
Endangered species	A wildlife species that is facing imminent extirpation (local extinction) or global extinction.
Environmental effect	A positive or negative change in the biophysical and/or socioeconomic environment caused by, or directly related to, a proposed activity.
Environmental impact statement	A statement of an evaluation of the predicted environmental and socio-economic effects of a proposed undertaking or project.
Enzymes	Proteins that either increase or decrease the rates of chemical reactions.
Ermine	Weasel

Flight response	Avoidance behaviour some animals use to escape capture by predators or disturbance.
Foliage	Plant leaves.
Foliar injuries	Physical or chemical damage to leaves.
Foliar uptake	Plants absorbing moisture and nutrients directly through the leaves.
Forage	Food eaten by animals. Refers to food that is acquired by searching/hunting.
Foraging habitat	Habitat where animals search for food (forage).
Frost boils	Upwellings of mud that occur through frost heave that are typically 1–3 metres in diametre with a bare soil surface.
Genetic	Caused or related to an animal's genes; for example, human eye colour is a genetic characteristic.
Germination	The process in which a plant or fungus emerges from a seed or spore and begins growth.
Glaciofluvial deposits	Unconsolidated rock material deposited by meltwater streams flowing from glaciers.
Glaciofluvial terraces	Elongate terraces of glaciofluvial deposits flanking the sides of floodplains.
Graminoids	All grasses and grasslike plants, including sedges and rushes.
Guild	A group of species that occupy a common niche in a given community, characterized by exploitation of environmental resources in the same way.
Habitat	The place where an organism lives that is characterized by the area's abiotic (non-living physical and chemical components) and biotic (living) properties. For terrestrial animals, habitat is often described by the dominant plants in the area.
Habituate	A decrease in behavioural response that occurs when an animal is exposed to a frequent and repeated stimulus that is not associated with a reward or punishment.
Heath	A dwarf-shrub habitat found on mainly infertile acidic soils, characterised by open, low growing woody vegetation.
Herd	Groupings of caribou that are defined by (on Baffin Island) fall distribution. Herd is used interchangeably with population in this report. *See Population*.
Homeostasis	The ability of a plant to maintain a stable, constant condition.

Ice-fast	*See landfast ice definition.*
Important Bird Area	Habitat areas designated by Bird Studies Canada and Nature Canada as being ecologically important to bird populations. These areas are identified using specified criteria that are internationally agreed upon, standardized, quantitative, and scientifically defensible.
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 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*.
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.
Invasive (plant species)	Invasive plants are non-indigenous species to an area and have the capacity to move into a habitat and reproduce so aggressively that they displace the original vegetation.
Isopleth	A line on a map connecting places registering the same amount, or ratio, of some geographical or meteorological phenomenon or phenomena.
Key marine habitat site	A marine or coastal area that is designated by Environment Canada's Canadian Wildlife Service as being considered essential to at least 1 % of the Canadian population of at least one bird species, and where special conservation measures may be required. These areas are determined using internationally standardized protocols to identify important bird habitats.
Key terrestrial habitat site	A terrestrial area that is designated by Environment Canada's Canadian Wildlife Service as being considered essential to at least 1 % of the Canadian population of at least one bird species, and where special conservation measures may be required. These areas are determined using internationally standardized protocols to identify important bird habitats.

Keystone species	A species that can alter the ecosystem dramatically if its presence or abundance is changed. The total biomass of keystone species may not be considerable; however the species plays a large role in maintaining the structure (balance) of the ecological community. Presence and abundance of this species can be used to assess the extent to which the resources of an area or habitat are being exploited.
Landfast Ice	Sea ice that is anchored to the shore or ocean bottom.
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.
Lichen	A plant that is actually a combination of a fungus (for structure) and algae (capable of producing food by photosynthesis).
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.
Local Study Area (LSA)	The study area that describes areas within, and directly adjacent to, the Project footprint and that may be subject to direct and indirect effects. *Refer* to *Regional Study Area (RSA)*.
Luxury zone	When concentrations of a particular nutrient are at, or above, a desirable concentration and there is no longer an improvement in growth with increasing concentrations.
Macronutrient	The class of chemical elements that are required in relatively large quantities for plant growth (e.g., nitrogen).
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.
Marine bird	Any bird that occupies a marine (salt water) environment at anytime during its annual cycle (e.g., migration, breeding, over-wintering) such as seabirds, geese, Eiders, ducks, terns and gulls.
Metabolic processes	The organic processes that are necessary for life.
Metalloids	The metalloids or semimetals that share some of the properties of metals and some of the properties of non-metals.
Microclimate	The weather variations in a small localized area.

