MARY RIVER PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME 9
CUMULATIVE EFFECTS AND OTHER ASSESSMENTS

DOCUMENT STRUCTURE

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Main Document

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- Impact Assessment Methodology

Volume 3
Project Description
- Project Description
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Volume 9
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- Transboundary Effects Assessment
- Navigable Water Assessment

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

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 - CUMULATIVE EFFECTS ASSESSMENT

1.1 INTRODUCTION

The Nunavut Impact Review Board (NIRB) defines a cumulative effect as:

> "…the impact on the environment that results from the incremental effects of a development when added to other past, present and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (NIRB, 2009)

This cumulative effects assessment (CEA) identifies the residual effects of the Mary River Project and the potential to interact with the residual effects of other projects or activities that could result in a greater effect to a valued component (VC) of the biophysical or socio-economic environments. The CEA consists of three main steps:

- Determine whether the Project will have a residual effect on identified valued components (VECs and VSECs, together referred to as VCs);
- If a residual effect is likely, assess the potential for the Project's residual effect to interact with residual effects resulting from other projects or activities (past, current, or future); and
- Determine if the interaction of the residual Project effect, in combination with other project effects, is likely to meaningfully influence a VC.

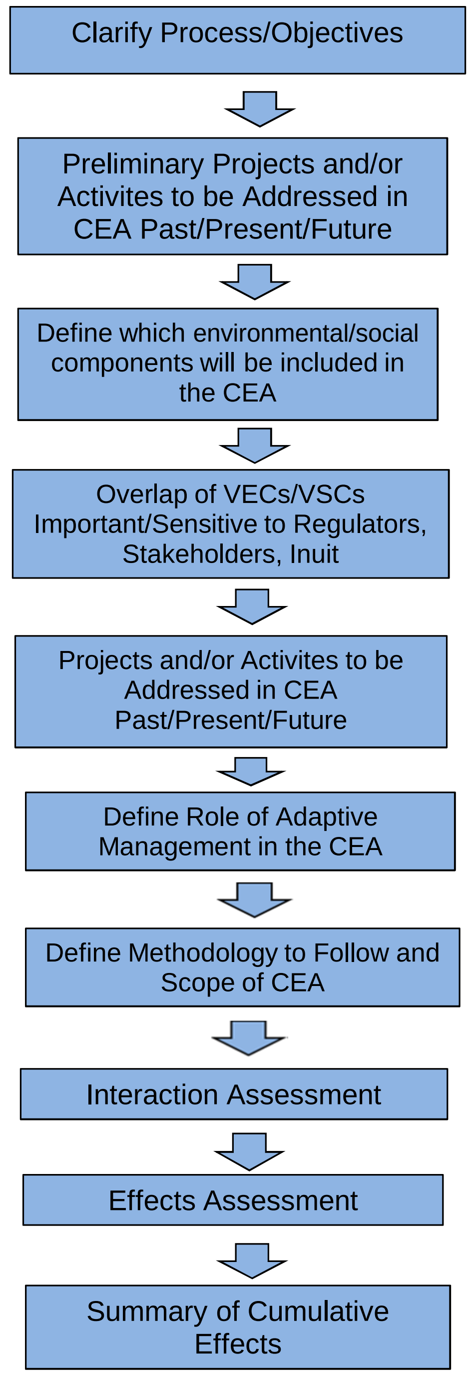
The assessment of a single project determines if *that* project is incrementally responsible for adversely affecting a VC beyond an acceptable level. The CEA must make clear to what degree the project under review is *alone* contributing to that total effect. Interactions are considered only if their assessment would influence the decision regarding approval by the regulatory reviewers.

1.2 APPROACH

1.2.1 Methodology

The CEA process adopted for this analysis is illustrated in Figure 9-1.1, which in accordance with the methodology put forth by the Canadian Environmental Assessment Agency (CEAA) (Hegmann *et al*., 1999), includes the following.

- Scoping:
  - Identification of Project residual effects and receiving VCs;
  - Identification of other past, present and future projects and activities with the potential to interact with residual Project effects; and
  - Determine where residual Project effects interact with other past, present and future projects and activities, resulting in the potential for cumulative effects.
- Analysis of cumulative effects;
- Identification of mitigation;
- Determination of significance; and
- Identification of monitoring.



NOTES:

1. ADAPTED FROM HEGMAN ET AL., 1999

BAFFINLAND IRON MINES CORPORATION	
MARY RIVER PROJECT	
CUMULATIVE EFFECTS ASSESSMENT FRAMEWORK	
Baffinland Iron Mines Corporation	REF No. **BL_Vol9_EXL_001**
	ᑎᑎᕋᐅᔭᖅᓯᒪᔪᖅ **FIGURE** **9-1.1** — REV A

A systematic screening method was used to identify and evaluate potential cumulative effects. The cumulative effects reported herein are based on residual effects identified in the discipline-specific impact statements (Volumes 4 through 8). On a VC specific basis, the zone of influence (ZOI) of residual Project effects was compared with the ZOI of other projects and activities. Cumulative effects were identified where an overlapping interaction in time and space was determined. Where cumulative effects were identified, they were ranked as described in Section 1.2.5.

For this assessment, cumulative effects were assessed when:

- A residual effect of the Project had a demonstrable effect (measured or reasonably expected) on a biophysical or human component; and
- It was reasonably foreseeable that the residual effect of the Project would interact with the effects of past, present, or future projects or activities.

For each residual Project effect, the CEA identified if there was:

- No anticipated interaction with other projects and activities that could result in cumulative effects;
- An anticipated interaction with other projects or activities, which could result in cumulative effects and available information allowed for consideration of measurable effects;
- An anticipated interaction with other projects or activities, which could result in cumulative effects and available information did not allow for consideration of measurable effects;
- An interaction with accidents and/or malfunctions of other projects and activities that could result in cumulative effects; these effects cannot be assessed, because they are dependent on other project/activity specific practises for prevention and response to accidents and malfunctions; and
- An interaction with accidents and/or malfunctions of other projects and activities, which could result in cumulative effects. Effects cannot be assessed due to the lack of information on the status or trends in the condition of the VC over time. Potential effects are dependent on the adoption and success of regionally based adaptive management practises.

1.2.2 Temporal Boundaries

Temporal boundaries define the period analyzed within which the Project or Project activities interact with environmental or socioeconomic components. The Project's own temporal boundaries are defined by Project phase as follows:

- Pre-development or Definition Phase (nine years - 2004 to 2012);
- Construction Phase (four years - 2013 to 2016);
- Operation Phase (21 years - 2017 to 2037); and
- Closure (three years - 2038 to 2040) and Post-Closure Phase (minimum five years – 2041 to 2045).

With respect to the above temporal boundaries, the following is noted:

- The Definition Phase is inclusive of all exploration and research programs, as well as the bulk sampling program carried out in 2007 and 2008; and
- The Closure and Post-Closure Phase, the period required for decommissioning and/or removing Project infrastructure.

The CEA considers the Project's residual effects in the context of the past, present and future actions of the Project and actions by others. The temporal boundary for the CEA was chosen based on the following criteria:

- The lifespan of the Mary River Project, including the pre-development, construction, decommissioning and monitoring phases (42 years); and
- To be inclusive of the lifespan of other projects and activities, where known or reasonably foreseeable.

Industrial development in the northern Baffin Island area started in the late 1970s with the development of the Nanisivik and Polaris mines, which opened in 1976 and 1980, respectively, and were preceded by several years of mineral exploration. Therefore, the temporal boundaries selected for the cumulative effects assessment is the 75-year period from 1970 to 2045.

1.2.3 Spatial Boundaries

A CEA scoping study area was adopted for initial consideration of other projects and activities that could potentially interact with the Project's residual effects (see Figure 9-1.2). The Nunavut settlement area boundary (4,025,445 km^2) was adopted, as it represents a sufficiently large scale to be inclusive of any other project or activity that could reasonably be foreseen to interact with the Project, and it represents NIRB's administrative boundary. Shipping to and from the Raglan Mine in the Nunavik region of Quebec was also included in the CEA scope. Current and future projects and activities in this area are listed in Section 1.3.3.

Study areas were determined on a VC-specific basis. The following describes the criteria and assumptions that were adopted for determining VC specific CEA study area boundaries.

Spatial boundaries were determined specifically for each VC on the basis of the following:

- To provide context to assess the magnitude of Project effects as well as interacting effects of other land uses;
- Overlaps with the expected ZOI likely affected by the Project;
- Conservative assumptions about the magnitude and probability of the effect;
- Adoption of an adaptive approach; and
- Large enough to allow meaningful assessment of VECs and VSECs that may be affected by the Project.

Where appropriate, they are different from (i.e., larger than) the boundaries for the corresponding residual Project effects;

- Set at a point at which potential cumulative effects become insignificant; and
- Determined based on ecological and/ or sociologically defensible rationale and/ or professional judgment.

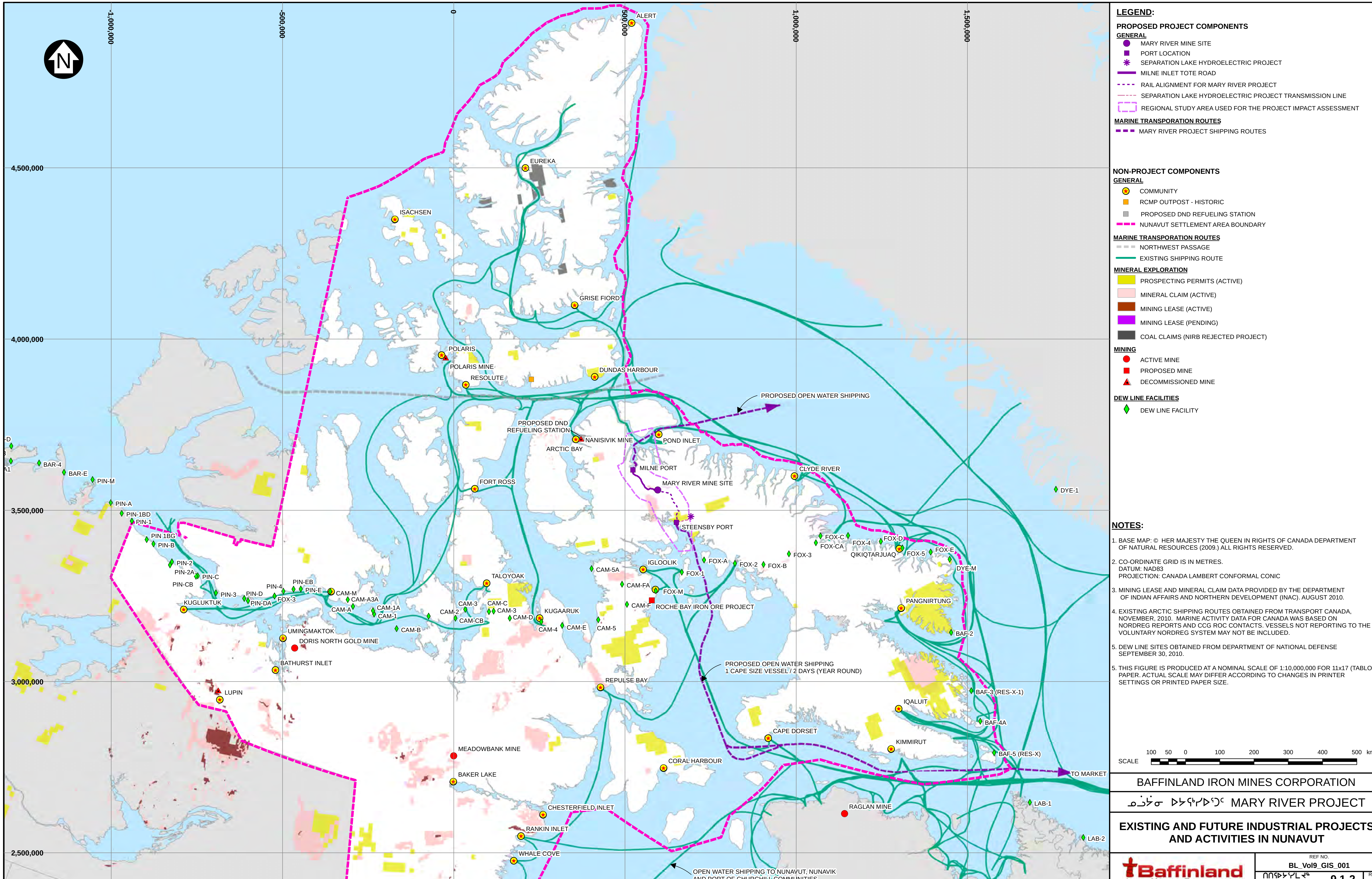


Figure ID: BL_Vol9_GIS_001 Existing and Future Industrial Projects and Activities in Nunavut Figure 9-1-2.mxd

1.2.4 Consideration of Alternative Development Scenarios

Several alternative means of delivering the Mary River Project were considered by Baffinland in the alternatives analysis (Volume 3, Section 6) as follows:

- Production rate - of greater, less than or equal to the proposed production rate of 18 Mt/a, which would not meaningfully affect the conclusions of the cumulative effects assessment;
- Power supply - the potential to induce the development of the potential hydro-electric scheme at Separation Lake, to supply power to the Project - evaluated in Section 1.3.2.16;
- Port location - no other port location was deemed viable in the alternatives analysis, so the cumulative effects of alternate port locations was not evaluated;
- Ore transport method - ore could potentially be transported to Steensby Port by truck;
- Railway routing to Steensby Port – five overland routes from the Mine Site to Steensby Port were evaluated and, while the selected route was identified to have fewer effects to the environment, none of the alignments are substantially different such that an evaluation of the cumulative effects of these scenarios is useful or meaningful; and
- Alternatives to year-round shipping - including open-water shipping only and/or decreasing the production rate - has been assessed with the use of year-round shipping via the Railway and Steensby Port and with open water shipping at a lower production rate via Milne Port.

Additionally, alternative development scenarios could include the mining of other iron ore deposits owned by Baffinland. These scenarios are described in Section 1.3.2.5.

1.2.5 Ranking of Cumulative Effects

The significance of cumulative effects uses the same evaluation criteria applied elsewhere in the EIS, as described in Volume 2, Section 3. This includes an effect's magnitude, duration, frequency, extent and reversibility and consideration of the significance determination in the original assessment for each VC.

1.2.6 Cumulative Effects of Accidents and Malfunctions and other Projects

Project related accidents and malfunctions are considered in the Project residual effects analysis (Section 3). There is no systematic inventory of historical accidents and malfunctions from other projects that could interact with the Mary River Project, so consequently it is not possible to quantitatively assess the potential contribution of cumulative effects from other project accidents and malfunctions. Although no residual effects from accidents and malfunctions are anticipated, the CEA considers the possibility of cumulative effects from accidents and malfunctions from shipping activities (Section 1.4.4).

The CEA also considers cumulative effects of potential environmental effects generated from an array of existing and proposed projects in Nunavut. Sources of uncertainty include imperfect knowledge of the scope of planned or proposed projects, potential changes and modifications to existing and planned projects and their interactions with shared environmental and social receptors. Therefore, the complexity associated with other projects scope and scale, and the inherent uncertainties associated with predicting future events and activities are greater in cumulative effects assessments. For example, project effects associated with existing mining operations (Meadowbank, Doris North, and, Raglan) are quantifiable, whereas potential effects from project under development (Roche Bay, Meliadine, and, Kiggavik) are less certain. As these planned projects evolve, more information on potential interactions will be available and the uncertainties with the cumulative effects predictions may in some instances be reduced or increased. Adaptive management and the use of information generated by regional institutions can assist in reducing uncertainties.

1.2.7 Adaptive Management

Baffinland has committed to mitigation, environmental management, adoption of best management practices, and monitoring in order to:

- Avoid, eliminate, or reduce adverse potential environmental effects of the Project, including cumulative effects;
- Verify the effectiveness of mitigation;
- Confirm effects predictions, including cumulative effects; and
- Contribute to a better understanding of the effects of mine development in Arctic regions and of potential cumulative effects in the North Baffin Region.

The data obtained through monitoring will help the proponent to continually improve the environmental management and environmental effects prediction. However, while Baffinland can manage effects of the Project, management of cumulative effects requires a coordinated, multi-stakeholder approach that focuses on managing specific effects on specific resources. In the absence of adequate data and jurisdiction for determining and managing cumulative effects, the best response to cumulative effects is adaptive management using coordinated information-sharing and feedback loops to reduce risk and increase the success of management actions. Baffinland has agreed to contribute data, where reasonable or possible, to the Nunavut General Monitoring Program with the objective of contributing to the knowledge base of changes to the long-term state and health of Nunavut.

Currently in development, the Nunavut General Monitoring Program (NGMP) is a regionally based monitoring program being developed as a requirement of the Nunavut Land Claims Agreement. The objective of the NGMP is to identify changes in the long-term state and health of Nunavut, identifying changes in the environment. The NGMP is being developed jointly by Nunavut Tunngavik Incorporated (NTI), the Government of Nunavut (GN), AANDC, Aboriginal Affairs and Northern Development Canada (formerly Indian and Northern Affairs Canada - INAC) and the Nunavut Planning Commission (NPC). With the intention of contributing to the avoidance and/or mitigation of negative cumulative effects in Nunavut, Baffinland is committed to contribute to the NGMP by sharing data used in the preparation of the EIS.

1.3 SCOPE

1.3.1 Project Components

Project components included in the assessment of cumulative effects include:

- Milne Port;
- Milne Inlet Tote Road;
- Mine Site;
- Railway;
- Steensby Port;
- Marine Shipping Routes within the Nunavut Settlement Area; and
- Accidents and Malfunctions.

Details of all the Project components are included in Volume 3.

1.3.2 Other Projects and Activities of Consideration

Projects and activities located within the CEA scoping area are shown on Figure 9-1.2. Other projects were identified as either certain or reasonably foreseeable based on the following definitions:

- **Certain:** Either the project or activity exists already or there is a high probability that it will proceed. This includes past and ongoing projects and activities as evidenced by existing disturbance areas and facilities, current land use tenures and activities, and documented land use.
- **Reasonably foreseeable:** There is some uncertainty about whether the action or project may proceed. NIRB (2009) defines reasonably foreseeable projects as those that are currently under regulatory review, or that will be submitted for regulatory review in the near future, as determined by the existence of a proposed project description, of letter of intent, or any regulatory application filed with an authorizing agency.
- **Induced:** Projects and/or activities that are more likely to occur if the Project proceeds.

Obtaining sufficient data for meaningful analysis is a challenge in evaluating the interactions of current and future projects and activities. Since future projects and activities are sometimes only conceptual, without formalized development plans, potential effects of many of these projects could not be accurately determined.

Other projects and activities were identified from stakeholder input, land use plans, government plans and published development plans for Nunavut. Other projects and activities that were considered for the potential to interact with Project VCs identified in the residual effects assessment include:

- Baffinland's previous exploration and bulk sampling programs;
- Baffinland's proposed monitoring programs concurrent with the Project;
- Mining and mineral exploration activities;
- Operating mines;
- Decommissioned mines;
- Induced mining projects;
- Marine transport/ shipping;
- Naval refuelling station;
- DEW-line decommissioning;
- Air transport;
- Military exercises;
- Traditional and recreational hunting, fishing and foraging;
- Communities;
- Tourism and commercial recreation activities;
- Hydroelectric facilities; and
- Climate change.

The following provides a description of other projects and activities and an evaluation of their potential to overlap with the Project's residual effects. Where there was a high degree of confidence that the other project or activity would not interact with any residual effects of the Project, it was removed from further consideration.

1.3.2.1 Baffinland's Exploration and Bulk Sampling Programs

The following summarizes the scope of Baffinland's activities in the region since 2004:

- Exploration started in 2004 with the establishment of an exploration camp at Mary River and drilling of Deposit No. 1;
- Drilling extended to adjacent Deposits No. 2 and 3 in 2007;
- A bulk sampling program was undertaken in 2007 and 2008, involving the mining of 113,000 t of iron ore, upgrade of the Milne Inlet Tote Road to all-season capability, establishment of camp and ship-loading facilities at Milne Port and shipment of supplies and ore in and out of Milne Port;
- Geotechnical investigations at Project development sites and along the Railway (helicopter-supported drilling program) over 2007 and 2008;
- Comprehensive environmental baseline studies from 2005 through 2008, including terrestrial and marine aerial surveys for wildlife; and
- Regional exploration programs, operation of established camp facilities, road maintenance and environmental monitoring programs in 2009 and 2010.

These programs were screened by NIRB and carried out in compliance with regulations and land use permits, water licences and other approvals. These activities are considered in the assessment.

1.3.2.2 Baffinland's Monitoring Programs Concurrent with the Project

The following summarizes the scope of Baffinland's proposed monitoring programs during the life of the Project:

- Socio-economic monitoring, consisting mainly of collection of human resources data;
- Ongoing stakeholder engagement, including meetings, updates and notifications, etc.;
- Ongoing operation of meteorological stations at each of the three development areas;
- Air quality and noise monitoring during the first few years of Operations to validate impact predictions - will include the installation and operation of equipment to monitor air, dustfall and noise levels in the vicinity of Project sites;
- Establishment of soil and vegetation sample plots in the vicinity of Project development sites;
- Monitoring of cliff-nesting raptors in relation to railway construction during construction and operation;
- Ongoing baseline research on seabirds;
- Periodic baseline contributions to shorebird monitoring (e.g., PRISM plots);
- Ground-based observational surveys of caribou along the Railway to observe trail use and behaviour in relation to these linear features;
- Logging wildlife sightings;
- A potential wildlife harvest study, including caribou and marine mammals;
- Ongoing operation of stream gauging stations around the Mine Site;

- Ongoing water, sediment quality and fish habitat monitoring in fulfilment of water licence, environmental effects monitoring and *Fisheries Act* authorization requirements; and
- A variety of marine monitoring programs to be conducted early in the Project life, including acoustic measurements of ore carriers, aerial marine surveys in Hudson Strait, and ship-board Inuit wildlife observers.