Migratory routes	Predictable and seasonal movement routes used by animals to travel between seasonal habitats.
Minerotrophic	Nourished by mineral-rich waters, used to describe wetlands and wetland plants.
Mitigation	An action taken against an effect in order to eliminate or minimize it.
Model, modelling	A hypothetical description of a complex entity or process. A mathematical representation of reality.
Monitoring	Repeated observations through time to observe effects and to determine their management.
Natural variation	Measureable change in an environmental indicator or variable (e.g., 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).
Nonvascular (plants)	The simplest of all land dwelling plants; they lack an internal means for water transportation and do not produce seeds or flowers. *Compare* to *Vascular (plants)*
Organic	Relating to an organism or living entity.
Pack Ice	Sea ice that is not landfast; it is mobile by virtue of not being attached to a fixed object or landmass (e.g., shoreline).
Palatable	Tasty food.
Parent material (soil)	The primary material from which soil is formed.
Particulate matter	Any material, except pure water, that exists in a solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, windblown dust particles to fine particle combustion products.
Parturition	Giving birth.
Passive gaseous exchange	Unlike vascular plants that can control gas exchange through stomatal control, lichens lack control of gas exchange, and deposition of gaseous pollutants occurs across their entire surface.
Perennial (plants)	Plants which usually grow and bloom over the spring and summer growing season and generally live for more than two years. In autumn and winter, the plant will lose its leaves and the root system lies dormant in the soil until the following growing season when it will rely on its root-stock for initial growth. *Compare* to *Annual (plants).*

Permeability	A measure of particles, gasses or an object passing through an incomplete barrier.
pH	A measure of the acidity or basicity of a liquid. The measurement range is from 0, for the most acidic, to 14, for the most basic. Lemon juice is 2.4, pure water is neutral at 7, and lye is about 13 on the scale. *Refer* to *Acidic (soils).*
Photosynthesis	A process that uses sunlight to provide the energy needed to take up carbon dioxide and synthesize sugars. Sugars provide energy for growth.
Plant cover	The relative area of the ground surface that is covered by different plant species in a small plot.
Plaques (iron)	A barrier that can be formed on the roots of plants that will inhibit uptake of some metals and nutrients.
Population	Groupings of caribou that are defined by fall distribution. Population is used interchangeably with herd in this report. *See Herd.*
Probability	The chance that some event will happen; for example, the chance that a caribou will use habitat.
Project footprint	Areas of direct disturbance and habitat loss due to Project facilities, roads and other infrastructure.
Proteins	A fundamental component of all living cells and include many substances such as enzymes, hormones, and antibodies that are necessary for the proper functioning of an organism.
Qualitative analysis	A non-numerical estimation of the magnitude of an effect. Usually a matter of professional expertise and experience.
Quantitative analysis	Use of numbers to estimate the magnitude of an effect.
Range (e.g., caribou range)	An area where a species can be found.
Rare plants	Vegetation species that are uncommon.
Reclamation	The restoration of a site to promote natural plant regeneration after the mining or exploration activity is complete.
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 effects.
Reproductive sink	Areas where reproductive attempts are high but reproductive success is low which can contribute to a population's overall decline.

Residual effects	Effects that remain in a system or population after all mitigation attempts have been made to minimize the effects.
Resource selection probability function	A mathematical function that describes the probability that a particular resource, as described by a series of environmental covariates, will be used by an individual animal.
Riparian	Inhabiting or situated on the bank of a river.
Root interface	The area in soil adjacent to plant roots.
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.
Seabird	A bird that spends more than 50 % of its annual cycle in the marine environment (e.g., coastal salt waters and the open ocean) and whose evolutionary history has been primarily marine (e.g., murres, dovekies, guillemots, razorbills, puffins, petrels, fulmars, shearwaters, cormorants, albatrosses, and gulls).
Sensory disturbance	A human caused disturbance that causes a change in an animal's behaviour.
Shoot-to-root ratio	The ratio of the amount of plant tissues that have supportive functions (roots) to the amount of those that have growth functions (shoots).
Smelter	An industrial plant that extracts pure metal from ore.
Soil chemistry	The elements and properties of dirt.
Soil type	Characteristics of dirt based on particle size, nutrients, drainage, permafrost content, etc.

Sparse	Uncommon.
Spatially quantified	The amount of something by a specific area (e.g., number per square kilometre).
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 at Risk	Under Canada's *Species at Risk Act* (*SARA*), a species that has been designated by COSEWIC as being extirpated, endangered, threatened, or a species of special concern.
Species diversity	A relative index describing the number of species found in an area and their relative abundance. *Compare to Species richness*.
Species richness	The number of different species within a given area. *Compare to Species diversity.*
Stomata	Microscopic pores in the outer layer of leaves and stems used for gas exchange.
Substrate	The base on which an organism lives.
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	Limits of acceptable change determined from regulated guidelines, research and monitoring, or by professional opinion.
Till	Non-sorted, non-stratified earth or rock materials carried and deposited by glaciers.
Toxic metals	Poisonous metals.
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. *Refer* to Toxicity *(metal).*
Toxicity (metal)	The accumulation of metals in plants to the point where the concentration becomes detrimental to plant growth. *Refer* to *Toxicity.*
Toxicity zone	When concentrations of a particular element are below or above a desirable range and the plant can no longer maintain homeostasis, and plant health gradually deteriorates.
Transpiration	The process where water contained in liquid form in plants is converted to vapour and released into the atmosphere.