The monitoring program has been designed to be as non-intrusive as possible. For example, a hunter-harvest study is proposed in lieu of caribou aerial surveys (although Baffinland may contribute to a Government of Nunavut-led caribou collaring or other monitoring program) and bird and marine mammal aerial surveys will be carried out early during the Project life and will be either discontinued or reduced in frequency as the Project advances. These activities are considered in the assessment.

1.3.2.3 Designated Areas

Designated areas include parks, reserves and wildlife sanctuaries. Figure 9-1.3 illustrates designated areas in the Nunavut Settlement Area. The two most relevant to the assessment, based on proximity and size, include Sirmilik National Park and the Bylot Island Migratory Bird Sanctuary.

Sirmilik National Park

Established in 2001, the park is bordered by Lancaster Sound and Baffin Bay to the north and east, Admiralty and Elwin Inlets to the west, and Pond Inlet and Eclipse Sound to the south. The nearest community is Pond Inlet, located south of Bylot Island. The park is distinguished for its natural and cultural heritage, including sea bird colonies, whales, polar bears and archaeological sites. Activities include tourist visits to experience the ecology and remoteness of the area, mainly between May and September, and involve backcountry camping, ski touring, wildlife viewing and boating.

Bylot Island Migratory Bird Sanctuary

Federally designated in 1965, the Bylot Island Migratory Bird Sanctuary is classified as a Category IV Habitat Species Management Area by the International Union for the Conservation of Nature (IUCN).

Located within the boundaries of Sirmilik National Park, the 12,635 km^2 bird sanctuary provides habitat for large populations of Thick-billed murres, Black-legged Kittiwakes and Greater Snow Geese. Of the total area, 1,500 km^2 is a marine zone with intertidal and sub-tidal components. Associated with the sanctuary is a seasonally used goose research station.

These designated areas were not carried forth into the assessment because of limited activities associated with the areas. Tourism-related shipping is included and is described below.

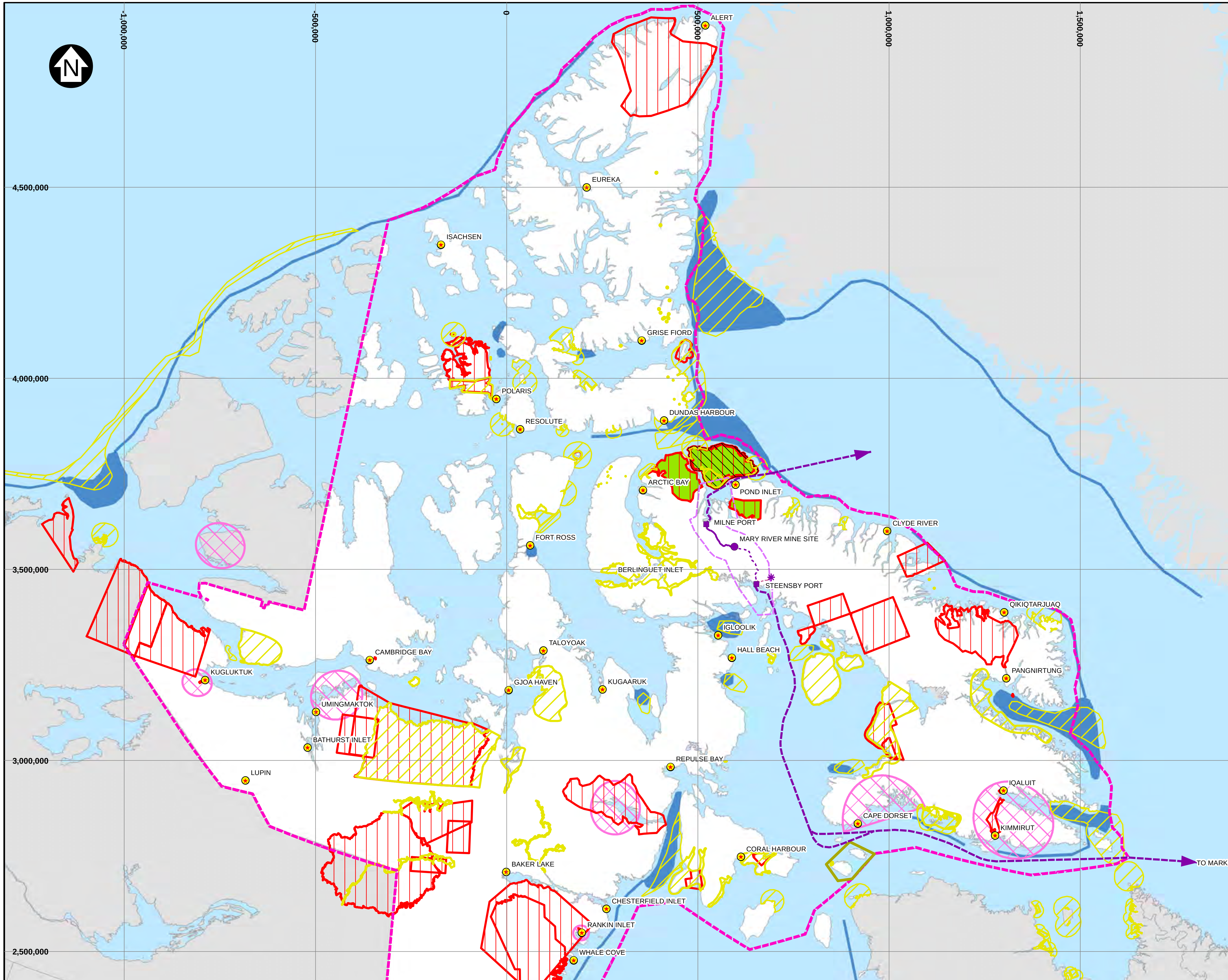


Figure ID: BL_Vol9_GIS_002 Special Management Areas Figure 9-1-3.mxd

LEGEND:

PROPOSED PROJECT COMPONENTS

GENERAL

- MARY RIVER MINE SITE
- PORT LOCATION
- SEPARATION LAKE HYDROELECTRIC PROJECT
- MILNE INLET TOTE ROAD
- RAIL ALIGNMENT FOR MARY RIVER PROJECT
- SEPARATION LAKE HYDROELECTRIC PROJECT TRANSMISSION LINE
- REGIONAL STUDY AREA USED FOR THE PROJECT IMPACT ASSESSMENT

MARINE TRANSPORATION ROUTES

- MARY RIVER PROJECT SHIPPING ROUTES

NON-PROJECT COMPONENTS

GENERAL

- COMMUNITY
- NUNAVUT SETTLEMENT AREA BOUNDARY
- SHORE LEAD
- POLYNYAS

SPECIAL MANAGEMENT AREA

- AREA OF EQUAL USE AND OCCUPANCY NUNAVUT AND NUNAVIK
- BYLOT ISLAND BIRD SANCTUARY
- SIRMILIK NATIONAL PARK
- IMPORTANT TERRESTRIAL AND MARINE BIRD HABITAT
- CRITICAL WILDLIFE AREA
- WILDLIFE AREA OF SPECIAL INTEREST (GYRFALCON & PEREGRINE FALCON)

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. CO-ORDINATE GRID IS IN METRES.
   DATUM: NAD83
   PROJECTION: CANADA LAMBERT CONFORMAL CONIC
3. CONSERVATION FEATURES PROVIDED BY THE GOVERNMENT OF NUNAVUT (2006) AND PARKS CANADA (2006).
4. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:10,000,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

SCALE 100 50 0 100 200 300 400 500 km

BAFFINLAND IRON MINES CORPORATION

ᓄᓘᔮᓂ ᐅᔭᕋᒃᓯᐅᕐᑐᑦ MARY RIVER PROJECT

SPECIAL MANAGEMENT AREAS

Baffinland Iron Mines Corporation

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ᑎᑎᕋᐅᔭᕐᓯᒪᐊᖅ FIGURE	9.1-3	REV 0

1.3.2.4 Mining and Mineral Exploration Activities

There are several companies and individuals prospecting and holding active mineral claims within a 100 km radius of the proposed Mary River Project as illustrated in Figure 9-1.2. These companies include:

- Prospecting permits (active):
  - Mark Raguz.
- Mineral claims (active):
  - 569514 Alberta Ltd.
  - BHP Billiton Diamonds Inc.
  - Ray - Dor Resources Ltd.
  - De Beers Canada Inc.
  - Diamonds North Resources Ltd.

Prospecting and exploration activities are often intermittent and unpredictable. Claims may be visited one year and then not again for decades. The sites identified in proximity to the Mary River Project are not known to have camps established. Exploration in this region, by Baffinland as well as others has taken place and can be expected to continue into the future.

Included for Consideration in the CEA: Yes

Although limited information is available on previous and existing exploration activities, this activity has been included in the assessment in a qualitative way.

1.3.2.5 Operating Mines

Raglan Mine at Deception Bay (Xstrata Nickel)

The Raglan Mine is a large nickel/copper mine in the Nunavik region of northern Quebec, approximately 100 km south of Deception Bay. It has an airport 22 km from the mine site and a gravel road leading from the mine site to the seaport at Deception Bay. The mine began production in 1997 and has an anticipated mine life of 30+ years. It produces 1.3 million tonnes of ore annually from three underground mines and two open-pit operations. Xstrata is looking to increase production to 2.0 million tonnes per year by 2013. The site does not connect to any community, so workers are flown in from local communities or from the south (Ville de Rouyn-Noranda, Quebec) and housed on-site. Concentrate is shipped from Deception Bay to Quebec City and shipped by rail to Xstrata's smelting facility in Falconbridge, Ontario. Once smelted, the concentrate is sent back to Quebec City by rail and shipped to Norway to be refined.

Shipping of concentrate and supplies is carried out year-round. Seven or eight trips are made annually, with five or six trips in the ice-free season and two trips between January and March. Inbound trips bring supplies (including petroleum products) and outbound trips carry nickel concentrate.

Included for Consideration in the CEA: Yes

Shipping activities (including icebreaking) associated with the Raglan Mine overlap with the Project's plans to ship through Hudson Strait, and were therefore considered to have the potential for cumulative effects to marine wildlife. An increase in shipping frequency of 67 % above the current shipping traffic was applied to consider the planned increase in production mentioned above, increasing the number of trips to 13 annually, including three to four each winter between January and March.

Doris North Mine (Newmont Mining Corp.)

The Doris North Mine is located 75 km northeast of Umingmaktok and 5 km south of Roberts Bay in the Hope Bay gold belt. The project consists of an underground mine, fuel storage facility, camp, access road, airstrip, tailings management facility, barge landing facility, and a modular portable mill and processing plant.

The Doris North Mine Project was approved by NIRB and underground mining was anticipated to commence in the fall of 2010, but Newmont has elected to postpone mining to focus on an expanded exploration program. There are 230 workers on-site, with 400 anticipated for full operation.

Mine life is permitted for 2.5 years, though work is underway to expand the current mine and prolong its life to 2016 (project extension proposal anticipated to be submitted to NIRB in the near future). In addition, Newmont is exploring the development of the neighbouring Madrid and Boston properties (see "induced projects" in Section 1.3.2.7). Newmont has indicated that they plan to have the second phase operational by 2014, with mining operations extended to 2029.

Doris North is anticipated to contribute one tug and up to five barges each year for the two years the mine is proposed to be in operation. All shipping will take place during the open-water season and within the West Kitikmeot Region of Nunavut, with no overlap of shipping activities with the Mary River Project.

Affected communities, those near the Project and from which employment is targeted, are all located within the West Kitikmeot Region of Nunavut.

Included for Consideration in the CEA: No

The Doris North Mine is located over 1,000 km from the Project with no overlapping shipping routes and is not expected to interact with residual effects from the Mary River Project. The Doris North Mine was not included in the CEA.

Meadowbank Mine (Agnico-Eagle Mines Ltd.)

The Meadowbank Mine is located approximately 100 km north of Baker Lake in Nunavut's Kivalliq region. The open pit gold mine, opened in 2010, is expected to produce about 300,000 ounces of gold annually through 2019. The site is accessed via Baker Lake, which provides summer shipping through Hudson Strait. Supplies for construction and operations are shipped to Baker Lake from late July to early October. Most ship traffic consists of shallow-draft tug and barge operations and small vessels.

Kivalliq Region communities have been AEM's focus for employment, and the socio-economic zone of influence is confined mainly to the Kivalliq Region of Nunavut. Given the project's physical location, it is not expected to have land-based or socio-economic cumulative effects with the Mary River Project; its potential overlap with the Mary River Project is expected to be related to shipping through Hudson Strait.

Included for Consideration in the CEA: Yes

Shipping activities associated with the Meadowbank mine overlap with the Project's plans to ship through Hudson Strait and were therefore considered to have the potential for cumulative effects to marine wildlife.

For this assessment, it has been assumed that AEM uses up to two resupply vessels per year through Hudson Strait, until the projected end of operations in 2019.

1.3.2.6 Reasonably Foreseeable Future Mines

Roche Point Iron Ore Project (Roche Bay PLC/Advanced Explorations Inc.)

The Roche Point Iron Ore Project, located 60 km south of Hall Beach on the Melville Peninsula, is a disclosed project in advanced stages of exploration, yet to enter into the NIRB review process. The potential for a project was first identified in 1965. Between 1975 and 1985, 3,000 m of exploratory drilling was undertaken, a feasibility study was carried out and an airstrip was built. Economic uncertainty caused the project to lie dormant until 1997, when Roche Bay PLC assumed ownership. Exploratory drilling did not resume until 2007. The company and its joint venture operator Advanced Explorations Inc. (AEI) control four mineral leases, containing five mineralized zones with a 20 km strike length. A preliminary economic assessment (PEA) report, issued on June 10, 2009, contemplated an open-pit mine with a production rate of 5 Mt/a and a pelletizing plant that would process 1 Mt/a of iron nuggets annually for a 20-year period (Met-Chem Canada Inc., 2010). The capital cost was estimated at $1.11 billon. The PEA report does not outline definitive shipping plans, but acknowledges the need to ship 1 Mt of pellets each year and the likely necessity of year-round shipping, most likely to the Port of Churchill, Manitoba, to supply the American steel industry. Europe was identified as a possible second market.

A feasibility study was recommended in the PEA, although AEI has not yet announced commencement of such a study. A review of the public registry indicates that no application for mine development had been submitted to NIRB in 2010. However, NIRB (2009) indicated that the Roche Bay Project may be a reasonably foreseeable project for this CEA.

Given the project's physical location, the Point Riche project is not expected to have land-based cumulative effects with the Mary River Project; its potential overlap with the Mary River Project is expected to be related to shipping through southern Foxe Basin and Hudson Strait, and likely overlap of socio-economic influence as the project is located in the Baffin Region.

Included for Consideration in the CEA: Yes

As specified in NIRB's Guidelines, and as it is a reasonably foreseeable project, the Roche Point Iron Ore Project was considered in the CEA. It has been assumed that 1 Mt/a of iron nuggets are shipped year-round from the Roche Bay project site south of Hall Beach, through the south of Foxe Basin and across Hudson Bay to the Port of Churchill, using Panamax sized ships of approximately 50,000 DWT. This would necessitate approximately 20 voyages per year for shipment of ore (roughly one ship every 2 to 3 weeks), plus annual resupply during open water (assumed to be 4 ships per year). The Roche Bay shipping will pass through the southern portion of Foxe Basin and western Hudson Strait into Hudson Bay. Based on the absence of a Project Proposal filed with NIRB, it has been assumed in this assessment that the Roche Bay project will start construction in 2016 and will operate from 2019 through 2039.

Kiggavik Project (AREVA Resources Inc.)

The Kiggavik Project is a proposed uranium mining and milling project near Baker Lake. AREVA submitted its Project Proposal in November 2008 and the project is currently in a Part 5 environmental review. AREVA submitted its DEIS to NIRB in December 2011.

The Project Proposal states that all project-related shipping will originate from Churchill, Manitoba.

Included for Consideration in the CEA: No

While the Kiggavik Project qualifies as a reasonably foreseeable project, there is no overlap of activities that may result in cumulative effects.

Meliadine Project (Agnico-Eagle Mines Ltd.)

The Meliadine Project is a proposed gold mine near Rankin Inlet. Agnico-Eagle (owner-operator of the Meadowbank Gold Mine near Baker Lake) submitted its Project Proposal in April 2011, and in September 2011 NIRB announced that the Minister of Aboriginal Affairs and Northern Development Canada (AANDC) had designated the project for a Part 5 review by NIRB. The land-based portion of the Project is entirely within the Kivalliq Region and the socio-economic zone of influence is stated to be the communities adjacent to the Project. The established harbour at Itivia (Rankin Inlet) is expected to receive barge traffic of supplies from either Churchill, Manitoba, or Canada's eastern ports during the open-water season (AEM, 2011). The level of traffic associated with the project is not known but can be expected to be much higher during the 3-year construction phase and reduced during the operating phase.

Given Meliadine's physical location, it is not expected to have land-based or socio-economic cumulative effects with the Mary River Project; its potential overlap with the Mary River Project is expected to be related to shipping through Hudson Strait.

Included for Consideration in the CEA: Yes

The Meliadine Project may involve shipping from Canada's east coast, which may overlap with shipping associated with the Mary River Project through Hudson Strait. The frequency of shipping is unknown, so for the purpose of this assessment the dates and frequency of shipping has been assumed to be four ships each open water season from 2013 through 2015 (the assumed construction phase) and two ships per year through the estimated 10-year operation phase (2016 through 2025).

Bathurst Port and Road Project (Bathurst Inlet Port and Road Joint Venture)

The Bathurst Inlet Port and Road (BIPR) Project consists of a port on Bathurst Inlet in the Kitikmeot Region, a new 211 km all-weather road connecting to the existing Tibbitt to Contwoyto Winter Road (TCWR) at Contwoyto Lake. The project is proposed to resupply local communities in the region and to facilitate mineral exploration and development projects in the region.

While a Part 5 environmental review by NIRB had progressed with a DEIS submitted in December 2007, the proponent suspended the review in mid-2008 and on July 7, 2011, announced to NIRB that it would no longer be re-engaging the NIRB review of the project.

Included for Consideration in the CEA: No

The BIPR Project does not qualify as a reasonably foreseeable project, given that the proponent has announced its intent not to re-engage the environmental review process.

High Lake Project (MMG Canada Inc.)

The High Lake Project is a proposed polymetallic mine (copper, zinc, gold and silver), with an associated road and new port at Grey's Bay, west of Bathurst Inlet, in the Kitikmeot Region. The original proponent, Wolfden Resources, submitted its Project Proposal in late 2006; this was later accepted by NIRB as its DEIS. The project has changed ownership through a series of corporate mergers and take-overs. The most recent correspondence on NIRB's Public Registry is a letter dated May 18, 2011, from NIRB to the current owner, Minerals and Metals Group (MMG), requesting the company provide a comprehensive project update to NIRB by January 6, 2012, in order to re-engage the review of the Project.

Given this project's physical location, it is not expected to have land-based or socio-economic cumulative effects with the Mary River Project; its potential overlap is expected to be related to shipping through Lancaster Sound and Baffin Bay. Two shipping routes were described and considered in the Project Proposal, one of which would involve shipping through Lancaster Sound and Baffin Bay, though the proponent indicated that a preferred route had not been selected.

Included for Consideration in the CEA: No

While the High Lake Project qualifies as a reasonably foreseeable project according to NIRB's definition (existence of a filed Project Proposal), the proposal no longer appears to be current. Further, the scope of the High Lake Project is similar to that of the BIPR Project, and it is understood the MMG is now considering focusing its attention on its IZOK lake project before High Lake.

Hackett River Project (Sabina Silver and Gold Inc.)

The Hackett River Project is a proposed silver mine near Bathurst Inlet in the Kitikmeot Region of Nunavut. Sabina Silver and Gold Inc. (Sabina) submitted a Project Proposal in January 2008, and in September 2008 the AANDC Minister referred the project to a Part 5 review by NIRB. A DEIS for the project has not been submitted to date.

The Project Proposal described a project that would rely on the proposed BIPR Project for road and port infrastructure; the company stated that, should the BIPR Project not proceed, it would construct its own road and a port at Bathurst Inlet. Given that the BIPR Project is no longer advancing, presumably the Hackett River Project will require its own port and road facilities. The Project Proposal describes concentrate to be shipped out by 50,000 DWT ice-class bulk carriers, with a total of 10 trips between August and mid-October. The ice-class bulk carriers will transfer their cargoes to other vessels at a terminal in Greenland for delivery to the final destination, smelters in Europe or North America (Sabina, 2008).

Included for Consideration in the CEA: Yes

While the Hackett River Project qualifies as a reasonably foreseeable project according to NIRB's definition (existence of a filed Project Proposal) and the file with NIRB remains active even though a DEIS has not yet been submitted.

Given the project's physical location, it is not expected to have land-based or socio-economic cumulative effects with the Mary River Project; its potential overlap is expected to be related to shipping through Lancaster Sound and Baffin Bay, and it will presumably add to the shipping traffic associated with the BIPR Project. For the CEA, it has been assumed that ten ships a year over a 3-year construction and 14-year operation phase would pass through Lancaster Sound. The start-up date for the project has been assumed to be 2015; this is considered the earliest the project would start given a DEIS has not yet been filed with NIRB.

Nunavik Nickel Project (Jien Mining Canada Inc.)

The Nunavik Nickel Project is proposed at Deception Bay in Nunavik (northern Quebec) near the current operating Raglan Mine. The project completed an environmental assessment in 2008, but construction has not started.

Given the project's physical location, it is not expected to have land-based or socio-economic cumulative effects with the Mary River Project; its potential overlap is expected to be related to shipping through Hudson Strait, with potential overlapping effects to marine mammals and marine mammal harvesting.

Included for Consideration in the CEA: Yes

Baffinland was not able to locate a description of this project. It is anticipated that the Nunavik Nickel Project will require a similar intensity of shipping as the initial Raglan Mine, which included shipment of concentrate approximately three to four times per year and annual resupply during the open water season. The start-up date for the project has been assumed to be 2015, in the absence of any additional information.

1.3.2.7 Induced Developments

Mary River Project: Deposits No. 2 through 9

This EIS is focused on the development of Deposit No. 1, which has been the subject to a positive feasibility study. Potential exists in the future for the current Project to be extended by increasing mine life and/or production rate and developing additional deposits. Since the 1960s, Deposit No. 1 was one of four known high-grade iron ore deposits (Deposits No. 1 through 4). In the past two years, Baffinland's regional exploration program has identified an additional five deposits (Deposits No. 5 to 9); locations are shown on Figure 3-1.2 in Volume 3. Exploration of these additional deposits to date has consisted of preliminary drilling at Deposits No. 4 and 5 in 2010 and surface sampling of the remaining deposits. Their viability to support mining has not yet been proven.

Deposits No. 2 and 3 are located within the Mary River watershed upstream of Deposit No. 1. Due to the close proximity to the proposed mining infrastructure of Deposit No. 1, little additional infrastructure would be required. If Deposits No. 2 and 3 were mined concurrent with Deposit No. 1, additional material handling and stockpiling infrastructure would be required at the Mine Site. More trains would move the additional ore to Steensby Port or Milne Port, and more material handling infrastructure (i.e., stockpiles, rail unloading equipment, conveyors and ship loading equipment) would be required at one or both ports, as appropriate. Additional vessel traffic would be needed to ship the additional ore to market.

Drilling at Deposits No. 4 and 5 commenced in 2010. Ore from these deposits, if developed, could be transported to Milne Port over the Milne Inlet Tote Road, which is close by, or could be accessed by an approximately 25-km railway spur from the Mine Site. New mining infrastructure would be required, as would additional material handling and shipping at one or both ports, as described above.

Deposits No. 6 through 9 were discovered in 2010 and have been sampled at surface only. These deposits are located within tens of kilometres (up to 50 km) of either the Mine Site or the Railway.

Mine infrastructure developed for Deposit No. 1 can be expected to improve the prospects of developing a portion of these ore bodies, all of them, or potentially yet unidentified iron ore deposits. It should be emphasized that, despite the existing infrastructure, development of any or all of these deposits within the temporal boundaries of this assessment is not a foregone conclusion. Strictly speaking, they do not meet the definition of "reasonably foreseeable projects".

Included for Consideration in the CEA: Yes

Baffinland has assumed that development of additional deposits would practically involve an approximate doubling of production output over the temporal scale of the assessment, through the development of one or two additional deposits. It is considered highly unlikely that more than this would be developed before the end of life of the current Project, based on a capital outlay required within this timeframe, the number of additional ships that would be required to transport this ore, and ore throughput capacity limitations at the Steensby port. Finally, there is only so much capacity in the market for additional iron ore.

Establishment of shipping activities for the Mary River Project is not expected to induce the use of the same shipping corridors for other projects. It may assist with a better operational understanding of commercial icebreaking at this level, which could lead to more of this activity occurring in the future in this part of the Arctic and elsewhere.

Madrid and Boston Properties (Newmont Mining Corp.)

The Madrid and Boston properties, part of the Hope Bay gold belt, were acquired by Newmont Mining Corporation in early 2008. They represent a reasonably foreseeable extension of the Doris North property, which will be operational in 2011. These properties continue to undergo advanced exploration, but have yet to enter into the permitting process.

Included for Consideration in the CEA: No

The Doris North mine is not anticipated to interact with residual effects from the Mary River Project, and was therefore not included in the evaluation, so by extension these potential extensions of the Doris North Project have also not been included.

1.3.2.8 Decommissioned Mines

Polaris Mine (Cominco) 1980-2002

Located 96 km north of the community of Resolute, the Polaris zinc mine was an underground mine on Little Cornwallis Island, over 600 km from the Mary River Project. It was approved for development in 1979 and closed in July 2002. Clean-up of the site occurred over two years, with environmental monitoring commitments extending to 2011.

Included for Consideration in the CEA: Yes

As specified in NIRB's Guidelines, the decommissioned Polaris mine has been considered for potential historic overlaps in shipping through Lancaster Sound and Baffin Bay.

Nanisivik Mine (Breakwater Resources) 1976-2002

The Nanisivik Mine is a decommissioned zinc-lead mine near Arctic Bay; it closed because of low metal prices and declining resources. Mine reclamation started in April 2003 and is on-going. Remaining facilities include an airport 7 km southwest of the mine, still in operation as the main airport for Arctic Bay, and a port and dock 2.7 km north of the mine, currently used by the Canadian Coast Guard for training. The dock is being considered by the federal government for use as a naval refuelling station for Arctic offshore patrol ships, as described in Section 1.3.3.8.

Included for Consideration in the CEA: Yes

As specified in NIRB's Guidelines, the decommissioned Nanisivik mine has been considered for potential historic overlaps in shipping through Lancaster Sound and Baffin Bay, and with respect to potential historic effects to caribou.

Jericho Mine (Shear Minerals Ltd.) 2006-2008

The Jericho mine, 420 km northeast of Yellowknife, was Nunavut's first and only diamond mine. Operations were suspended in 2008 as a result of financial losses caused by operational difficulties, the high value of the Canadian dollar, high oil prices and the short operating season of the ice road. Shear Diamonds (Nunavut) Corp purchased the mine from the original owner (Tahera Diamond Corp.) in July 2010. A Type A water licence was issued by the Nunavut Water Board in December, 2011, for the re-commissioning, operation and ultimate reclamation of the project

Included for consideration in the CEA: No

Shear Minerals intends to initiate processing of the recovery reject pile in 2012; however, no interactions are be anticipated.

1.3.2.9 Shipping

General

Shipping within the CEA study area (the Nunavut Settlement Area) generally consists of the following:

- Annual resupply of fuel and dry cargo to communities and industrial outposts (mines and exploration projects) during the open-water shipping season;
- Transport of goods to and from the Port of Churchill, through Hudson Strait, during the open-water shipping season;
- Transport of ore concentrate from operating mines (historic, current and reasonably foreseeable), in open water and through ice;
- Government icebreaking exercises;
- Canadian military exercises; and
- Limited transit of commercial and recreational vessels through the Northwest Passage.

Primary shipping lanes within and peripheral to the study area are shown on Figure 9-1.2. Marine transport and shipping records for Eclipse Sound, Baffin Bay, Foxe Basin and Hudson Strait from 2002 to 2010, from the Canadian Coast Guard Marine Communications and Traffic Services Program (INNAV), were obtained from Xpert Solutions Technologiques (2010) and are presented in Table 9-1.1.

Shipping Lanes with the Potential to Interact with the Project

Hudson Strait

- Open-water shipping occurs through Hudson Strait to access Igloolik, Hall Beach, Cape Dorset, Kimmirut, the seven communities in the Kivalliq Region of Nunavut along the west coast of Hudson Strait, Nunavik communities in Northern Quebec, and the Port of Churchill. Most of this traffic occurs during the open-water season approximately July through November (Table 9-1.1). During the open-water season for the 9-year period of 2002 through 2010, an average of 187 ships reported being within Quebec waters of Hudson Strait. Another 108 ships reported being in Nunavut waters of Hudson Strait, although it is expected that there is overlap with these two numbers, where the same ships have passed through Nunavut and Quebec waters during the same voyage.

Table 9-1.1 Current Levels of Shipping in the Eastern Arctic (2002-2010)

AREA	SUB AREA	January			February			March		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Eclipse Sound	Tay Sound	2	2	2	na	na	na	1	1	1
Eclipse Sound	White Bay	2	2	2	na	na	na	1	1	1
Eclipse Sound	Eskimo Inlet	2	2	2	na	na	na	1	1	1
Eclipse Sound	Milne Inlet	2	2	2	na	na	na	1	1	1
Eclipse Sound	Tremblay Sound	2	2	2	na	na	na	1	1	1
Eclipse Sound	Koluktoo Bay	2	2	2	na	na	na	1	1	1
Eclipse Sound	Eclipse Sound	2	2	2	na	na	na	1	1	1
Foxe Basin	Steensby Inlet	2	2	2	na	na	na	1	1	1
Foxe Basin	NW Foxe Basin	2	2	2	na	na	na	1	1	1
Foxe Basin	NE Foxe Basin	2	2	2	na	na	na	1	1	1
Foxe Basin	E Foxe Basin	2	2	2	na	na	na	1	1	1
Foxe Basin	SE Foxe Basin	2	2	2	na	na	na	1	1	1
Foxe Basin	SW Foxe Basin	2	2	2	na	na	na	1	1	1
Frobisher Bay	Frobisher Bay	2	2	2	na	na	na	1	1	1
Hudson Strait	Hudson Strait QC	1	3	2	1	1	1	1	2	1
Hudson Strait	Ungava Bay	2	2	2	na	na	na	1	1	1
Hudson Strait	Hudson Strait NU	1	3	2	1	1	1	1	2	1
Hudson Bay	Hudson Bay	2	2	2	na	na	na	1	1	1
Baffin Bay	Baffin Bay	2	2	2	na	na	na	1	1	1
Lancaster Sound	Lancaster Sound	2	2	2	na	na	na	1	1	1
Eclipse Sound	Navy Board Inlet	2	2	2	na	na	na	1	1	1

Table 9-1.1 Current Levels of Shipping in the Eastern Arctic (2002-2010) (Cont'd)

AREA	SUB AREA	April			May			June		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Eclipse Sound	Tay Sound	1	2	2	3	3	3	2	2	2
Eclipse Sound	White Bay	1	2	2	3	3	3	2	2	2
Eclipse Sound	Eskimo Inlet	1	2	2	3	3	3	2	2	2
Eclipse Sound	Milne Inlet	1	2	2	3	3	3	2	2	2
Eclipse Sound	Tremblay Sound	1	2	2	3	3	3	2	2	2
Eclipse Sound	Koluktoo Bay	1	2	2	3	3	3	2	2	2
Eclipse Sound	Eclipse Sound	1	2	2	3	3	3	2	2	2
Foxe Basin	Steensby Inlet	1	2	2	3	3	3	2	2	2
Foxe Basin	NW Foxe Basin	1	2	2	3	3	3	2	2	2
Foxe Basin	NE Foxe Basin	1	2	2	3	3	3	2	2	2
Foxe Basin	E Foxe Basin	1	2	2	3	3	3	2	2	2
Foxe Basin	SE Foxe Basin	1	2	2	3	3	3	2	2	2
Foxe Basin	SW Foxe Basin	1	2	2	3	3	3	2	2	2
Frobisher Bay	Frobisher Bay	1	2	2	3	3	3	1	3	2
Hudson Strait	Hudson Strait QC	1	3	2	3	3	3	2	6	4
Hudson Strait	Ungava Bay	1	2	2	3	3	3	1	2	1
Hudson Strait	Hudson Strait NU	1	2	2	2	3	3	1	7	3
Hudson Bay	Hudson Bay	2	2	2	3	3	3	1	2	2
Baffin Bay	Baffin Bay	1	2	1	3	3	3	1	2	1
Lancaster Sound	Lancaster Sound	1	2	2	3	3	3	2	2	2
Eclipse Sound	Navy Board Inlet	1	2	2	3	3	3	2	2	2

Table 9-1.1 Current Levels of Shipping in the Eastern Arctic (2002-2010) (Cont'd)

AREA	SUB AREA	July			August			September		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Eclipse Sound	Tay Sound	1	3	2	1	5	3	1	9	3
Eclipse Sound	White Bay	1	3	2	1	5	3	1	9	3
Eclipse Sound	Eskimo Inlet	1	3	2	1	5	3	1	9	3
Eclipse Sound	Milne Inlet	1	3	2	1	11	4	1	11	5
Eclipse Sound	Tremblay Sound	1	3	2	1	11	4	1	9	5
Eclipse Sound	Koluktoo Bay	1	3	2	1	5	3	1	9	4
Eclipse Sound	Eclipse Sound	1	5	3	13	25	18	5	19	11
Foxe Basin	Steensby Inlet	1	3	2	1	5	3	1	9	3
Foxe Basin	NW Foxe Basin	1	4	2	4	11	7	4	20	10
Foxe Basin	NE Foxe Basin	1	3	2	1	6	3	2	14	6
Foxe Basin	E Foxe Basin	1	3	2	1	6	3	2	12	6
Foxe Basin	SE Foxe Basin	1	4	2	1	10	6	2	11	7
Foxe Basin	SW Foxe Basin	1	4	3	3	14	8	7	20	12
Frobisher Bay	Frobisher Bay	15	31	23	10	33	20	13	33	19
Hudson Strait	Hudson Strait QC	39	61	46	29	61	41	29	60	43
Hudson Strait	Ungava Bay	11	25	19	8	16	12	7	19	13
Hudson Strait	Hudson Strait NU	18	29	23	14	38	26	21	38	27
Hudson Bay	Hudson Bay	17	42	25	10	66	37	20	50	35
Baffin Bay	Baffin Bay	8	21	12	24	47	32	16	41	24
Lancaster Sound	Lancaster Sound	4	9	5	16	31	23	8	27	14
Eclipse Sound	Navy Board Inlet	1	4	2	3	8	5	2	10	5

Table 9-1.1 Current Levels of Shipping in the Eastern Arctic (2002-2010) (Cont'd)

AREA	SUB AREA	October			November			December		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Eclipse Sound	Tay Sound	1	3	2	1	4	2	na	na	na
Eclipse Sound	White Bay	1	3	2	1	4	2	na	na	na
Eclipse Sound	Eskimo Inlet	1	4	2	1	4	2	na	na	na
Eclipse Sound	Milne Inlet	1	7	3	1	4	2	na	na	na
Eclipse Sound	Tremblay Sound	1	7	2	1	4	2	na	na	na
Eclipse Sound	Koluktoo Bay	1	3	2	1	4	2	na	na	na
Eclipse Sound	Eclipse Sound	2	7	4	1	4	2	na	na	na
Foxe Basin	Steensby Inlet	1	3	2	1	4	2	na	na	na
Foxe Basin	NW Foxe Basin	2	10	6	1	4	3	na	na	na
Foxe Basin	NE Foxe Basin	1	5	3	1	4	2	na	na	na
Foxe Basin	E Foxe Basin	1	5	2	1	4	2	na	na	na
Foxe Basin	SE Foxe Basin	2	10	4	1	4	2	na	na	na
Foxe Basin	SW Foxe Basin	2	11	6	1	5	2	na	na	na
Frobisher Bay	Frobisher Bay	14	33	19	1	10	5	1	2	2
Hudson Strait	Hudson Strait QC	26	57	43	5	28	14	1	4	2
Hudson Strait	Ungava Bay	6	17	10	1	11	6	na	na	na
Hudson Strait	Hudson Strait NU	17	38	26	1	13	6	1	4	2
Hudson Bay	Hudson Bay	16	58	34	1	15	7	na	na	na
Baffin Bay	Baffin Bay	6	17	10	1	5	2	1	1	1
Lancaster Sound	Lancaster Sound	1	9	3	1	4	2	na	na	na
Eclipse Sound	Navy Board Inlet	1	4	2	1	4	2	na	na	na

NOTE(S):

1. SOURCE DATA FROM THE CANADIAN COAST GUARD MARINE COMMUNICATIONS AND TRAFFIC SERVICES PROGRAM (INNAV), SUMMARIZED BY XPERT SOLUTIONS TECHNOLOGIQUES INC., 2010

- Limited shipping (icebreaking) occurs during periods of ice-cover through Hudson Strait. According to Table 9-1.1, there are currently 1-2 transits in each winter month. The icebreaker *MV Arctic*, operated by Fednav, sails through Nunavut waters of Hudson Strait to call at the Raglan Mine at Deception Bay in Northern Quebec.

Foxe Basin

- Open-water shipping occurs through Foxe Basin mainly for sea-lift operations, but possibly commercial fishing as well, based on the vessels that have been tracked. An average of 28 vessels per year travel into the northwest and southwest of Foxe Basin and an average of ten vessels enter Steensby Inlet.
- Limited icebreaking appears to have occurred within various portions of Foxe Basin including Steensby Inlet each winter, with an average of a ship a month over the nine year period.

Baffin Bay

- A level of traffic similar to that in Hudson Strait also passes through Baffin Bay during the open-water shipping season. Traffic is expected to include community sea-lifts to Pangirtung, Qikiqtarjuaq, Clyde River, Pond Inlet, Arctic Bay and Resolute; commercial fishing; cruise ships; ships transiting the Northwest Passage; and government surveillance vessels.
- Limited icebreaking appears to have occurred within various portions of Baffin Bay each winter, with an average of one to two ships per ice-cover month over the nine year period.

Eclipse Sound (Including Milne Inlet)

- Open-water shipping occurs in Eclipse Sound mainly for sea-lift operations, but possibly commercial fishing as well, based on the vessels that have been tracked. An average of 36 vessels per year travel into Eclipse Sound and an average of 14 enter Milne Inlet. Baffinland's exploration and bulk sampling operations have contributed to these numbers. Traffic into Eclipse Sound is expected to include community sea-lifts, commercial fishing, cruise ships, ships transiting the Northwest Passage and government surveillance vessels.
- Limited icebreaking appears to have occurred within various portions of Eclipse Sound including Milne Inlet each winter, with an average of a ship a month over the 9-year period.

Canadian Coast Guard Activities

The Canadian Coast Guard (CCG) carries out icebreaking for commercial vessels to move efficiently and safely. The CCG also carries out northern resupply, transporting dry cargo and fuel during the annual resupply of northern settlements and government sites when commercial operators are unable. In addition, the CCG is involved in search and rescue, environmental response to ship-sourced spills and maritime security. The dock at the decommissioned Nanisivik mine is used by the CCG for training purposes.

In the Baffin region, CCG icebreaking service dates (day/month) are as follows:

Hudson Bay:	03/07-24/10
Foxe Basin:	20/08-15/09
Hudson Straight:	03/07-24/10
East Baffin:	14/08-18/09
Parry Channel East:	10/08-15/10
Pelly:	12/08-13/10

CCG activities are recorded within the shipping activity levels discussed above and totalled in Table 9-1.1.

Nanisivik Naval Facility

In 2008, DND initiated a feasibility study for the construction of a naval refuelling station using the decommissioned Nanivisik mine dock. The station is expected to be the base for Arctic offshore patrol ships as part of Canada's effort to exert sovereignty in the Arctic, operating from July through October and shut-down and unmanned the remainder of the year. DND submitted a full document for Part 4 screening by NIRB in the fall of 2011 and the screening process is not yet completed, pending DND responses to intervener responses. According to information available on the NIRB public registry, construction was expected to begin in 2011, with operations beginning in 2015, and the naval facility will serve frigates, destroyers, coastal defense vessels, heavy gulf icebreakers, medium icebreakers and commercial tankers (Stantec, 2011). No data on anticipated level of shipping traffic was provided by DND.

Included for Consideration in the CEA: Yes

As specified in NIRB's Guidelines, the naval facility is a reasonably foreseeable project and is included in the CEA. Baffinland has not located any publicly available information on the anticipated shipping operations that may be associated with the naval station, which limits the ability to incorporate the activity into the assessment.

1.3.2.10 DEW Line Decommissioning

The Distant Early Warning (DEW) Line was a system of 63 radar stations (42 of which were in Canada) positioned along a line across the north from Alaska to Baffin Island. Additional sites were located in Greenland and Iceland. The stations generated hazardous wastes that were poorly disposed of on-site (judged by today's standards) following deactivation. Decommissioning activities have been under way and have generally involved moving one or more supply barges in and out from each site and regular air traffic to local airstrips to move clean-up staff during summer months. DEW Line decommissioning of facilities on or around Baffin Island by AANDC and DND are anticipated to be completed by 2012 (Plato, pers. comm.). Sites Fox 1, Fox A, Fox D and Fox E are Class 3 sites, meaning they are low priority and are not currently slated for decommissioning.

Included for Consideration in the CEA: Yes

These recent activities have involved air and marine traffic and human presence in the region. Given that the DEW Line sites are operated remotely and most remediation activities are currently winding down, the sites are expected to have limited land-based and socio-economic effects, and that marine based resupply activities are included in the ship traffic estimates presented in Table 9-1.1.

1.3.2.11 Air Transport

Air transport is the lifeline of Nunavut communities and regular scheduled flights transport people, perishable items and other goods. Fixed-wing aircraft and helicopters are used for access and exploration of resource projects in Nunavut. Most active mines and exploration projects in northern Canada use fixed-wing aircraft to transport shift workers.

Included for Consideration in the CEA: Yes

Air transportation was considered in general terms where it could contribute to GHG emissions and/or sensory disturbance to terrestrial wildlife and/or marine mammals.

1.3.2.12 Military Exercises

Operation Nanook is an annual joint exercise of Canada's Maritime Command and the Canadian Coast Guard for the training for disaster preparedness, as well as for Arctic sovereignty patrols. The exercises last approximately three weeks and take place in or around August. In 2010, Operation Nanook was conducted in proximity to Pond Inlet and assembled three ships, divers and helicopters, as well as troops from Denmark and the United States. In 2011 a similar exercise was undertaken in the Resolute Bay area.