Tussock	A small hill of grassy or grass-like growth.
Uptake	Absorbing nutrients or metals.
Valued ecosystem component	Environmental attributes or components perceived to be locally important based on local ecological, social, cultural, and/or economic reasons.
Vascular (plants)	Those plants that have lignified tissues for conducting water, minerals, and photosynthetic products through the plant. *Compare* to *Nonvascular (plants)*
Vegetation plots	Small areas along the road and proposed rail corridor where plants were counted and measured.
Weathering	The physical and chemical processes where rock minerals are disintegrated, eventually releasing nutrients and other elements.
Wet deposition	Rain drops collide with airborne particles, bringing them to the ground. *Refer* to *Acid Deposition*, *Deposition* and *Dry deposition*.
Wetland	An area of land where the soil is saturated either permanently or seasonally.
Zone of Influence	The geographic area where species behaviour and/or abundance may be influenced by Project activities.

7.2 ABBREVIATIONS

°C .... Degrees Celsius
% .... Percent (per hundred)
ACIA .... Arctic Climate Impact Assessment
agl .... Above Ground Level
ARD .... Acid Rock Drainage
AMAP .... Arctic Monitoring and Assessment Program
API .... Air Photo Interpretation
asl .... Above Sea Level
ATV .... All Terrain Vehicle
BACI .... Before After Control Impact
BF .... Basic Friction
$C_3H_7NO_2S$ .... Cysteine
CCME .... Canadian Council of Ministers of the Environment
CEC .... Commission for Environmental Cooperation
CEPA .... Canadian Environmental Protection Act
CESCC .... Canadian Endangered Species Conservation Council
cm .... Centimetre(s)
COSEWIC .... Committee on the Status of Endangered Wildlife in Canada
Cu_2+ .... Cupprous copper ion
CU[(NH_3)4]2+ .... Cupprous ammonia
CWS .... Canadian Wildlife Service

EcoSSL .... Ecological Soil Screening Level
EIS .... Environmental Impact Statement
ELC .... Ecological Land Classification
EPA .... Environmental Protection Agency
Fe_2O_3 .... Hematite (ferric oxide)
Fe_3O_4 .... Magnetite (ferrous oxide)
FOS .... Factor of Safety
FPAC .... Federal-Provincial Advisory Committee
g .... Standard Gravity or gram(s)
$g/m^2/30$ day .... Gram(s) per square meter per 30 days
$g/m^2/a$ or $g/m^2/a$ or $g/m^2/year$ .... Gram(s) per square meter per annum (year)
$g/m^2/d$ .... Gram(s) per square meter
Ga .... Gigaannum (billion years)
GIS .... Geographical Information System
GN .... Government of Nunavut
GNDoE .... Government of Nunavut Department of Environment
H .... Horizontal
Ha .... Hectare(s)
HTO .... Hunters and Trappers' Organization
IBA .... Important Bird Area
IQ .... Inuit Qaujimajatuqangit
kg .... Kilogram(s)
kg/ha/a or kg/ha/year .... Kilogram(s) per hectare per year
kg N/ha/a or N kg/ha/a .... Kilogram(s) nitrogen per hectare per year
KI .... Key Indicator
km .... Kilometre(s)
km/h .... Kilometre(s) per hour
km^2 .... Square kilometre(s)
LIDAR .... Light Detection And Ranging
LSA .... Local Study Area
m .... Meter(s)
m asl .... Meter(s) Above Sea Level
mg/kg .... Milligram(s) per kilogram
ML/ARD .... Metal Leaching and Acid Rock Drainage
N .... Nitrogen
Na .... Not available/applicable
NAG .... Non Acid Generating Waste Rock
NH_3 .... Ammonia
NIRB .... Nunavut Impact Review Board
NO_2 .... Nitrogen dioxide
NP .... Neutralizing Potential
ORV .... Off-Road Vehicle
PAG .... Potentially Acid Generating Waste Rock
PGA .... Peak Ground Acceleration
PDA .... Potential Development Area

ppt .... Parts Per Trillion
RMR .... Rock Mass Rating
RSA .... Regional Study Area
RSPF .... Resource Selection Probability Function
SAR .... Species at Risk
SARA .... Species at Risk Act
SO_2 .... Sulphur dioxide
TSP .... Total Suspended Particle(s)
TSP/m^2/year .... Total Suspended Particle(s) per square meter per year
UCS .... Unconfined Compressive Strength
μg NO_2/m^3/a .... Microgram(s) nitrogen dioxide per cubic meter per year
μg/m^3 .... Microgram(s) per cubic meter
μg/m^3/a or ug/m^3/a .... Microgram(s) per cubic meter per annum
U.S. .... United States (of America)
V .... Vertical
VEC .... Valued Ecosystem Component
WHO .... World Health Organization
WMMP .... Wildlife Mitigation and Monitoring Plan
ZOI .... Zone of Influence