Included for Consideration in the CEA: Yes

Military exercises occurring near Pond Inlet have the potential to interact with the residual effects of Project shipping activities. Interactions are most likely along the Project's shipping routes in the vicinity of Pond Inlet. It is expected that ship-related traffic is included in Table 9-1.1.

1.3.2.13 Communities, and Traditional and Recreational Hunting, Fishing and Foraging

Communities have a terrestrial footprint and represent a human presence in the region. On-going traditional sustenance and recreational (sport) hunting, fishing and foraging activities occur in the terrestrial and marine environments, concentrated mainly concentric to the communities but also extending outward hundreds of kilometres, primarily targeting game species.

Included for Consideration in the CEA: Yes

The potential for interactions exists with Project effects on traditional and recreational hunting species and thus on traditional sustenance. The possibility of induced hunting/fishing pressure as a result of the Project was considered, and while the IIBA is expected to allow traditional harvesting by workers, it is expected that the harvesting actually undertaken during work hours will be limited due to the 12-hour work-days.

1.3.2.14 Tourism and Commercial Recreation Activities

Tourism and commercial recreation activities on northern Baffin Island are primarily:

- Adventure tourism: where participants engage with the natural and cultural uniqueness of the area (e.g., kayaking, hunting, hiking and nature watching). Tourism numbers are low and generally confined to the summer months; and
- Cruise ships: travelling through Pond Inlet and past Sirmilik National Park several times each summer. There is also an increasing trend in use of the Northwest Passage by private and commercial recreation vessels.

Included for Consideration in the CEA: Yes

The main overlap of tourism activities with the Project is expected to be related to shipping during the open water season. Cruise ship traffic is included in the shipping frequency statistics presented in Table 9-1.1.

1.3.2.15 Potential Separation Lake Hydroelectric Project

A hydroelectric project is being considered by Baffinland to meet the needs of the Mary River Project. A site at Separation Lake was identified, roughly 100 km east of the proposed Steensby Port (see Figure 9-1.2). The hydropower project, which would be induced only if the Mary River Project proceeds, is anticipated to create a reservoir, a power generation facility and a transmission line to the Mary River Project, connecting at the proposed Steensby Port. The feasibility of this project is being evaluated and the Project has yet to enter into the NIRB review process. Development of the Separation Lake hydroelectric project would be contingent on the approval and development of the Mary River Project, future consideration by management and approval from regulators.

Included for Consideration in the CEA: Yes

Strictly speaking, the Separation Lake Hydroelectric Project does not qualify as "reasonably foreseeable project", according to the definition. However, because Baffinland has acknowledged the intent to investigate the feasibility of the project as an alternate energy supply to supplement the Project, it has been included as a reasonably foreseeable induced future project in this assessment.

1.3.2.16 Seismic Study

The Eastern Canadian Arctic Seismic Experiment was blocked by a Nunavut court in 2010 as a result of concern for northern marine mammals and the people that depend on them. The project, jointly run by Natural Resources Canada and Germany's Alfred Wegener Institute, aimed to study the composition of the sub-sea continental crust of Baffin Bay.

Included for Consideration in the CEA: No

As a result of uncertainty over the future of marine seismic research activities in proximity to Project activities, seismic study is not considered a reasonably foreseeable future activity and therefore was not considered in the CEA.

1.3.2.17 Commercial Fishery

There are small-scale shrimp and offshore turbot fisheries near Pangirtung, as well as an unused Arctic char quota near Steensby Inlet. A feasibility assessment of the possibility of a fishery in Pond Inlet has been initiated, but the preliminary results suggest a commercial fishery is not likely at this time.

Included for Consideration in the CEA: No

There is no reasonably foreseeable interaction between the current and future fishery and the Project and consequently the commercial fishery was not included in the CEA.

1.3.2.18 Climate Change

Global climate change is expected to accelerate in the next century, notably in the Arctic, where average annual temperatures are anticipated to increase, precipitation is expected to increase, sea ice is expected to decline, reflecting less solar radiation, and the area of land covered by snow is expected to decline. Evidence of the recent warming of the Arctic is found in records of increasing temperatures, melting glaciers, sea ice and permafrost, as well as rising sea levels.

Key Project related considerations:

- Reduced sea ice may result in an increase in marine transport and access to resources; and
- Increased icebreaking will affect traditional winter travel, hunting and affect marine mammals.

Included for Consideration in the CEA: Yes

As specified in the Guidelines, effects of climate change were considered in the CEA.

1.3.3 Summary of Other Projects and Activities

Criteria used for this screening of other projects and activities were based on their potential for interaction with the Project. For instance, if the other project did not have any measured or potential effect on a Project

VC, it was excluded from further consideration. If a project or activity was too far away for any overlapping interaction to occur, it was not considered further in the CEA. On completion of screening, the projects and activities that were carried forward into the CEA are:

- Baffinland's previous exploration and bulk sampling programs;
- Baffinland's proposed monitoring programs concurrent with the Project;
- Past, current and future mineral exploration in the region, by Baffinland and others;
- Operating mines (Meadowbank mine in the Kivalliq Region and Raglan Mine in Nunavik) and reasonably foreseeable mines (Roche Bay Iron Ore Project);
- Decommissioned mines (former Nanisivik and Polaris mines);
- Induced development of other Mary River iron ore deposits;
- Marine transport/shipping;
- Nanisivik Naval Facility;
- Air transport;
- Military exercises;
- Traditional and recreational hunting, fishing and foraging;
- Communities;
- Tourism and commercial recreation activities;
- Baffinland's potential Separation Lake hydroelectric project; and
- Climate change.

Marine shipping is a key aspect of the cumulative effects assessment; a summary of the forecasted summer and winter shipping traffic for the northern (Milne Port) and southern (Steensby Port) shipping routes within the Nunavut Settlement Area are summarized below.

Summary of Forecasted Shipping Activities in Milne Inlet, Lancaster Sound, Baffin Bay

The baseline shipping levels in Eclipse Sound and Baffin Bay are presented in Table 9-1.1. It is assumed that in many instances the reportings may capture the arrival and return voyages of a ship entering the area. For the months of August and September, an average of 29 ship occurrences were recorded in Eclipse Sound and 56 in Baffin Bay. It is assumed that tourism-related ship traffic is included in this number and will remain relatively constant over time, in the absence of any information suggesting otherwise. Construction of the proposed Nanisivik Naval Facility is likely to increase marine shipping in the area, though the level of military shipping in relation to current military exercises undertaken in the past several years is unknown; it is assumed in this assessment that this traffic remains relatively constant.

Mary River Project will require open water shipping through Baffin Bay, Pond Inlet, and Eclipse Sound to Milne Inlet during the 4-year construction phase (2013 through 2016), with up to 23 vessels arriving in Years 1 and 2 of construction, and reducing to 6 vessels in the final two years of construction (the latter being within the range of variation of shipping from year to year). For the first two years, project-related shipping in Eclipse Sound will nearly double the baseline. During this period, it is possible that shipping related to the Hackett River Project may add up to 10 ships per year to this number, though these ships are unlikely to enter Eclipse Sound and are likely to pass through Lancaster Sound into Baffin Bay, and the schedule and certainty of this project remains unknown given it has been more than 3 years since the Project Proposal was filed and no DEIS has been submitted.

The credible scenario of doubling of production (and shipping) of the Mary River Project is unlikely to change shipping in the area meaningfully; it is possible that a second construction phase could occur at some time in the future associated with an expansion.

Neither the Mary River Project nor other reasonably foreseeable projects involve icebreaking in these waters over the temporal boundaries under assessment.

Summary of Forecasted Shipping Activities in Foxe Basin and Hudson Strait

The baseline shipping levels in Foxe Basin and Hudson Strait are presented in Table 9-1.1. The baseline during the ice covered period includes icebreaking to the Raglan Mine in Nunavik and other incidental ice-breaking, and shipping during the open water season represents shipping related to community resupply (in Foxe Basin, Hudson Strait and Hudson Bay), and commercial shipping to and from the Port of Churchill.

Mary River Project will require open water shipping through Hudson Strait and Foxe Basin during the 4-year construction phase (2013 through 2016), with up to 24 vessels arriving in Years 1 and 2 of construction, and reducing to seven to ten vessels in the final two years of construction. Approximately 100 voyages a year will occur over the 21 operational life of the mine. Shipping frequency is highest during the operational phase of the project.

In northern Foxe Basin there is a relative absence of shipping traffic such that the Mary River Project shipping traffic (under the base case and induced scenario of doubled production) will dominate.

In southern Foxe Basin there is the possibility of overlapping shipping with the Roche Bay Project, which may add 20+ ships per year (likely to be year-round shipping) to the Mary River Project`s 100+ transits (or 200+ transits under doubled production).

In Hudson Strait there will be a number of potential contributors to increased shipping over the baseline of an annual average of 114 ship occurrences within Nunavut waters of Hudson Strait, 202 ship occurrences in Quebec waters of Hudson Strait (presumably with some overlap in these numbers):

- The proposed Mary River Project (100+ round trip transits under the base case; 200+ round trip transits under the doubled production scenario; year-round)
- Proposed Roche Bay Iron Ore Project (20+ round trip transits; year-round)
- Raglan Mine (up to 13 round trip transits; year-round)
- Proposed Nunavik Nickel Mine (up to eight round trip transits; year-round)
- Proposed Meliadine Gold Project (assumed two round trip transits; during open water only)

Based on review of the above, the induced doubling of production of the Mary River Project would be the dominant increase in ship traffic through Hudson Strait, with the other projects adding another 40+ transits per year.

1.3.4 Screening of VEC and VSECs for Potential Cumulative Effects

The VECs and key indicators assessed in the EIS that resulted in residual effects after mitigation were screened for the applicability of cumulative effects, considering the outcome of the impact assessments (Volumes 4 through 8) and the potential projects/activities that could contribute to cumulative effects. The key VECs and VSECs identified as the focus on the cumulative effects assessment are presented in Tables 9-1.2 and 9-1.3.

The screening considers whether a VEC/VSEC/Key Indicator is likely to be subjected to effects from other past, present or reasonably foreseeable projects or activities, given the nature of the VEC/key indicator.

Tables 9-1.2 and 9-1.3 also indicate the spatial boundaries selected for each VEC and key indicator.

The VECs/VSECs/Key Indicators identified as potentially being affected cumulatively by the Project and other projects and activities were carried forth for assessment.

Table 9-1.2 Screening of VECs/VSECs and Key Indicators for Potential Cumulative Effects

VEC/VSEC	Key Indicator(s)	Spatial Boundary for CEA	Rationale for Inclusion in CEA
Climate change	Greenhouse gas emissions	Nunavut Settlement Area (NSA)	GHG emissions from a single project are typically negligible, but climate change is a cumulative effect arising from global GHG emissions
Air quality	Air quality	Air quality LSA	Expansions of the existing Project can contribute cumulatively to local air quality effects
Noise	Noise levels	Noise LSA	Expansions of the existing Project can contribute cumulatively to local noise effects
Vegetation	Abundance and diversity Plant health Culturally valued plants	Terrestrial RSA	Additional development within the terrestrial RSA has the potential to cumulatively affect vegetation
Migratory birds and habitat	Peregrine falcon Snow geese King and Common eider Lapland Longspur Red-throated loon	Terrestrial RSA	Additional development within the terrestrial RSA has the potential to cumulatively affect bird key indicators
Terrestrial mammals and habitat	Caribou	Range of the North Baffin caribou herd	Additional development within the range of the herd has the potential for cumulative effects
Freshwater quantity and quality	Water quantity Water quality	Freshwater LSAs	Additional development within the range of the herd has the potential for cumulative effects
Freshwater biota	Arctic char	Freshwater RSA	Additional development within the range of the herd has the potential for cumulative effects
Sea ice	Landfast ice	Marine LSA	Icebreaking may occur from other projects
Marine water and sediment quality	Marine water and sediment quality	Marine LSA	Increased production rates will increase ore throughput at port sites
Marine habitat and biota	Marine habitat Arctic char health Invasive species introduction	Marine LSA	Increased production rates will increase ore throughput at port sites
Marine mammals	Ringed seals Bearded seals Walrus Beluga whale Narwhal Bowhead whale Polar bear	Marine RSA	Shipping and harvesting throughout the marine RSA have the potential to cumulatively affect marine mammals

Table 9-1.3 Screening of VSECs and Key Indicators for Potential Cumulative Effects

Population Demographics	Demographic stability	North Baffin LSA	Additional projects drawing employment from the same communities could cumulatively affect demographic stability through in- or out-migration
Human health and well-being	Substance abuse Community and social stability	North Baffin LSA	The Mary River Project and additional projects could draw employment from the same communities, affecting the availability of abused substances
Community infrastructure and services	Competition for skilled workers	North Baffin LSA	The Mary River Project could compete for workers within the direct-hire communities, adversely affecting staffing to provide community services
Cultural Resources	Archaeology	RSA	Additional development within the RSA has the potential for cumulative effects
Land and resource use	Inuit Harvesting, Travel and Camps	Land use study area	Additional development within the land use study area has the potential to cumulatively affect land use

1.4 ASSESSMENT

The following section describes potential cumulative effects identified for each Valued Component and Key Indicator. A summary of identified cumulative effects is presented in Table 9-1.4.

1.4.1 Atmospheric Environment

1.4.1.1 Climate Change - Greenhouse Gas Emissions

Increased GHG emissions from all Project components in all Project phases are expected to interact with GHG emission from other potential projects and activities, specifically all existing and reasonably foreseeable mines, shipping and air transport, Mary River Deposits No. 2 through 9 and construction of the Separation Lake hydroelectric project. Overall, global climate change effects such as GHG levels related to Project activities are insignificant. However, the Project GHG contributions represent a substantial increase in Nunavut GHG emissions, a measurable portion of Canadian mining GHG contributions and a small but not infinitesimal portion of Canada's overall emissions.

The proponent is committed to developing an adaptive management strategy to work towards reducing the Project's relative contribution to GHG emissions in Nunavut. Project GHG data will be shared with the Nunavut General Monitoring Program to assist that program with managing GHG emissions in Nunavut.

1.4.1.2 Air Quality

Project activities will result in residual effects in the LSA for measured air quality criteria (CO, N, SO_2, NO_2, $PM_{2.5}$, PM_{10} and TSP) that are predicted to be not significant (Volume 5, Section 2). Within a common airshed or air quality LSA, the following other projects/activities may occur, causing cumulative effects to air quality:

- Concurrent development of either one or both of Deposits No. 2 and 3 while Deposit No. 1 is being mined. Emissions from combustion, waste incineration and fugitive dust emissions from both operations could cumulatively affect local air quality through increased concentrations of criteria air

Table 9-1.4 Cumulative Effects Summary

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	**Direction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**	
GREENHOUSE GASES								
Greenhouse gas emissions	Negative	Reduce project emissions to the extent possible	Level 1 - minor in relation to global emissions	Level II - life of mine	Level III - Continuous	Level III - beyond the RSA	Level III - irreversible	Not Significant
AIR QUALITY								
Air quality emissions of criteria of concern (COC) at the Mine Site from concurrent development of Deposits No. 2 and/or 3	Negative	Implement air quality abatement measures, in Project design and/or as adaptive management	Level II, possibly Level III	Level II - life of mine	Level III - Continuous	Possibly Level II for some parameters, based on current project	Level I - reversible	Not Significant
Air quality emissions of criteria of concern (COC) along the Milne Inlet Tote Road or Railway, from concurrent development of Deposits No. 2 and/or 3, or development of other deposits in the region that utilize the tote road or railway	Negative	Implement air quality abatement measures, in Project design and/or as adaptive management	Level II, possibly Level III	Level II - life of mine	Level III - Continuous	Possibly Level II for some parameters, based on current project	Level I - reversible	Not Significant
Air quality emissions of criteria of concern (COC) at Milne Port or Steensby Port from larger tonnages of ore handled through the port sites, from concurrent development of Deposits No. 2 and/or 3, or development of other deposits in the region, and construction of the Separation Lake hydroelectric site staged from Steensby Port	Negative	Implement air quality abatement measures, in Project design and/or as adaptive management	Level II, possibly Level III	Level II - life of mine	Level III - Continuous	Level I, or possibly Level II	Level I - reversible	Not Significant

Table 9-1.4 Cumulative Effects Summary (Cont'd)

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	Direction	Mitigation Measure (s)	Magnitude	Duration	Frequency	Extent	Reversibility	
NOISE								
Increased noise within the noise study areas of each of the Project sites, resulting from an increased mining production rate and construction of the Separation Lake hydroelectric project (applicable to Steensby Port)	Negative	Implement noise abatement measures, in Project design and/or as adaptive management	Level I for main Project, could increase to Level II with additional activities	Level II - life of mine	Level III - Continuous	Level I, or possibly Level II	Level I - reversible	Not Significant
VEGETATION								
Reduction in vegetation abundance and diversity within the terrestrial RSA	Negative	Minimize area of disturbance	Level I - Effect expected to be indistinguishable from natural variation	Level III - beyond life of the Project (permanent)	Level I - Infrequent	Level I - will occur within the PDA	Level II - partially irreversible (some natural regeneration will occur, post-closure)	Not Significant
Reduction in vegetation health due to deposition of dust and metals in soil	Negative	Dust suppression	Level I - Effect expected to be indistinguishable from natural variation	Level III - beyond life of the Project (permanent)	Level III - Continuous	Level I, or possibly Level II	Level III - irreversible	Not Significant
Reduction in culturally valued vegetation (represented by blueberries)	Negative	Minimize area of disturbance	Level I - Effect expected to be indistinguishable from natural variation	Level III - beyond life of the Project (permanent)	Level III - Continuous	Level I, or possibly Level II	Level III - irreversible	Not Significant

Table 9-1.4 Cumulative Effects Summary (Cont'd)

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	**Direction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**	
TERRESTRIAL WILDLIFE AND HABITAT								
Reduction in caribou habitat	Negative	Minimize area of disturbance; manage dust emissions; minimize noise and other sources of sensory disturbance	Level I - Effect expected to be indistinguishable from natural variation	Level III - beyond life of the Project (permanent)	Level III - Continuous	Level III - confined to RSA	Level II - partially irreversible (some natural regeneration will occur, post-closure)	Not Significant
Reduction in caribou movement	Negative	Utilize existing transportation corridors for future development activities	Level I - Effect expected to be indistinguishable from natural variation	Level II - life of mine	Level III - Continuous	Level III - confined to RSA	Level I - reversible	Not Significant
Caribou mortality	Negative	Apply mitigation in current Project to minimize potential for additional mortality	Level I - Effect expected to be indistinguishable from natural variation	Level II - life of mine	Level I - Infrequent	Level II - confined to LSA	Level I - reversible	Not Significant
Migratory birds	Negative	Apply mitigation in current Project to minimize potential for additional mortality	Level I - Effect expected to be indistinguishable from natural variation	Level II - life of mine	Level I - Infrequent	Level II - confined to LSA	Level I - reversible	Not Significant
FRESHWATER QUANTITY AND QUALITY								
Doubling of water takes from water supply lakes at Milne Port, the Mine Site and Steensby Port	Negligible	No mitigation required - water taking is below thresholds	Level I - Effect expected to be indistinguishable from natural variation	Level II - life of mine	Level III - Continuous	Level II - confined to LSA	Level I - reversible	Not Significant

Table 9-1.4 Cumulative Effects Summary (Cont'd)

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	**Direction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**	
Increased loading of runoff from mining areas into the Mary River	Negative	Water management (diversion to alternate receiving waters) or water treatment, if necessary	Level II - Effect expected to be moderate magnitude following mitigation, meeting compliance requirements of water licence, fisheries authorization and aquatic effects monitoring (MMER) requirements.	Level II - life of mine	Level II - Intermittent	Level II - confined to LSA	Level I - reversible	Not Significant
FRESHWATER FISH								
Effects to Arctic char health and habitat resulting from water quality effects	Negative	Mitigation to be identified within an authorization under the *Fisheries Act*. Compliance with water licence and aquatic effects monitoring under the MMER.	Level I - Effects expected to be low magnitude after mitigation	Level II - life of mine	Level II - Intermittent	Level II - confined to LSA	Level I - reversible	Not Significant
SEA ICE								
Disruption of fast ice (ringed seal habitat)	Negative	Confine ice breaking to narrow corridor to manage disturbance of fast ice to less than 10 % threshold	Level II - Effect expected to approach but not exceed established threshold.	Level II - life of mine	Level III - Continuous	Level II - confined to LSA	Level I - reversible	Not Significant

Table 9-1.4 Cumulative Effects Summary (Cont'd)

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	**Direction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**	
Changes to marine water quality at port sites due to more frequent shipping and discharge of ballast water	Negative	Ballast water exchange as required by law	Level I - Effects expected to be low magnitude after mitigation	Level II - life of mine	Level II - Intermittent	Level II - confined to LSA	Level I - reversible	Not Significant
Effects to marine biota, including Arctic char, due to potential water and sediment quality changes.	Negligible	Apply mitigation for water and sediment quality	Level I - Effects expected to be low magnitude after mitigation	Level II - life of mine	Level II - Intermittent	Level II - confined to LSA	Level I - reversible	Not Significant
RINGED SEAL								
Increased disruption of fast ice in Steensby Inlet	Negative	Confine ice breaking to narrow corridor to manage disturbance of fast ice to less than 10 % threshold	Level II - Effect expected to approach but not exceed established threshold	Level II - life of mine	Level III - Continuous	Level II - confined to LSA	Level I - reversible	Not Significant
BEARDED SEAL								
Habitat change, disturbance, and masking.	Negative	Apply mitigation in current Project	Level I - low (habitat change); Level II - moderate (disturbance, masking)	Level II - life of mine	Level III - Continuous	Level II - confined to LSA	Level I - reversible	Not Significant
WALRUS								
Habitat change, disturbance, and masking.	Negative	Apply mitigation in current Project	Level I - low	Level II - life of the Project	Level III - Frequent	Level I - confined to LSA	Level I - reversible	Not Significant

Table 9-1.4 Cumulative Effects Summary (Cont'd)

Potential Effects			Evaluation Criteria					Rated Significance of Residual Effects
Effect	**Direction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**	
NARWHAL								
Habitat change, disturbance, and masking.	Negative	Apply mitigation in current Project	Level I - low (habitat change); Level II - moderate (disturbance, masking)	Level II - life of the Project	Level III - Frequent	Level I - confined to LSA; possibly Level II - beyond the LSA and within the RSA	Level I - reversible	Not Significant
BELUGA WHALE								
Habitat change, disturbance, and masking.	Negative	Apply mitigation in current Project	Level I - low (habitat change); Level II - moderate (disturbance, masking)	Level II - life of the Project	Level III - Frequent	Level I - confined to LSA; possibly Level II - beyond the LSA and within the RSA	Level I - reversible	Not Significant
BOWHEAD WHALE								
Habitat change, disturbance, and masking.	Negative	Apply mitigation in current Project	Level I - low (habitat change); Level II - moderate (disturbance, masking)	Level II - life of the Project	Level III - Frequent	Level I - confined to LSA; possibly Level II - beyond the LSA and within the RSA	Level I - reversible	Not Significant
POLAR BEAR								
Habitat change, disturbance, and possibly mortality.	Negative	Apply mitigation in current Project	Level I - low	Level II - life of the Project	Level III - Frequent	Level I - confined to LSA	Level I - reversible	Not Significant

NOTE(S):
1. CACs = CRITERIA AIR CONTAMINANTS [TSP, PM10, PM2.5, SO2, NO2, CO, Fe, Mn, As, Ca, Co and POI (potential acid input).

contaminants, or CACs; (TSP = total suspended particulate; particulate matter <10 µ diameter and <2.5 µ = PM10 and PM2.5; sulphur dioxide = SO_2; nitrogen dioxide = NO_2; carbon monoxide = CO, iron = Fe; manganese = Mn; arsenic = As; calcium = Ca; cobalt = Co; and potential acid input = POI). The magnitude of air quality effects would likely be similar to the proposed mining operation at Deposit No. 1 but could result in higher magnitude effects; will likely be confined to or slightly beyond the LSA (moderate level extent); of medium duration; and reversible. With additional mitigation/adaptive management measures, the effects of increased air quality are predicted to be not significant.

- Additional mining operations, at Deposits No. 2, 3, at the Mine Site or at other deposits identified during regional exploration, would likely result in increased CAC emissions along either the Milne Inlet Tote Road (if ore is hauled to Milne Port) or the Railway (if ore is hauled to Steensby Port). The emissions would be expected to be an increment of predicted emissions of the planned Project and are likely not significant.
- Additional mining operations, at Deposits No. 2, 3, at the Mine Site or at other deposits identified during regional exploration would likely result in increased CAC emissions at either the Milne Port or Steensby Port, depending upon where ore is transported. Similar to the assessment for the Mine Site above, the emissions would be expected to be an increment of predicted emissions of the planned Project and are likely not significant.

It is expected that if the magnitude of effects to air quality were to unexpectedly increase too high (Level III) magnitude, these effects could be mitigated by design or by adaptive management measures to bring such effects to a lower magnitude, resulting in cumulative effects that are not significant.

1.4.1.3 Noise

Like air quality, noise emissions will also increase incrementally over the Project under the same scenarios of increased mining activity and material handling through transportation infrastructure, or from construction of the Separation Lake hydroelectric project staged from Steensby Port. The resultant cumulative effects are predicted to be not significant.

1.4.2 Terrestrial Environment

With respect to the terrestrial environment, the following VCs and key indicators have been evaluated for cumulative effects:

- Vegetation;
- Migratory birds and habitat (four key indicator species); and
- Terrestrial wildlife and habitat (key indicator is caribou).

The EIS predicted no residual effects to landforms, soil and permafrost VEC (Volume 6, Section 2), so this VEC was not considered in the cumulative effects assessment.

1.4.2.1 Vegetation

The Project is expected to result in the following residual effects to vegetation measurable parameters:

- A loss of vegetation in the Project Development Area (PDA) and the potential for introduction of invasive plant species;
- A reduction in plant health (due mainly to deposition of dust) within the local study area (LSA); and
- A loss of culturally valued vegetation, such as blueberry, within the PDA.

These effects, in the context of the terrestrial RSA, were predicted to be not significant.

Other projects/activities that may also affect vegetation within the terrestrial RSA include:

- Past, present and future mineral exploration activities;
- Potential development of Baffinland's other iron ore deposits;
- Potential development of the Separation Lake hydroelectric project; and
- Climate change.

Baffinland's previous exploration and bulk sampling programs, while relevant as activities for the cumulative effects assessment, have already been considered in the main effects assessment, as they overlap effects of the Project.

Potential for Reduction in Vegetation Abundance and Diversity

The Project is expected to have an indistinguishable effect on vegetation abundance and diversity in the context of the terrestrial RSA, with an estimated 0.36 % reduction in abundance (Volume 6, Section 3.2.2). Assuming a doubling of the affected area due to the combined development of all of the above additional projects/activities, the cumulative effect of these projects on vegetation abundance and diversity would be an estimated 0.72 %, which remains a low magnitude effect that will be indistinguishable.

Generally, climate change is expected to result in changes to vegetation communities in the Arctic, with an overall increase in biomass and plant diversity, with a tendency for high Arctic polar deserts to become tundra and for tundra to more resemble boreal forest (Arctic Council and the International Arctic Science Committee, 2005).

The effects to individual species are more complicated and diverse and will occur on different timescales depending on soil conditions and other factors. Where suitable soil conditions exist, the Arctic Council and the International Arctic Science Committee (2005) predict that changes will be evident this century. Mosses and lichens, for example, are expected to generally decline as warming increases. It is likely that climate change effects to vegetation will be slower to occur than Project-related effects and visible changes may occur beyond the temporal boundaries selected for the assessment (i.e., the next 35 years, up to 2045). As the terrestrial RSA is located on an island and not the mainland Arctic, it represents a physical barrier to transport of seeds and it is likely that the predicted changes will occur slower than in other Arctic locations. Based on this, it is predicted that vegetation changes resulting from climate change will be relatively modest over the assessed time period and the cumulative effects on vegetation abundance and diversity due to the above projects/activities will remain indistinguishable and insignificant.

Potential for Reduced Vegetation Health

The Project is expected to result in a Level I magnitude effect to vegetation health that is predicted to be not significant (Volume 6, Section 3.2.4).

Dust and metals deposition at Project sites will increase with increased ground disturbance and scaled up material handling operations. Metals deposition to soils may also increase within the PDAs. Under the same assumption of a doubling of the extent of affected vegetation from 0.14 % of the RSA to 0.28 % of the RSA, the effects will remain not significant.

Culturally Valued Vegetation

Blueberries were assessed as an indicator plant species important to Inuit. Blueberry habitat within the terrestrial RSA was predicted based on the Ecological Land Classification (Volume 6, Appendix 6D; Volume 6, Figure 6-3.5). Assuming complete removal of blueberry within the PDAs, the Project is predicted to have a minor and indistinguishable effect on blueberry availability within the RSA (Volume 6, Section 3.2.2.3). Under the same assumption of a doubling of development footprint within the terrestrial RSA due to development of the additional deposits and ongoing exploration activities, the effect will remain indistinguishable, and therefore not significant.

1.4.2.2 Terrestrial Wildlife and Habitat - Caribou

The cumulative effects of the Project on terrestrial wildlife were considered for the key indicator wildlife species: caribou. Cumulative effects were considered at the scale of the north Baffin Island caribou herd (Volume 6, Section 5; Volume 6, Figure 6-5.1), that encompasses the known habitats and seasonal use patterns. The two reasonably foreseeable projects with the potential to interact with the Project's residual effects on caribou include the development of Deposits No. 2 to 9 and the Separation Lake hydroelectric project. The interaction between the Project and other projects will not result in significant cumulative effects on north Baffin Island caribou, primarily because the reasonably foreseeable projects in the range of the herd that could occur at the same time as the Project will result in only an additional 0.006 % loss of habitat. If any of Deposits No. 2 to 9 were to be developed, it is most likely that they will be developed sequentially instead of concurrently. In addition, there are assumed residual effects on caribou range from the Nanisivik mine, which could interact with the Project. However, because these can neither be detected nor reasonably determined, they are excluded from this analysis.

If Deposits No. 2 to 9 are mined, there will be a gradual increase in habitat loss as new road or rail spurs are developed, but the ZOI as a result of sensory disturbances will simply shift (disappear from abandoned sections, move to new sections). As most of the habitat loss is a result of the loss of effectiveness resulting from traffic, then development of spur lines/roads and decommissioning of existing spur lines/roads will balance the overall habitat loss within the development. Presuming an additional 100 km of linear access to the additional deposits, there may be an additional loss of 300 ha (3.0 km^2) of potential caribou habitat. This is equivalent to 0.002 % of the potential habitat in the 134,308 km^2 north Baffin Island caribou range.

A hydroelectric development at Separation Lake is another reasonably foreseeable project. It is predicted to include a 58 km transmission line (and probable matching access road) and an impoundment area that will increase the surface area of Separation Lake by 309 ha (existing surface area = 1,551 ha; predicted impoundment area = 1,860 ha). Assuming a 30 m-wide right-of-way for the road (174 ha footprint), this project could result in an additional loss of 483 ha (4.83 km^2) of potential caribou habitat. This is equivalent to an additional loss of 0.004 % of potential caribou habitat.

Habitat

The Project will have a "*not significant*" cumulative effect on habitat loss (or reduced habitat effectiveness) on north Baffin Island caribou. The residual habitat loss of the Project was assessed as an overall reduced effectiveness of ~2.0 % across the range of the herd. The additional loss of habitat from reasonably foreseeable projects amounts to 0.006 % of the north Baffin Island caribou range. This level of effect will be undetectable.

The decommissioned Nanisivik mine had no measurable habitat loss discernible at the scale of the north Baffin Island caribou range. Ongoing exploration activities will also have indiscernible effects on habitat loss. There are no other known or reasonably foreseeable activities in the north Baffin Island caribou range (Figure 9-1.2).

Movement

The Project could result in a cumulative effect on caribou movement but it is predicted to be not significant. Project features including the Milne Inlet Tote Road and the proposed Railway to Steensby Inlet and associated access road, may act cumulatively with the existing road corridor from Nanisivik to Arctic Bay to limit caribou movement. However, the significance of this interaction is considered to be negligible because the road corridor by Arctic Bay has a low traffic volume, and based on its position near the northern extent of the north Baffin Island caribou range, there is significantly less directional movement of caribou across that road. Future projects, including the Separation Lake hydroelectric project and the development of Deposits No. 2 to 9, will require linear features (roads and transmission lines) that could also act cumulatively with the linear disturbances from the Project to affect caribou movement. Project effects on caribou movement will be monitored and adaptive management will minimize the effects.

Mortality

The Project will not have a significant cumulative effect on caribou mortality. It will not significantly increase caribou mortality, either directly (e.g., road collisions) or indirectly (e.g., increased hunter access). There are no other projects in the north Baffin Island caribou range that will result in increased activity along caribou travel corridors. The Milne Inlet Tote Road has been in place since the late 1960s, and improvements to that road will not provide direct access from a community (and thus access to caribou habitat for hunting purposes remains at pre-existing levels). Future projects, including the Separation Lake hydroelectric project and the development of Deposits No. 2 to 9, will require linear features (roads and transmission lines) that could also act cumulatively with the linear disturbances from the Project to affect caribou mortality. It is expected that if these induced projects go ahead, they will adopt measures to minimize or eliminate the risk of caribou mortality.

1.4.2.3 Migratory Birds and Habitat - Peregrine Falcons, Snow Geese, Common and King Eiders, Red Throated Loons, Lapland Longspur

Migratory birds, particularly geese, use wetlands throughout the Project area, some of which will be impacted, most likely in locations near the railway and Steensby Port. The potential residual effects on migratory birds and their habitat were assessed by focusing on the following key indicator species: Peregrine Falcons, Snow Geese, Common and King Eiders, Lapland Longspur and Red-throated Loons. No seabird species were included in the residual effects analysis because they occurred in low numbers within the Project's footprint and LSA, and no large seabird colonies were recorded within the RSA.

Residual Project effects for migratory birds, identified for all five key indicator species, will result primarily from habitat loss and sensory disturbance of habitats used for staging, nesting, foraging and brood-rearing. Some mortality might be expected from accidents and collisions (air, vehicular and rail traffic), increased harvesting and/ or exposure to contaminants. While some individual-level displacement and disturbance is expected to occur in a relatively small zone of influence during all Project phases, no changes to key indicator populations are expected.

Other projects with the potential to interact with these Project effects are limited to those in its immediate vicinity, which include the potential future development of Deposits No. 2 to 9 and the Separation Lake hydroelectric project. If a decision is made to seek approval to proceed with development of Deposits No. 2 to 9 and the Separation Lake hydroelectric project, an environmental assessment will be conducted and a detailed assessment of the potential effects of these projects in conjunction with effects of the Project will be provided. The significance of potential cumulative effects will be reviewed by the appropriate regulatory agencies and significant cumulative effects on migratory birds will be avoided.

The effects assessment on migratory birds (Volume 6, Section 4) considered the Project's effects on bird species at risk to be minimal. The credible expansion scenario is not expected to change these conclusions.

1.4.3 Freshwater Aquatic Environment

With respect to Freshwater Aquatic Life and Habitat, the following Valued Components and Key Indicators were considered in the CEA:

- Freshwater quantity;
- Freshwater and sediment quality; and
- Freshwater fish and fish habitat (Arctic char).

1.4.3.1 Freshwater Aquatic Environment– Surface Water Quantity

Residual surface water quantity effects identified for the Project include water quantity reductions in certain lakes resulting from withdrawals, and from diversions of small watercourses, the main diversion being the collection of runoff around the waste rock stockpile at the Mine Site.

There are two potential projects/activities with the potential for cumulative effects on the Freshwater Quantity VC in combination with the residual effects on freshwater quantity of the Mary River Project:

- Development of Deposits No. 2 through 9; and
- Climate change.

Key water quantity related considerations:

- Development of Deposits No. 2 and 3 will require an increase in the use of water at the Mine Site. Development of Deposits No. 4 and 5, or 6 and 7, if mined as satellite operations based from the Mine Site, could also result in an increase (assumed to be a doubling) of water requirements. A doubling in production would result in a doubling of throughput at Steensby Port and possibly Milne Port and camp occupancies will increase accordingly.
- As discussed in Section 1.3.2.7, a doubling in the production rate, from any or all of the additional deposits, is considered the only credible expansion scenario.
- Development of Deposits No. 2 and 3 could also involve additional diversions of runoff around mining and stockpiling areas, although it is expected that these diversions would occur around these deposits, where runoff reports to the Mary River, rather than in the catchments that drain to tributaries of Camp and Sheardown lakes, as is the case with the current Project. Therefore, a cumulative effect on local watercourses due to water diversions around mining areas from development of Deposits No. 2 and 3 are not expected.
- Development of other deposits involving the establishment of camps and other mine site infrastructure at another location outside of the freshwater LSAs.

Based on the above considerations, cumulative effects to water quantity could occur with respect to water withdrawals for potable and other uses to supply larger accommodation facilities at each of the Mine Site, Milne Port and Steensby Port.

Under the assumption that development of additional resources in Deposits No. 2 and 3 would require a doubling of the Project's proposed water consumption, the resulting under-ice volume reductions in Camp Lake (Mine Site), 10-km lake (Steensby Port) and km-32 lake (Milne Port water supply) would all be less than 1 %, well below the recommended withdrawal threshold of 10 % identified by DFO, and does not represent a significant adverse cumulative effect.

Climate change and Water Quantity

Global temperatures are expected to increase in the next century, notably in the Arctic, where average annual temperatures are anticipated to increase, precipitation is expected to increase, sea ice is expected to decline reflecting less solar radiation and the area of land covered by snow is expected to decline (Arctic Council and the International Arctic Science Committee, 2005).

Key water quantity related considerations:

- Increased temperatures may result in a longer open-water season and an increased proportion of precipitation falling as rain;
- Increased precipitation may result in greater volumes of runoff; and
- Increased extreme precipitation may result in larger flood events.

Since potential effects of the Project (and cumulatively, from expansion scenarios) are water withdrawals, it is expected that climate change effect of increased runoff will not result in a cumulative effect. Increased flows have been accounted for by designing to higher return periods and this would also be carried out for expansion development scenarios.

1.4.3.2 Freshwater Aquatic Environment - Water and Sediment Quality

Residual surface water and sediment quality effects identified for the Project include changes to the measurable freshwater quality and sediment parameters, and occasional exceedances of CCME guidelines resulting from non point-source, point-source and airborne emissions.

Effects of the Project on water and sediment quality are confined to portions of the five freshwater LSAs (Volume 7, Figures 7-1.2 through 7-1.6) and are not expected to extend into the freshwater RSA (Volume 7, Figure 7-1.1).

Other projects/activities that may also affect freshwater within the terrestrial RSA include:

- Past, present and future mineral exploration activities (including Baffinland's exploration and bulk sampling programs);
- Potential development of Baffinland's other iron ore deposits;
- Potential development of the Separation Lake hydroelectric project; and
- Climate change.

To date, Baffinland has been the main exploration company operating in the region, and the bulk sampling program has been the largest industrial activity within the freshwater RSA. Local waters have been influenced by drilling operations (Mary River) and discharge of treated sewage effluent from the exploration camp to Sheardown Lake. These effects have been documented by compliance monitoring and water quality baseline studies, and were incorporated into the effects assessment in Volume 7, Section 3.

Deposits No. 2 through 9 are located within the freshwater RSA and have the potential to result in cumulative effects on surface water and sediment quality. Deposits No. 2 and 3 are located in close proximity of Deposit No. 1, and surface runoff from the deposits flows to the Mary River. Factors such as ore and waste rock geochemistry, the location of waste rock and temporary ore stockpiles and other factors will determine the potential water quality effects to the shared receiving water. Mining of these two adjacent deposits would involve an expansion of camp facilities, involving increased water use and higher volumes of treated sewage requiring discharge. There would presumably be additional discharges reporting to the Mary River from runoff of mining Deposits No. 2 and/or 3. The Mary River has additional assimilative capacity, based on calculations carried out in the assessment (Volume 7, Section 3) and parameters of potential concern are not approaching thresholds, so it is a reasonable assumption that the Mary River could assimilate additional discharges of mine runoff and that additional discharges are not likely to increase water quality parameters beyond thresholds. This can be confirmed only with a mine plan and sufficient geochemistry for these deposits, and additional analysis, but ultimately it is expected that significant cumulative effects can be avoided through Project design, as applied in the base case Project. Options include diversion of runoff to other receiving waters and/or additional water treatment.

Development of Deposits No. 2 and 3 are not expected to have cumulative effects to water quality outside of the Mine Site.

The other iron ore deposits recently identified as part of Baffinland's regional exploration program are further removed from the Mine Site, and development of these locations can be expected to involve temporary construction facilities, and either incremental population numbers at the Mine Site camp during operations, or new facilities at the respective deposits, which will have water quality effects within local waters and within the same freshwater RSA. Again, it is reasonable to expect that significant cumulative effects can be avoided through Project design. At a regional scale, even if these additional activities (and discharges) were to occur within the same catchment areas, it is expected the cumulative effects would be insignificant.

Water quality effects from other exploration activities are expected to be minor (low magnitude) and temporary.

Development of the Separation Lake Hydroelectric Project

The likely residual surface water and sediment quality effects (i.e., creation of the reservoir and hydraulic alterations of the system) of the Separation Lake hydroelectric facility would be outside of the Mary River Project RSA for the freshwater environment. Effects of the Project are not anticipated to extend outside of the RSA. No direct spatial overlap of residual hydrological effects is anticipated, and consequently no cumulative effects are anticipated.

There is potential for spatial and temporal interaction of the residual surface water and sediment quality effects resulting from the construction of the transmission line from the hydroelectric facility to Steensby Port with residual effects of the Project. Specifically, construction of the transmission line may result in localized water quality effects (e.g., increases in TSS) where construction activities occur in or near surface waters. Construction activities in or near fresh water would be subject to BMPs and standard mitigation measures to avoid or minimize effects on aquatic ecosystems, including use of sediment and erosion control. Effects that cannot be mitigated would likely be localized, infrequent, of small magnitude, short-term and fully reversible.

Climate Change

Climate change may have direct and indirect effects on freshwater and sediment quality in the Project LSAs and RSA through changes in air temperatures, precipitation and ultraviolet radiation. These effects may lead to the following changes in water and sediment quality:

- Increased productivity due to increases in water temperatures and/or lengthening of the open-water season;
- Lake bottom waters are likely to experience reduced oxygen levels as lake productivity increases;
- Earlier and more open water will result in more wind mixing, upwelling and greater nutrient availability;
- Earlier onset of stratification within lakes;
- Increased flows and reduced ice cover in river systems will result in increased erosion and sediment transport and increased nutrient transport and mixing;
- Permafrost thaw is likely to increase when mean annual air temperature rises and approaches 0°C resulting in a potential positive feedback loop;
- Potential increases in elemental (e.g., metal) availability and biomagnification; and
- Water quality parameters may become concentrated as shallow river systems dry out and ponds/wetlands experience reduced water volume due to increased percolation and evaporation.

There is a high level of uncertainty in predicting the effects of climate change on freshwater and sediment quality and determining the potential for cumulative effects. Monitoring and adaptive management are recommended to confirm effects predictions and ensure mitigation measures are adequate.

1.4.3.3 Freshwater Fish, Fish Habitat and Other Aquatic Organisms - Arctic Char

Residual freshwater fish, fish habitat and other aquatic organisms effects identified for the Project include effects to char health, habitat and mortality.

There are three potential projects/activities with the potential to interact with the residual freshwater fish, fish habitat and other aquatic organism effects of the Mary River Project:

- Development of the Mary River Project Deposits No. 2 to 9;
- Development of the Separation Lake hydroelectric project; and
- Effects of climate change on aquatic ecosystems.

Mary River Project Deposits No. 2 to 9

Development of these other deposits could potentially overlap spatially and/or temporally with the effects of the Mary River Project on freshwater biota and habitat. Major linkages may include effects on Arctic char health and condition (due to water and/or sediment quality changes), effects on char habitat and/or direct mortality.

Cumulative effects may occur in two ways:

- A spatial overlap of the current Project with an expansion scenario that doubles the production output with the development of the adjacent Deposits No. 2 and 3. Under this scenario, cumulative effects to Arctic char health and condition could result from cumulative effects to water and/or sediment quality. Development of these adjacent deposits is expected to result have minimal effects to habitat and no direct mortality.

- Development of other deposits removed from the Mine Site, which will likely result in new impacts to Arctic char health, habitat and mortality that contribute to a cumulative effect on char at a regional scale (i.e., within the freshwater RSA).

Either scenario will require environmental assessment. Any additional effects to fish and fish habitat will require an authorization under the *Fisheries Act*. With appropriate compensation measures implemented to the satisfaction of the Department of Fisheries and Oceans, it is expected that effects to fish and fish habitat are adequately mitigated. All effluents will be subject to an aquatic effects monitoring program under the Metal Mining Effluent Regulations of the *Canadian Environmental Protection Act*. Due to the nature of these regulatory requirements, it is expected that cumulative effects of the current Project and any doubling expansion scenario will be mitigated to acceptable levels. The cumulative effect on Arctic char is predicted to be not significant.

Development of Separation Lake Hydroelectric Project

The Separation Lake hydroelectric project is located outside of the freshwater RSA. Therefore, any effects to Arctic char resulting from this potential project will not contribute to cumulative effects to within the spatial boundaries of the cumulative effects assessment on Arctic char (the freshwater RSA).

A transmission line associated with the hydropower project will run through the freshwater RSA to Steensby Port at a minimum. Construction of the transmission line may result in localized water quality effects (i.e., increases in TSS) where construction activities occur in or near surface waters. Construction of transmission lines generally does not involve direct loss of fish habitat, as Project footprints are typically restricted to the terrestrial environment. There is limited potential for cumulative effects.

Climate Change

Climate change may have direct and indirect effects on freshwater biota in the Project LSAs and RSA through changes in air temperatures, precipitation and ultraviolet radiation. Climate change effects on aquatic biota will also be mediated through changes to hydrology and water quality, which are described in Sections 1.4.3.1 and 1.4.3.2, respectively.

The cumulative effects of the Project and climate change on Arctic char and freshwater biota in general are inherently difficult to predict and associated with high uncertainty. The Arctic Climate Impact Assessment predicts that increasing water temperatures are likely to result in an increase in food chain productivity that will likely result in an increase in growth rates of Arctic char (Arctic Council and the International Arctic Science Committee, 2005). It is possible that climate change could also result in adverse effects such as an increase in the accumulation of metals in fish tissue due to a higher respiration rate associated with warmer water (lower in dissolved oxygen). These two competing effects of climate change on are not expected to cumulatively affect Arctic char in a meaningful way, although there is a high degree of uncertainty in the predicted effects of climate change.

1.4.4 Marine Environment

1.4.4.1 Sea Ice

The Project will have residual effects to landfast ice and pack ice within the marine LSA.

Icebreaking will disrupt landfast ice in Steensby Inlet. The sea ice impact assessment (Volume 8, Section 2) identified residual effects to landfast ice, conservatively estimating a track width of 1.36 km wide to cause a disruption of 1.9 % along the shipping route in May when the spatial extent of landfast ice is at a maximum, and an estimated disruption of 4.0 % along the shipping route in July when break-up occurs.

Under proposed production levels, five repeat uses of the ship tracks in landfast ice are anticipated. Should iron ore production double, the maximum anticipated disruption of landfast ice would be expand proportionally, i.e., to approximately 3.0 km wide (4 % in May and 8 % in July) and should the production be halved, the landfast ice disruption would be approximately 0.75 km wide (1 % in May and 2 % in July).

Table 9-1.5 Approximate Width of Landfast Ice Disruption from Vessel Traffic with Various Transits Under Different Production Levels

Vessel Traffic	5 Repeat Transits	7 Repeat Transits	20 Repeat Transits
Proposed (136 transits)	1.36 km	0.97 km	0.34 km
Doubled (272 transits)	2.72 km	1.94 km	0.68 km
Halved (68 transits)	0.68 km	0.49 km	0.17 km

Based on the threshold limit of disruption of 10 % of ringed seal landfast ice habitat per year and 10 % disruption of bearded seal pupping habitat along the landfast ice edge per year, significant effects to these habitats are not anticipated to occur as a result of proposed or doubled shipping activities.

Pack ice was considered as a subject of note in the residual effect analysis in Volume 8. The subject of note identified a disruption of pack ice in Hudson Strait and Foxe Basin by Project shipping activities. The analysis identified a negligible effect on ice regime, on the assumption that ship tracks would closed within hours of the ship passing. This is based on the mobile characteristic of pack ice, subject to wind and tide currents and on the low frequency of Project shipping activities in the ice-cover season.

The current Project will involve icebreaking through pack ice in Foxe Basin and Hudson Strait of a frequency of one ship passage (either direction) about every other day. Under the credible scenario of doubling the production rate at the Mary River Project, this level of traffic could conceivably double. At present, only two icebreaking passages occur into the Raglan Mine each winter. Another reasonably foreseeable project is the Roche Bay Iron Ore Project, which could ship iron nuggets to the Port of Churchill (Section 1.3.2.6). No details on shipping are available other than an acknowledgement that year-round shipping may be required. Based on an assumption that 50,000 DWT Panamax sized icebreakers were utilized, approximately 20 voyages per year would be required to transport 1 Mt/a of iron nuggets, equating to a shipping frequency of one ship every two to three weeks. It is likely the Roche Bay's ships, sailing direct to the Port of Churchill, would sail some distance from the Mary River nominal shipping route. Given the distance from Roche Bay's assumed shipping route in the context of sea ice effects due to the Mary River Project's operations, the minor amount of current icebreaking that occurs (Table 9-1.1), mainly the *MV Arctic* sailing to Raglan Mine, the expansion scenario of the Mary River Project will be the main potential increase in icebreaking through Foxe Basin and Hudson Strait. As with the base case, cumulative effects of the expansion scenario are not anticipated, as effects of ship passage on sea ice are all considered as standalone events within a highly dynamic ice environment where the ship track usually becomes indiscernible within hours of ship passage. Additionally, the spatial distribution of ship tracks is miniscule in the context of the large geography of Foxe Basin and Hudson Strait.

Ice cover is expected to be reduced by climate change. It is not expected that icebreaking through the pack ice combined with climate change will result in a measurable cumulative effect.

1.4.4.2 Marine Water and Sediment Quality

Under the credible scenario of a doubling of production at Mary River by mining additional deposits, no changes to infrastructure at Steensby Port will be required. However, an approximate doubling of the number of ships that call on Steensby Port (and possibly Milne Port) can be expected. This will result in a doubling of the frequency of discharge of ballast water. The effects assessment for the current Project predicted that localized effects on temperature (i.e., slight increase) will occur in the immediate vicinity of the dock sites, that salinity and metal concentration thresholds will not be exceeded, and that a ballast water eddy of lower nutrient (silicate and nitrate) concentrations could occur in offshore areas. Therefore, it is predicted that the effects of ballast water discharge at the port sites will be of low magnitude (Volume 8, Section 3.5.2.3).

The Project will also result in the deposition of ore dust around the ore docks. The heaviest deposition will occur at the Steensby Port, since the stockpiles and ore dock are surrounded by water. The effects assessment predicted that, based on air quality modelling for the Project, changes to marine water and sediment quality would be within acceptable limits. A doubling of production would increase ore dust deposition in the marine environment. Should the expansion scenario proceed, revised air quality modelling would form part of another environmental assessment, and the effects of increased dust deposition to the marine environment would be required. Monitoring of dust deposition through an air quality monitoring program (Volume 5, Section 2) and an expected aquatic effects monitoring program (Volume 8,Section 3.3) during the Project will also provide real data regarding ore dusting and deposition rates in the terrestrial and marine environments. If initial modelling of the higher production rate suggested high magnitude effect that is significant, additional mitigation of dust emissions would be needed to reduce those effects to levels that are not significant.

1.4.4.3 Marine Habitat and Biota

Volume 8 identified residual effects to marine habitat (<1 % disruption of marine coastal habitat in Steensby and Milne Inlets), Arctic char health (as determined through changes to water quality) and invasive species introduction (as a result of ballast water introduction).

Doubling of production at Mary River may require a larger dock infrastructure at Steensby Port. However the description of marine coastal habitat remains less than 10 %. No cumulative effects to marine coastal habitat are expected. As described in Section 1.4.4.2, doubling the frequency at which ore carriers discharge ballast water at each of the ports, this will not adversely affect water quality; therefore, an increase in effects to Arctic char health are not expected.

The possibility of invasive species introduction as a result of ballast water management was identified in the marine biota assessment. Adherence to legal requirements regarding ballast water exchange (or alternatively, treatment) will be effective mitigation in addressing this potential concern, and an increase in shipping as a result of the Project will not change this conclusion.

1.4.4.4 Marine Mammals

Residual effects are predicted for the marine mammal VEC (all six indicator species). Project effects, with the exception of potential masking for bowhead whales, are not predicted to occur outside of the LSAs. The following lists the types of residual effects and the Project activity that may cause the effect for each indicator species.

- Ringed seals: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and mortality (icebreaking).
- Bearded seals: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and masking (shipping).
- Walruses: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and masking (shipping).
- Beluga whales: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and masking (shipping).
- Narwhals: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and masking (shipping).
- Bowhead whales: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction) and masking (shipping).
- Polar bears: habitat change (changes in ice from icebreaking), disturbance (shipping, aircraft overflights, construction, camp operations) and possibly mortality (if a polar bear is killed in defence of human life).

Routine Project Shipping

Cumulative effects to marine mammals are possible, particularly in the marine LSA, where other vessels (e.g., Canadian Coast Guard) engage in icebreaking that may interact with Project shipping activities along the southern shipping route. Based on information acquired from INNAV for 2002-2010 (see Table 9-1.1), there are relatively few vessel transits during the ice-cover period in Hudson Strait and Foxe Basin. From November to June, an average of two icebreaking vessels per month can be expected in these areas. The vessels that operate in and near the southern shipping route might cause some localized avoidance behaviour by pinnipeds, whales and polar bears and some masking in whales (as discussed in Volume 8, Sections 5.6 to 5.12). But the effects are predicted to be short-lived and will not affect the overall well-being of the animals. Icebreaking ore carriers in the Baffinland Project are expected to transit the southern shipping route every two days. Given the length of the southern shipping route, it is unlikely that Project ore carriers would occur close enough to other icebreaking vessels to create synergistic noise effects on marine mammals.

During the open-water period, Project shipping may interact with other vessel traffic along the northern and southern shipping routes, particularly in the LSA. Based on information acquired from INNAV for 2002-2010 (see Table 9-1.1), vessel traffic increases substantially in some areas during July to October, with most traffic in August and September. It should be noted that vessels in the INNAV database include barges, CCG, DFO, fishing, tugs, tankers, naval ships and pleasure craft that vary in size, engine type, operational speeds and noise output. In Hudson Strait, about 26 vessels per month transit through this area during July to October (see Table 9-1.1). Only 2-6 vessels per month continue on into the eastern side of Foxe Basin, where Baffinland's southern shipping route extends into Steensby Inlet. There is potential for cumulative disturbance effects between Project vessels (expected 15 per month based on a vessel every two days) transiting the southern shipping route, particularly Hudson Strait. However, relatively few pinnipeds, whales and polar bears are expected in Hudson Strait waters during the open-water period because marine mammals are located in summering areas (in the case of whales), widely dispersed (in the case of seals), or located at and near haul-out sites, typically tens of kilometres away from the shipping lane (in the case of walruses). Based on the INNAV data, there is a moderate increase in vessel activity along the northern shipping route during the open-water period (see Table 9-1.1). On average, 18 and 11 vessels per month transit through Eclipse Sound in August and September, respectively. Only 4-5 per month occur in Milne Inlet. As ship transits to Milne inlet are anticipated to be infrequent during operation (less than one per year), there is a low potential for cumulative disturbance effects on marine mammals to occur along the northern shipping route

A doubling of mine production would see a similar increase in ore shipping, with a consequent doubling in the quantities of ballast water released at the Steensby port site. A numerical model was developed for Steensby Inlet (Volume 8, Appendix 8B-1) and this model was used to assess the distribution and dispersion of ballast water from ore carriers during Project operations. The sensitivity analysis of the model results included a doubling of the volume of ballast water released. The study result indicated a very low concentration of ballast water throughout Steensby Inlet (less than 0.4 %) under the planned level of ore production. This value remained low everywhere, even when discharge rates are doubled. The concentration of ballast water at all places in the inlet varies nearly linearly with the discharge rate of ballast water. The effect of ballast water on temperature and salinity in Steensby Inlet is well below natural variation and hence predicted to be negligible (not discernible), even with a doubling of input.

A doubling in ore production will increase the number of vessel transits, and hence the number of times/locations where vessels will pass each other when in transit. The potential increase in received sound level was considered for the event of two cape-size ore carriers passing in close proximity to each other. Ore carriers are expected to maintain a minimum separation distance of 1 nautical mile (T. Keane, FedNav, pers. comm.) along the shipping route. For purposes of this assessment, it was conservatively assumed that the minimum separation distance between two ore carriers will be 1 km. The acoustic noise literature (e.g., Richardson *et al*. 1995; Hansen 2005; Bies and Hansen 2009) indicates that the combined source level of two identical and co-located incoherent noise sources is the value of the source level from one of the sources plus 3 dB. The more dissimilar the two noise sources, then the lower the adjustment factor will be; for e.g., when the source levels are 20 dB different, then the combined source level will be one source level plus 0.043214.

The maximum increase (3 dB) in the combined received levels will occur at locations near or far from both vessels where the separate received levels from both sources is identical. For two identical ships and in the case of marine mammals, this would occur when the marine mammal is perpendicular to the mid-point of the shortest path between the two vessels. If the two vessels are abeam of each other, then this location would be forward or astern of the two vessels. If one vessel is astern of the other then this location would be abeam of both vessels. Marine mammals that may occur between two vessels passing in close proximity would be exposed to increased sound levels for a relatively short period of time. As assessed for a single vessel passage, effects on marine mammals from exposure to noise from two ore carriers are predicted as not significant.

Future Development at Mary River

If iron ore Deposits No. 2 to 9 at the Mary River Project and the Separation Lake hydroelectric project proceed, aircraft overflights will likely increase. A modest increase in air traffic at Steensby Port (and the mine site) may occur. It is anticipated that the Project would be in the Operations Phase and that air traffic at Steensby Port would be very limited. In addition, all aircraft will maintain a minimum altitude of 450 m over marine waters when possible, and will be prohibited from flying low over marine mammals for photography or sight-seeing. Increased air traffic at Steensby Port would have minor disturbance effects on marine mammals over the short-term.

For purposes of this assessment, doubling of production at Mary River is assumed to result in an approximate doubling in shipping frequency, i.e., approximately one transit every day along the southern and northern shipping routes. This would likely increase the potential for synergistic cumulative effects through the likelihood of more than one ore carrier transiting a given area at the same time. Synergistic disturbance and masking effects are most likely to act on belugas, narwhals and bowhead whales in Hudson Strait during the ice-cover season. During the open-water period, cetaceans, particularly narwhals in Eclipse Sound and Milne Inlet, may also experience synergistic disturbance and masking effects. These cumulative effects, especially masking, could extend beyond the LSA. If a decision is made to seek approval to proceed with the development of additional Mary River ore deposits, an environmental assessment will likely be required, and no doubt it will include a detailed cumulative effects assessment. Special consideration would be given to marine mammal species listed on Schedule 1 of the *Species at Risk Act* (SARA). The certainty level in cumulative effects predictions at that time will be increased by the results of the marine mammal monitoring program proposed for shipping activities associated with the current Project; this monitoring program is expected to address the uncertainties in marine mammal response to ore carrier traffic in Hudson Strait.

1.4.5 Communities

With respect to Communities, the following Valued Components and Key Indicators were considered in the cumulative effects assessment:

- Population demographics (demographic stability);
- Human health and well-being (substance abuse, community and social stability); and
- Community infrastructure and public service (competition for skilled workers).

For the purpose of this assessment only negative residual effects were addressed, though it should be noted that most of the residual socio-economic effects of the Project will be positive. In considering the cumulative effects that may arise through interactions with other projects and other reasonably foreseeable projects, none of the positive residual effects are expected to become adverse, and therefore, these positive residual effects are not considered further.

The following VSECs were determine to have the potential for negative residual effects:

- Population demographics;
- Human health and well-being;
- Community infrastructure and public services; and
- Culture, resources and land use.

1.4.5.1 Population Demographics – Demographic Stability

Spatial Scope

The spatial scope is considered to include the LSA. This includes five communities of the North Baffin Region - Hall Beach, Igloolik, Arctic Bay, Pond Inlet and Clyde River - and the community of Iqaluit. In addition to these priority point-of-hire communities, cumulative effects on population demographics of other communities in the RSA are also considered.

Temporal Scope

The communities are continuing to adapt to the tremendous demographic changes that have been experienced since Inuit first started moving into government-serviced communities in the 1950s. Population growth has been rapid, leading to a situation where, for the first time, the older generation finds itself living in an environment where they do not recognize everyone in their community. The recent decentralization of government departments to Igloolik and Pond Inlet has further led to demographic changes as Inuit and non-Inuit from across the RSA and Canada have moved to take on these and other government service jobs. This process of adaptation to demographic change is expected to continue well into the future as the youth, demographic profile ages. Combined with limited economic opportunity, migration out of the community is expected to maintain a degree of demographic adjustment well into the future, beyond the life of the Project. For the purpose of cumulative effects assessment, a temporal limit of two generations is considered - roughly 40 years.

During this time frame, further mine developments in the LSA, including advancement of any of the Mary River Deposits No. 2 through 9 and the Roche Bay Iron Ore Project, are possible. In addition, the proposed Nanisivik Naval Facility may proceed, which may influence nearby Arctic Bay. The Roche Bay Iron Ore Project would likely prioritize employment from Igloolik and Hall Beach and possibly nearby Kivalliq Region communities of Coral Harbour and Repulse Bay.

1.4.5.2 Population Demographics Assessment

These potential projects are not yet adequately defined to support assessment of probability of their advancement or of the magnitude of their effects on population demographics. However, sufficient insight can be gained to support a qualitative assessment of the cumulative effects.

In-migration

No direct in-migration interactions are expected between mining operations such as the Meadowbank, Doris North and the Raglan projects and the LSA. Nor is advancement of the Mary River Deposits No. 2 through 9 expected to lead to additional in-migration, since such a project is expected to use similar labour components as the currently proposed Project. Should Roche Bay proceed, a modest level of in-migration may arise if local offices are established in Hall Beach or Igloolik. This is an uncertain effect, but is considered to be a possibility.

The advancement of the Nanisivik Naval Facility may lead to an unknown level of in-migration to Arctic Bay. The project is expected to primarily affect Arctic Bay. However, uncertainty related to this project prevents reliable assessment of the level of positions such a facility might introduce to that community. Arctic Bay is not considered to be a likely candidate for Project-related in-migration, so any such effect arising from the Naval Facility is unlikely to be cumulative to Project-related in-migration in that community.

The possibility for indirect in-migration interactions is recognized. Should one of the RSA projects undergo temporary or final closure during the temporal scope of the Project, it is reasonable to anticipate that the laid-off skilled work force may seek employment elsewhere across the RSA. It is assumed that they would first seek employment in areas where they would not be required to migrate away from their home communities. However, if employment were not available locally, some may migrate to a point-of-hire community where they can access other projects, including the Baffinland Project. This is expected to more probably involve moving to Iqaluit than to the North Baffin, since the capital is already home to Inuit from across the RSA and likely to include some extended family or friends.

The reverse effect may also be anticipated. Within the temporal scope, the Baffinland Project will close. By that time, a large number of local residents will have gained considerable skills of value to other projects across the RSA. If no further projects pick up these skilled workers, some may choose to migrate to point-of-hire communities in other regions. Out-migration from the LSA will be experienced as in-migration in these communities.

Potential cumulative in-migration effects are acknowledged as possibilities. They are highly contingent on future developments of the relative labour markets of each of the regions of Nunavut. Where such cumulative in-migration effects do occur, they are expected to be of low magnitude and focused primarily in the larger regional centres where thresholds for in-migration are higher than in the smaller North Baffin communities. In light of current expansion of mineral exploration and mining activities across all regions of Nunavut, such effects are not likely to be experienced in the near to medium term. It is expected that on-going development of Iqaluit as Nunavut's capital city will strengthen its ability to accommodate Nunavummiut from across the territory moving to seek opportunity. Cumulative effects may arise in the future under this scenario, however these are not expected to be experienced as adverse effects.

Out-migration

The decision process that leads families or individuals to migrate away from their home community is complex and multi-dimensional, related to factors such as opportunity, wealth, personal relationships, access to health care, education services and so forth. Mobility options are considered to be a positive effect at the level of individuals and families. The adverse dimension relates to the outcome that high levels of out-migration may have on the stability or "fabric" of a community.

The scale of the Project is large enough that North Baffin residents who gain skills of potential value at any of the other mine projects in the LSA or RSA will also be able to work at the Baffinland Project itself. The potential for cumulative effects on out-migration is expected to arise if there is a temporary or final closure of the Project. At that point, residents who have gained skills and experience at the Project may seek work elsewhere. It is expected that those who have chosen to remain resident in North Baffin communities — rather than choosing to relocate to either Iqaluit or Ottawa while working at the Project — will initially seek work that allows them to continue living in the North Baffin. The Roche Bay project, if it were operating, would be expected to provide points-of-hire in some of the LSA communities, but perhaps not all of them. The specific effects cannot be assessed since that project has not yet entered the NIRB review process and details are not available. For example, it is not known if Roche Bay would, if it were to become a mine project, provide transportation for residents of all LSA communities or only those closest to that project. If the latter is the case, the possibility that Project workers from non-Roche Bay points of hire might leave their LSA community to move to a Roche Bay hiring point would rise.

If neither the Roche Bay nor the Mary River Deposits No. 2 to 9 is developed within the temporal scope of this assessment, then final closure of the Project is expected to lead to out-migration as some residents who gained skills during the Project seek work at other mining projects across the territory or across Canada. This is most likely to occur at final closure of the Project, some twenty years into the future. There is no generally accepted threshold for the level of out-migration that would lead to significant adverse effects on community fabric in small Nunavut communities. For the purpose of this assessment, a "low" out-migration effect was set at <1 % of the population—equivalent to up to 15 individuals in a community the size of Igloolik or Pond Inlet. A "high" level of out-migration was considered to be 5 % or more, or some 70 individuals moving away. Whether or not these thresholds are reached at some future time will be contingent on many factors related to the direction of development in the region, economic opportunities in other regions, and individual choices and preferences related to lifestyle. Given the uncertainty related to outmigration effects and its implications for communities, the area of demographic change is included in the socio-economic monitoring framework (Volume 4, Section 15).

1.4.5.3 Human Health and Well-being

Spatial Scope

The spatial scope is considered to include the LSA. This includes five communities of the North Baffin Region - Hall Beach, Igloolik, Arctic Bay, Pond Inlet and Clyde River - and the community of Iqaluit.

Temporal Scope

A temporal scope for consideration of cumulative effects on human health and well-being is established in relation to ongoing adaptation to rapid socio-economic changes in the LSA over the past fifty to seventy-five years. Exposure to alcohol and drugs, for example, is a fairly recent phenomenon, as is access to substantial monetary wealth. These changes have raised new challenges for Inuit individuals, families and society generally as they seek to establish new norms that reflect values and vision. This adaptation process can reasonably be expected to continue well into the future. To establish a temporal scope for cumulative effects assessment, two generations (approximately 40 years) will be considered.

Substance Abuse

Project effects on substance abuse are assessed to be complex, with both positive and negative direction. The positive influence relates to changes in attitudes and support for overcoming addictions. However, as personal income increases due to employment at the Project, residents will be more able to afford substances. The interplay between “availability,” “attitudes” and “wealth” will determine the outcome. Baffinland’s mitigation measures are designed to tilt the balance toward positive residual effects – i.e., less substance abuse. These are described in the Human Resource Management Plan (Appendix 10F-3) and include the following measures:

- The use of alcohol and illegal drugs at the site will be prohibited. Baffinland has also committed to strict measures to prevent use of the Project as a means to transport illegal substances into the North Baffin.
- Planned orientation and training programs to include components that provide information about substances, substance abuse, productive approaches to stress management, healthy living, money management practices and other components that may influence lifestyle choices.
- An employee and family assistance program (EFAP) will be implemented to support some individuals in recognizing and dealing with their addictions.
- Community support programs funded through the Ilagiiktunut Nunalinnullu Pivalliajutisait Kiinaujat.

The potential for other mine projects to interact with the Project to affect the cumulative outcomes on substance abuse is considered limited. Concern would arise if another project provided points of hire in the North Baffin without effective measures to prevent substance imports and support healthy attitudes toward the responsible use of alcohol. This could lead to a situation where the balance between “availability,” “attitude” and “wealth” is tipped toward adverse effects. This scenario is considered improbable. The potential for acceptance of drug and alcohol use on-site at any remote fly-in/fly-out mine site is considered low within the temporal scale being considered. The negative safety and liability implications are too high.

Whether this assumption of prohibitive policy toward substances would hold true for the Nanisivik Naval Facility is not known. If that project were linked by a road to Arctic Bay and if a permissive environment were allowed with respect to the importation of substances, some spill-over effects could be envisioned. These might be considered to be cumulative in the sense that Project income could combine with increased availability. Monitoring of substance abuse is identified in the Volume 4 socio-economic monitoring framework as a dimension of health and well-being; collaboration will be required among multiple stakeholders. In this scenario, the naval facility would, presumably, be expected to participate in monitoring discussions related to substance abuse.

Absence from the Community

Fly-in/fly-out projects require residents to be absent from their community for a period of time. At some threshold level that is not well-defined, community processes and "community fabric" may be disrupted. The rate at which change occurs from "residents staying in the community" to "residents leaving to work away" is expected to affect the level of disruption. In the LSA, Inuit have long experienced situations where prolonged absence from family groups was a necessary characteristic of a hunting lifestyle. More recently, intermittent absence is caused by hunting trips, medical travel and education pursuit.

The Project will substantially increase the intermittent absence of community members. The magnitude of this effect is contingent on the number of residents who find employment there. It is anticipated that at the start of the Project, the level of employment will be limited more by local labour force capacity than by demand for workers. As this capacity increases through improved life skills, education and technical skills, the potential level of engagement—and therefore absence from the community—will increase. This is expected to take place in a gradual manner, providing time for community adaptation.

The addition of other fly-in/fly-out projects that provide point-of-hire opportunities will contribute to the magnitude of absence from communities only when labour demand constraints outweigh the current labour supply limitations. This will not be the case during the short or medium term of the Project. Rather, participation in fly-in/fly-out work will be limited by the number of qualified people willing to engage in Project employment. A cumulative increase in the number of fly-in/fly-out workers may occur over the longer term as progress is made in improving "readiness to work," education, and technical skills of residents, and if development of Roche Bay and/or Mary River Deposits No. 2 to 9 proceed. Development of local community-based employment opportunities for these same skilled workers could also arise, and this would serve to provide alternatives to jobs that require workers to be absent from the community.

Given these considerations, cumulative effects associated with the addition of foreseeable fly-in/fly-out employment opportunities are not anticipated over the short to medium term of the Project. The potential that over the longer term, cumulative worker absence brought on by additional projects and increased labour force capacity to engage in these projects could reach a level where communities begin to be affected is acknowledged. Monitoring the implications of worker absence on community fabric is addressed in the socio-economic monitoring framework of Volume 4. The implications of cumulative levels of worker absence should also be included in regional cumulative effects monitoring.

1.4.5.4 Community Infrastructure and Public Services

Spatial Scope

The spatial scope is considered to include the LSA. This includes five communities of the North Baffin Region - Hall Beach, Igloolik, Arctic Bay, Pond Inlet and Clyde River - and the community of Iqaluit.

Temporal Scope

The establishment of local communities began during the 1950s. Since then, infrastructure and services have developed gradually, with a focus on essential services. More recent investments have led to social infrastructure and services in areas of education and health. These are ongoing and gradual with substantial gaps in services between North Baffin, Iqaluit and typical Canadian “standards.” Given the small economies and remote nature of the LSA communities, particularly those of North Baffin, access to the labour required to carry out essential hamlet services has been procured in a largely buyer’s market—local residents with skills have essentially had one employer from whom to seek work.

The initiation of the Project will change the terms of labour exchange in North Baffin communities by introducing competition for labour. This will lead to a period of adaptation as local employers learn the new rules of the labour market game. The temporal scope of the assessment of cumulative effects is therefore set as twenty years, a reasonable adaptation period.

Competition for Skilled Workers

Three factors will affect the new equilibrium in the local labour market for municipal employment:

- The level of demand for workers having the skills required by municipalities;
- The level of these skills available “for rent” in the local labour force; and
- The relative ability of municipal employers to compete for these skills.

Three classes of projects have the potential to increase demand for workers. The Roche Bay Project and the development of Mary River Deposits No. 2 to 9, if they proceed, may increase demand for workers who are willing to engage in the fly-in/fly-out lifestyle. As with the Project, this competition may lead to some local transitional effects that may persist until municipal employers adapt to the competitive environment. Generally, local employment is expected to have some competitive advantage over fly-in/fly-out work, so this adaptation is expected to be readily achievable. In the medium and long-term, it is expected that the positive labour force capacity development effects associated with the Project—and assumed to be included in future projects as well—will lead to improved conditions for procurement of skilled labour from the local communities.

A second potential effect on the terms for local labour procurement may arise from mine developments in the RSA—such as Meadowbank and Doris North. These projects have been assessed during their respective NIRB review processes and no adverse cumulative effects on the LSA were identified. Nor are any such effects anticipated from this renewed consideration of these projects.

Additional employers in the LSA communities may present direct competition for labour. The projects that may have such an effect include Roche Bay and the Nanisivik Naval Facility, if they establish local offices in LSA communities. This is foreseeable; however, while there is not adequate detail to quantitatively assess these effects, they are not expected to be substantial.

Consideration of these potential interactions on the cumulative effects on competition for skilled workers leads to a conclusion that no significant adverse cumulative effects will arise in the area of Community Infrastructure and Public Services VSEC.

1.4.6 Culture, Resources and Land Use

With respect to the Culture, Resources and Land Use VSEC, the following key indicators were considered in the cumulative effects assessment:

- Archaeological sites; and
- Land use (harvesting; travel and camps).

Archaeological Sites

As described in Volume 4, Section 9, archaeological sites can be affected by ground disturbance and human presence. Provided archaeological surveys are conducted and identified sites are systematically mitigated under permits authorized by the Government of Nunavut, Department of Culture, Language, Elders and Youth (CLEY), the adverse residual effect is considered negligible. The chance still remains that sites can be discovered and damaged by increased human presence, and that chance finds during Project activities may result in a partial or complete loss of the archaeological record in a site. Baffinland has established measures to reduce the potential for the latter two effects to occur.

The potential for cumulative effects exist through the following other projects and activities:

- The credible expansion scenario of Deposits No. 2 to 9 by Baffinland;
- Ongoing exploration by Baffinland and others;
- Separation Lake hydroelectric project; and
- Traditional land use and harvesting activities.

Additional exploration or development activities by Baffinland are expected to have a low potential for adverse effects to archaeological sites, given that there is an understanding of the importance of such cultural resources, protocols and training within the organization. Exploration by others has the potential to cumulatively affect the archaeological resources in the region, if archaeological surveys do not precede ground disturbance activities and if training and protocols are not in place. Inuit land use is expected to have a very minor potential effect to archaeological sites, given the small scale of such activities, although many archaeological sites continue to be used by Inuit today, and this in fact represents an important connection to their past. Overall, the potential cumulative effect on archaeology within the study area is predicted to be not significant.

Land Use

Residual effects of the Project on land use include effects on caribou harvesting that, while they are expected to be minor, relate to the potential for caribou mortality due to collisions with the Railway (Volume 4, Section 10). Additional effects to land use will occur, including disturbance to camping areas at Milne Port, general disturbance and safety concerns related to Project-related traffic and Inuit hunters along the Milne Inlet Tote Road, potential crossing issues along the Railway and a detour on the Steensby Inlet fast ice. Mitigation has been identified and the residual effects are predicted to be not significant.

Other Project or activities that could also affect land use include:

- Baffinland's proposed monitoring programs;
- Mineral exploration activities, by Baffinland and others;
- Expansion scenarios for Deposits No. 2 to 9;
- Development of the Separation Lake hydroelectric project; and
- Shipping activities by others, including potentially the Nanisivik Naval Facility and the Roche Bay Iron Ore Project.

Helicopter activities associated with baseline (and potentially, monitoring) programs as well as mineral exploration has been noted as a nuisance to local hunters. Baffinland has designed a monitoring program that minimizes the need for terrestrial aerial surveys, opting for a hunter-harvest study as a potential alternate monitoring tool. Establishment of Project infrastructure including the Milne Inlet Tote Road and eventually the Railway, as well as site access roads, will reduce dependence on helicopters, although they will be necessary for mineral exploration by Baffinland and others, as well as development scenarios for the other iron ore deposits or development of the hydropower project. Adherence to the government's minimum flight altitude of 600 m will help to mitigate disturbance effects.

The Project will also result in interactions with marine water and fast-ice use for travelling and hunting. Under the credible expansion scenario for the other deposits, increased shipping will occur. This will mainly affect the frequency of ore carrier-small boat interactions in the open water, which is expected to be a low magnitude effect. The effect of icebreaking through the fast ice in Steensby Inlet will not change.

Other projects that may have interactions with marine use (open water and fast ice) are removed from the Project's shipping routes and, if effects occur, they will likely be to the communities of Hall Beach and Arctic Bay. The effect would not be cumulative above and beyond the effects of the Mary River Project, as they will affect other users within the land use study area.

Overall, cumulative effects to land use are predicted to be not significant.

1.5 MONITORING CUMULATIVE EFFECTS

The potential for cumulative socio-economic effects arising from interactions between the Project and other foreseeable projects is acknowledge. None of these cumulative effects are assessed to lead to significant impacts. However, uncertainty related to thresholds, the choices people make, and the direction of future development suggests that monitoring needs to take place. The socio-economic monitoring framework described in Volume 4, Section 15, addresses the need for collaboration in many areas of monitoring. Initiatives such as the Q-SEMC are well-designed to undertake monitoring related to cumulative effects. As indicated in the socio-economic monitoring framework, Baffinland intends to participate in these collaborative initiatives.

1.6 SUMMARY AND CONCLUSIONS

The cumulative effects assessment identifies assumed residual Project effects or preliminary indications of residual effects, other projects and activities that may interact with the Project residual effects, potential cumulative effects of the Project, and proposes mitigation measures.

Although cumulative effects have been identified as a possibility for several VCs, particularly caribou and marine mammals, no significant cumulative effects are anticipated to result from the Project. With the exception of marine mammals, most potential cumulative effects identified were the result of potential interactions with projects that may be induced by the Mary River Project (development of Deposits No. 2 to 9 and the Separation Lake hydroelectric project). As noted, if a decision is made to move forward with these projects (contingent on the Mary River Project proceeding), an environmental assessment will be conducted, including a detailed assessment of the potential effects of these activities in conjunction with effects of the Mary River Project. In this capacity, the potential cumulative effects would be reviewed by the appropriate regulatory agencies and any potential significant cumulative effects would be identified and avoided.

1.7 AUTHORS

The cumulative effects assessment framework was prepared by Richard Cook of Knight Piésold. Discipline-specific cumulative effects assessments were prepared by Richard Cook (air quality, noise, vegetation, land use, water quality and quantity); Mike Setterington of EDI (birds and caribou); Megan Cooley of North/South Consultants (freshwater fish); Warren Bernhardt of North/South (marine environment); and Val Moulton of LGL Ltd. (marine mammals). Doug Brubacher of Brubacher Development Strategies Inc. prepared the cumulative effects assessment on communities, and Carole Burnham prepared the archaeological cumulative effects assessment.

SECTION 2.0 - EFFECTS OF THE ENVIRONMENT ON THE PROJECT

2.1 ENGINEERING HAZARD ASSESSMENT

The environment has the potential to affect the Project. Extreme weather (storms, extreme rainfall or snowfall, extreme low temperatures) and geo-hazards (seismicity, ground and slope instabilities) have the potential to affect infrastructure, and in turn represent concerns for human safety and the environment. Included in the context of extreme weather is the potential for global climate change to affect the Project.

Environmental hazards that could potentially affect the engineering structures in the Project are assessed in Tables 9-2.1 to 9-2.5, which identify the potential engineering hazards that could occur for each component, describe the hazard within the context of the specific Project component, describe and assess potential consequences of the hazard, assess the risk factor and describe potential mitigation measures.

At Milne Port, some low to moderate risks associated with ice-rich permafrost and thaw-sensitive soils could result in failures of structures, creep settlement, or movement of foundations of heavy structures. Permafrost protection measures will be used to mitigate these risks.

Along the Milne Inlet Tote Road there are a number of risks associated with the ice-rich permafrost and thaw-sensitive soils that could result in creep settlement in high embankment, thermokarst development along the route or in borrow areas, thaw settlements under the bridge culverts and some general road embankment instability. These risks will generally be mitigated through proper design and construction to protect and maintain the thermal conditions along the road. Maintenance will most likely be required at some locations due to thermal degradation of the underlying foundations. Another more significant risk is related to the hydrology and the fact that high runoff events can lead to flows beyond the capacity of the hydraulic structures established along the road alignment. This risk is further increased by the spring icing of culverts further reducing capacity, leading to potential overtopping and wash-outs and causing high sediment loadings to the downstream environment and increase erosion.

The risks at the Mine Site are related to ice-rich and thaw-sensitive soils associated with the waste rock stockpile and open pit overburden cut slopes. The high ice content anticipated below the waste rock stockpiles are expected to lead to significant creep settlement once the stockpiles are fully loaded. Additionally, the stockpiles could become unstable and have other settlement issues without proper permafrost protection measures and stockpile construction scheduling. A thermal barrier will be required at the base of the stockpiles as to protect the exposed overburden cut slopes above the open pit to preventing thaw and instabilities. For ice rich areas near other Mine Site infrastructure, the majority of the structure locations have been optimized to avoid problem areas or founded on competent bedrock. In areas where this optimization is not possible, adequate permafrost protection measures will be implemented.

Along the Railway risks associated with the ice-rich permafrost and thaw-sensitive soils could result in creep settlement in high embankment sections, thaw settlements under the bridge culverts, thermokarst development along the route or in borrow areas and some general embankment instability. Relatively deep competent bedrock, and the presence of large boulders and ice rich in the overburden at some of the railway bridge crossing locations represent additional challenges for the bridge foundations. These risks will generally be mitigated through proper design and construction.

Table 9-2.1 Engineering Hazard Assessment - Milne Port

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Permafrost / Thaw Susceptible Soils	- Construction over ice rich or thaw sensitive permafrost ground causing technical issues with project infrastructure foundations - Saline permafrost - Problems potentially leading to environmental impacts	- Heavy structure experiencing creep settlement over ice-rich permafrost - Thaw weakening of surficial soils causing failure or movement of foundations - Melting of massive deposits below or adjacent to structure causing settlement or movement	MODERATE	MODERATE	- Geotechnical investigations to understand ground conditions - Relocation of structures to avoid problem areas - Excavations in overburden materials will be avoided as much as possible. - If possible found most significant structures on bedrock - Disturbance of the natural ground surface will be avoided - Over excavation of natural materials and backfill with an insulating cover of thaw stable granular fill materials of a minimum 1.5 m thickness to protect against thaw and instability in the underlying ice rich overburden soils - Embankments or granular fill pads used to protect underlying permafrost should be constructed with maximum side slopes of 2H:1V - Use cooling or refrigerated foundations where required and possible - Rock socketed and add freeze piles
Seismicity	- Significant earthquake event subjecting structures to dynamic loading - Moderate seismicity of region (higher in north, lower in south)	- Failure of infrastructure or foundations (dock)	LOW	HIGH	- Concerns mitigated through seismic hazard assessment and understanding loading potential - Adequate design of structures and dock piers - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems - Impact of seismicity on structures in permafrost is low - Many of same mitigation measures as for static stability
Flood / Hydrology	- Although not expected to have significant impact, runoff and water pooling could impact thermal regime. - Although carefully sized, significant runoff event exceeds capacity of access road culverts (i.e., icing of culverts or debris reduces capacity)	- Surface water induced thermal degradation leading to thaw settlement or weakening of soils/foundations - Overtopping of roads causing failure and potential downstream sediment issues	MODERATE	LOW	- Where surface water collection or diversion is required, the thermal impact of runoff must be considered. Ideally, ditches should be avoided wherever possible. Diversion berms are the preferred method of redirecting surface water flows if feasible. If ditches are required, they may have to be created by over-excavation and replacement with thaw stable processed rock fill material and perhaps be lined with geotextile. - Maintain grading and drainage of all areas near infrastructure - Extensive hydrology baseline studies - Over design of culvert capacity - Regular monitoring of culverts to identify icing or other debris blockages

Table 9-2.2 Engineering Hazard Assessment - Milne Inlet Tote Road

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Permafrost / Thaw Susceptible Soils	- Massive ice or ice rich soils at depth below higher embankments or in areas of cut - Thaw sensitive soils near ground surface below low embankments - Thermal degration of borrow areas and development of thermokarst areas	- High embankments may experience creep settlement over time - Cut areas may cause thermal degradation and settlement - Thaw weakening of soil leading to instability of structures - Construction disturbance or new ponding of water could impact thermal regime causing settlement, thermokarst development and potentially impact stability of road - Poor aesthetics	HIGH	LOW	- Geotechnical investigations should be conducted, although issues associated with settlement of road not as significant as rail line - Adequate design of embankments (i.e., flatter slopes in problem areas, minimum fill thickness for thermal protection, over excavation and backfill in cuts, etc.) - 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.) - Minimize cuts - Maintain proper grading and drainage from borrow areas - Replace some of cover material removed during excavation in borrow areas - Runoff and sediment control measures - On-going inspections and maintenance
Seismicity	- Significant earthquake event subjecting structures to dynamic loading - Moderate seismicity of region (higher in north, lower in south)	- Failure of larger bridge structure along rail alignment - Sudden failure of road embankment - Landslide, overburden/bedrock cut slope instability impacting road - Same impacts for items above	LOW	MODERATE	- Adequate design (i.e., suitable slopes for seismic design parameters) - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems - Impact of seismicity on structures in permafrost is low - Many of same measures as for standard/static stability
Flood / Hydrology	- Significant runoff event exceeds capacity of culverts or other water crossings. - Icing of culverts reduces capacity for normal flows - Debris build-up causes reduced capacity for flows	- Overtopping of road leading to operational shutdown, repairs and environmental impacts due to high downstream sediment loading - Ponded water impacting thermal regime and overall stability of structures	HIGH	LOW to MODERATE	- Hydrology baseline studies - Over design culvert capacity - Regular monitoring of culverts to identify icing or other debris blockages

Table 9-2.2 Engineering Hazard Assessment - Milne Inlet Tote Road (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Road Embankment Stability	- Sudden failure of road embankment due to physical failure of embankment fill or underlying foundations	- Failure causing operational shutdown - Costs of repairs - Environmental impacts due to high downstream sediment loading	LOW	LOW	- Geotechnical investigations - Adequate design (i.e., suitable slopes) - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems
Landform Stability	- Large scale landslide or slope instability outside footprint of road - Medium or large scale landslide through embankment footprint	- Sudden failure of road embankment - Blockage of culverts - Impact to thermal regime effecting longer term integrity of embankment permafrost foundations - Temporary shutdown of road operations	LOW	MODERATE	- Avoiding areas of major concern - Monitoring of potential problem areas
Stability of Overburden Cuts	- Failure of large slope upstream of rail cut into overburden causing impacts to rail.	- Slope failure could block, interrupt or even destroy section of road - Blockage of culverts - Impact to thermal regime effecting longer term integrity of embankment permafrost foundations - Temporary shutdown of road operations	LOW	LOW	- Geotechnical investigations - Minimize cuts - 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 utilized where seasonal flows can impact the cut face
Bridges Stability	- Failure of larger bridge structure - Bridge abutment failure due to thawed areas or impacts of flows on thermal regime - Erosion of abutment or pier foundations by water flows causing failure	- Failure of bridge causing operational shutdown, - Costs of repairs - Injury or fatality - Environmental impacts	LOW	MODERATE	- Geotechnical investigations - Adequate design (i.e., maximize use of bedrock, piles, refrigerated piles, thermal protection above pile caps, etc.) - Scour protection around abutments and piers - Instrumentation and monitoring for notification in event of potential failure

Table 9-2.3 Engineering Hazard Assessment - Mine Site

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Permafrost /Thaw Susceptible Soils	- Construction over ice rich or thaw sensitive permafrost ground causing technical issues with project infrastructure foundations - Problems potentially leading to environmental impacts	- Heavy structure experiencing creep settlement over ice-rich permafrost - Thaw weakening of surficial soils causing failure or movement of foundations - Melting of massive deposits below or adjacent to structure causing settlement or movement	MODERATE	HIGH	- Geotechnical investigations to understand ground conditions - Movement of structures to avoid problem areas - Found significant structures on bedrock to maximum extent possible - Excavations in overburden materials will be avoided as much as possible. In areas which require excavation to remove ice rich soils, over excavation of natural materials and backfill with thaw stable granular fill materials to provide strength to the soils and promote drainage during thaw season. - Disturbance of the natural ground surface will be avoided - Over excavation of natural materials and backfill with an insulating cover of thaw stable granular fill materials of a minimum 1.5 m thickness to protect against thaw and instability in the underlying ice rich overburden soils - Embankments or granular fill pads used to protect underlying permafrost should be constructed with maximum side slopes of 2H:1V - Use cooling or refrigerated foundations where required and possible - Rock socketed and adfreeze piles
Seismicity	- Significant earthquake event subjecting structures to dynamic loading - Moderate seismicity of region (higher in north, lower in south)	- Pit slope failure - Failure of waste stockpile slopes - Failure of infrastructure	LOW	MODERATE to HIGH	- Concerns mitigated through seismic hazard assessment and understanding loading potential - Adequate design (i.e., suitable slopes for seismic design parameters) - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems - Impact of seismicity on structures in permafrost is low - Many of same mitigation measures as for static stability

Table 9-2.3 Engineering Hazard Assessment - Mine Site (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Flood/ Hydrology	- Although not expected to have significant impact, runoff and water pooling could impact thermal regime. - Significant runoff event exceeds capacity of access road culverts - Icing of culverts reduces capacity for normal flows - Debris build-up causes reduced capacity for flows	- Surface water induced thermal degradation leading to thaw settlement or weakening of soils/foundations - Overtopping of roads causing failure and potential downstream sediment issues	MODERATE	LOW	- Where surface water collection or diversion is required, the thermal impact of runoff must be considered. Ideally, ditches should be avoided wherever possible. Diversion berms are the preferred method of redirecting surface water flows if feasible. If ditches are required, they may have to be created by over-excavation and replacement with thaw stable processed rock fill material and perhaps be lined with geotextile. - Maintain grading and drainage of all areas near infrastructure - Over design culvert capacity - Regular monitoring of culverts to identify icing or other debris blockages
Open Pit Stability	- Overall slope stability - Rock fall potential - Freeze/thaw cycles within the active zone will cause or accelerate the deterioration of the bench faces and increasing the chances of rock falls	- That rock falls or an overall slope stability issue will result in material impacting men or equipment working at lower elevations within the pit	MODERATE	MODERATE to HIGH	- Bench face angles selected to reduce instabilities. - Catch benches were incorporated into the design to reduce the impact of small scale instabilities - Inter-ramp and overall slope angles selected to achieve target Factor of Safety against multi-bench or overall slope failures. - Bench maintenance program will be developed that will include a monitoring program, scaling and the cleaning of accumulated debris from the catch benches.
Open Pit Overburden Slope Stability	- Failure of natural overburden slope above open pit.	- Slope failure could impact men or equipment working at lower elevations within the pit - Thermal degradation could lead to increase sediment reporting to open pit	MODERATE	MODERATE	- 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 utilized where seasonal flows can affect the slope

Table 9-2.3 Engineering Hazard Assessment - Mine Site (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Waste Rock Stockpile Stability	- Stability problems associated with stockpiles of waste rock and waste overburden 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 impacting thermal regime outer slope failure - 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 stockpile and at the stockpile surface. - Acid rock drainage	HIGH	HIGH	- Geotechnical investigations and installation of thermistors to obtain background ground temperature readings for design of the stockpile. - Adequate design of stockpiles (i.e., slopes) - An initial layer of NAG waste will be placed over previously uncovered ground surface during the winter months or when the active layer is fully frozen to act as a thermal barrier and prevent thaw over the short term prior to placement of waste materials during warmer months. - Ground disturbance will be minimized prior to placement of the thermal barrier. Only surface ice and snow to be removed from the footprint during the winter prior to placement of waste rock. - Depending on the conditions at the perimeter of stockpile 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. - Management of surface runoff will be an important component of the stockpile construction/operation. Minimizing erosion and/or the effect of flowing/standing water on thermal regime within the pile foundation soils and in close proximity to the toes will be critical. - Ongoing monitoring of slopes. Any cracks that develop will be monitored and repaired as required to minimize inflow of surface water and subsequent ice wedge formation within the stockpiles. - Encapsulate PAG waste materials in waste rock to maintain frozen state and prevent release of ARD. - Encapsulate ice-rich materials in waste rock to maintain frozen state and prevent release of sediment.

Table 9-2.4 Engineering Hazard Assessment - Railway

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Permafrost / Thaw Susceptible Soils	- Massive ice or ice rich soils at depth below high embankments or in areas of cut - Thaw sensitive soils near ground surface below low embankments	- High embankments may experience creep settlement over time - Cut areas may cause thermal degradation and settlement - Thaw weakening of soil leading to instability of structures - Construction disturbance or new ponding of water could impact thermal regime causing settlement	HIGH	MODERATE	- Geotechnical investigations - alignment routed around problem areas to maximum extent possible - adequate design of embankments (i.e., ventilated/cooling embankments, flatter slopes in problem areas, minimum fill thickness for thermal protection, over excavation and backfill in cuts, etc.) - 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.) - regular inspections and maintenance - minimize cuts
Seismicity	- Significant earthquake event subjecting structures to dynamic loading - Moderate seismicity of region (higher in north, lower in south)	- Failure of larger bridge structure along rail alignment - Sudden failure of rail embankment - Landslide, overburden/bedrock cut slope instability impacting embankment - Same impacts for items above	LOW	MODERATE to HIGH	- Rail alignment routed to avoid potential problem areas. Air photo interpretation used to identify potential issues prior to planning rail alignment. - Geotechnical investigations - Adequate design (i.e., suitable slopes for seismic design parameters) - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems - Impact of seismicity on structures in permafrost is low - Many of same mitigation measures as for static stability - Instrumentation may be utilized to detect a rock fall within the tunnel based on rock conditions - Instrumentation used to detect rock fall and/or slope failures impacting embankments - Rigorous bridge inspection requirements after seismic events

Table 9-2.4 Engineering Hazard Assessment – Railway (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Flood / Hydrology	- Significant runoff event exceeds capacity of culverts through rail alignment. - Icing of culverts reduces capacity for normal flows - Debris build-up causes reduced capacity for flows	- Overtopping of rail embankments leading to operational shutdown, costly repairs and environmental impacts due to high downstream sediment loading - Ponded water impacting thermal regime and overall stability of structures - Surface flow may accelerate the deterioration of the cut face	MODERATE to HIGH	MODERATE	- Hydrology baseline studies - Over design culvert capacity - regular monitoring of culverts to identify icing or other debris blockages - Use of diversion ditches - Regular Railway maintenance activities will include thawing ice blocked culverts and removing debris that may impede flow through culverts
Embankment Stability	- Sudden failure of rail embankment due to physical failure of embankment fill or underlying foundations	- Failure of rail embankment causing operational shutdown - Costs of repairs - Environmental impacts due to high downstream sediment loading	LOW	MODERATE	- Geotechnical investigations - Optimized alignment to avoid problem areas - Adequate design (i.e., suitable slopes) - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Monitoring during operations for indicators of potential problems - Inspection frequencies will be increased during the summer 'thaw" period in areas with a risk of foundation failure
Landform Stability	- Large scale landslide or slope instability outside footprint of embankment - Medium or large scale landslide through embankment footprint	- Sudden failure of rail embankment - Blockage of culverts - Impact to thermal regime effecting longer term integrity of embankment permafrost foundations - Shutdown of rail operations	LOW	HIGH	- Rail alignment routed to avoid potential problem areas. Air photo interpretation used to identify potential issues prior to planning rail alignment. Geotechnical drilling used where necessary to confirm favourable conditions. - Monitoring of potential problem areas - Regular safety inspections will include monitoring problem areas

Table 9-2.4 Engineering Hazard Assessment – Railway (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Stability of Overburden Cuts	- Failure of large slope upstream of rail cut into overburden causing impacts to rail.	- Slope failure could block, interrupt or even destroy section of rail line - Blockage of culverts - Impact to thermal regime effecting longer term integrity of embankment permafrost foundations - Shutdown of rail operations	LOW	MODERATE	- 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 - diversion ditches may be utilized where seasonal flows can impact the cut face - regular safety inspections will include monitoring problem areas
Stability of Major Rock Cuts	- Failure of large slope upstream of rail cut into bedrock causing impacts to rail.	- Slope failure could block, interrupt service, or destroy section of rail line - Potential environmental impacts in event of failure due to sediment loading rail accident.	LOW	MODERATE to HIGH	- Geomechanical site investigations - Cut slopes will be designed to reduce bench scale and overall cut stability issues. - diversion ditches may be utilized where seasonal flows can impact the cut face - slope monitoring, early warning systems, rockfall fence, ditches/berms, use of shotcrete. - For the higher cuts, catch benches will be incorporated in the design to reduce the likelihood of dislodged rock material impacting the rail line.
Rockfall Hazards	- Falling rocks from upper slopes adjacent to rail embankment - Freeze/thaw cycles within the active zone or surface flow will cause or accelerate the deterioration of the rock slope increasing the chances of a shallow failure - Main concerns are along Cockburn Lake	- Falling rocks causing damage or impacts to rail alignment/track or operational trains - There will be a rockfall that will block the rail line or interrupt service. - Injury or death to human life	HIGH	MODERATE to HIGH	- Preliminary rockfall hazard assessment has been completed. High risk areas will be addressed using appropriate mitigation strategies. - For the higher cuts, catch benches will be incorporated in the design to reduce the likelihood of dislodged rock material impacting the rail line. - Slope monitoring, early warning systems, rockfall fence, ditches/berms. - Rockbolts, blasting loose rock, netting, fencing and shotcrete in place for Railway Portals - Maintenance program will be undertaken with appropriate scaling of any "loose" rock on the slope or cut face.

Table 9-2.4 Engineering Hazard Assessment – Railway (Cont'd)

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Bridges Stability	- Failure of larger bridge structure along rail alignment - Bridge abutment failure due to thawed areas or impacts of flows on thermal regime - Erosion of abutment or pier foundations by water flows causing failure	- Failure of bridge causing operational shutdown, - Costs of repairs - Injury or fatality - Environmental impacts	LOW	HIGH	- Geotechnical investigations - adequate design (i.e., maximize use of bedrock, piles, refrigerated piles, thermal protection above pile caps, etc.) - scour protection around abutments and piers - instrumentation and monitoring for notification in event of potential failure - bridge structures will be inspected annually, including assessment of piers and abutments, any suspect piers or abutments will be instrumented and checked regularly - scour protection will be inspected and if necessary restored after the spring freshet
Stability of Tunnels	- Failure of tunnel causing impacts to rail operation. - Ventilated air will create an active zone surrounding the periphery of the tunnel - Warming and cooling will change the depth of the active zone around the periphery of the tunnel	- Ground fall will occur that will block the rail line or interrupt service - Thawing of the excavation periphery will reduce the strength of the rock and eventually generate falls of ground. - Drilling into frozen ground will be a safety issue if the drill water freezes.	LOW	LOW to MODERATE	- Geotechanical investigations - Rock mass characteristics will be considered during the tunnel design and will include consideration of: any faults or large scale discontinuities. - Excavation and ground support recommendations will be appropriate for ground conditions expected. - Further site investigation work will be undertaken to better characterize the rock mass. - Regular inspections by trained personnel and underground instrumentation will be used to monitor the long-term performance of the excavation

Table 9-2.5 Engineering Hazard Assessment - Steensby Port

Engineering Hazard	Hazard Description	Potential Consequences	Risk Factor	Consequence Factor	Mitigation Measures
Permafrost / Thaw Susceptible Soils	- Construction over ice rich or thaw sensitive ground causing technical issues with project infrastructure foundations - Problems potentially leading to environmental impacts	- Heavy structure experiencing creep settlement over ice-rich permafrost - Thaw weakening of surficial soils causing failure or movement of foundations - Melting of massive deposits below or adjacent to structure causing settlement or movement	LOW	HIGH	- Geotechnical investigations to understand ground conditions - Movement of structures to avoid problem areas - Majority of structures on bedrock - Excavations in overburden materials will be avoided as much as possible. - Disturbance of the natural ground surface will be avoided - Overexcavation of natural materials and backfill with an insulating cover of thaw stable granular fill materials of a minimum 1.5 m thickness to protect against thaw and instability in the underlying ice rich overburden soils - Embankments or granular fill pads used to protect underlying permafrost should be constructed with maximum side slopes of 2H:1V
Seismicity	- Significant earthquake event subjecting structures to dynamic loading - Moderate seismicity of region (higher in north, lower in south)	- Failure of infrastructure or foundations (dock)	LOW	HIGH	- Concerns mitigated through seismic hazard assessment and understanding loading potential - Adequate design of structures and dock piers - Adequate construction using suitable fill materials, construction practices and QA/QC procedures - Impact of seismicity on structures in permafrost is low - Many of same mitigation measures as for static stability
Flood / Hydrology	- Although not expected to have significant impact, runoff and water pooling could impact thermal regime. - Significant runoff event exceeds capacity of access road culverts (i.e., icing of culverts or debris reduces capacity)	- Surface water induced thermal degradation leading to thaw settlement or weakening of soils/foundations - Overtopping of roads causing failure and potential downstream sediment issues	MODERATE	LOW	- Where surface water collection or diversion is required, the thermal impact of runoff must be considered. Ideally, ditches should be avoided wherever possible. Diversion berms are the preferred method of redirecting surface water flows if feasible. If ditches are required, they may have to be created by over-excavation and replacement with thaw stable processed rock fill material and perhaps be lined with geotextile. - Maintain grading and drainage of all areas near infrastructure - Hydrology baseline studies - Over design culvert capacity - Regular monitoring of culverts to identify icing or other debris blockages

Maintenance may be required at some locations due to thermal degradation of the underlying foundations. Areas of cut along the Railway will require over-excavation and backfill to ensure thermal stability of foundations. Cut slopes in ice-rich overburden will require a protective thermal barrier. Another risk is related to the hydrology and high runoff events that may lead to flows beyond the capacity of the hydraulic structures. This risk is further increased by the spring icing of culverts, further reducing capacity and leading to potential overtopping, localized changes to the thermal regime and potential wash-out of embankment sections. Regular inspections and maintenance programs implemented throughout operations will be critical for mitigating many of the risks associated with permafrost and hydrology related issues.

The Steensby Port area is mainly bedrock controlled; the majority of the on-shore infrastructure will be founded on the bedrock, or using short pile foundations that extend to the bedrock. The offshore structure locations will be optimized to avoid thick layers of soft clay sediments present in the area and will have foundations that extend to bedrock, or having the sediments removed. The risks associated with the offshore structure foundations will be mitigated through proper design and construction.

Snow Drifts and Snow Banks

Potential for significant snowdrifts exists in highly exposed and hilly areas such as the Milne Inlet Tote Road, access roads and the Railway. Significant volumes of snow may exceed what was naturally collected by the existing terrain on the downwind sides of hills, especially when they are cut to accommodate a transportation link. Detailed snowdrift assessment of designs is recommended where the terrain is higher than the transportation corridor within a lateral distance of 75 m. Inactive mitigation measures include snow fencing, terracing and exposed (raised) road surfaces. Active mitigation measures include the use of snow berms and shaping snow banks to minimize snowdrifts. Changes in snow accumulation will have an indirect effect on run-off, slope stability/erosion and permafrost impact, and may also require assessment of the change in local drift patterns that they will create (RWDI, 2010).

2.2 POTENTIAL EFFECTS OF CLIMATE CHANGE ON THE PROJECT

Changes to Permafrost

The Project is situated within the zone of continuous permafrost, which is likely more than 500 m thick across the terrestrial RSA. The thickness of the active layer varies from less than 0.3 m in areas blanketed with organic soils to over 2.0 m in coarse-grained soils. The surficial geology is variable, with materials consisting of organic soils, alluvium, colluvium, marine and glacio-marine deltaic sediments, glaciofluvial deposits, glaciolacustrine and lacustrine deposits, glacial deposits and highly fractured to competent bedrock outcrops. Soils can be ice-rich, with the amounts of ground ice varying significantly from site to site. A more detailed description of geotechnical investigations carried out of the Project is provided in Volume 6, Section 2.1.3. The potential impacts on sensitive landforms (the key indicator for the Landforms, Permafrost and Soils VEC) are provided in Volume 6, Section 2.3.

Based on accepted climate change models, it is generally believed that global warming will have little impact on the very cold and deep permafrost conditions over the currently planned life of the project. Geotechnical investigations and studies have been completed, to identify areas of concern related to permafrost and potential geo-hazards that could impact the infrastructure. Although it is projected that the Mary River Project will remain within the zone of continuous permafrost, it is predicted that the active layer thickness could increase by 50 % (Arctic Council and the International Arctic Science Committee, 2005). Other potential impacts include changes to drainage pattern resulting from subsidence and thermokarst formation, increased sediment loadings and mass wasting on sensitive slopes. In general, the location of infrastructure has been optimized to avoid potential problem areas to the maximum extent possible. Additionally, areas where problems cannot be avoided will be constructed with conservatively designed permafrost protection measures and thermal barriers. Thus, the project is not sensitive to changes in climate-related parameters.

Changes to Sea Ice Conditions

As global temperatures rise, sea ice can be expected to form later and clear earlier in the year. Current Arctic sea ice extent in March is approximately 14 million km^2 but will reduce by about 2 to 4 million km^2 by 2100 (International Arctic Science Committee, 2010). Current Arctic sea ice extent in September (when ice over is at its minimum) ranges from about 5 to 6 million km^2 (Arctic Council and International Arctic Science Committee, 2005).

Projected changes in sea-ice conditions for the 21st century are summarized in tables 9-2.6 (winter) and 9-2.7 (summer) based on output from the five Arctic Impact Climate Assessment (AICA)-designated global climate models (International Arctic Science Committee, 2010). The projections vary widely, especially for the summer. The CSM_1.4 (National Center for Atmospheric Research) model consistently projects the greatest sea-ice extent and the least amount of change, while the CGCM2 (Canadian Centre for Climate Modeling and Analysis) model consistently projects the least sea ice and the greatest amount of change. However, all five ACIA- designated models agree that sea-ice coverage will decrease in summer and winter.

Table 9-2.6 Sea-ice extent (10^6 km^2) in Winter (March) as projected by the five ACIA-designated models (International Arctic Science Committee, 2010)

Model	1981–2000	2011–2030	2041–2060	2071–2090
CGCM2	7.28	3.33	0.55	0.05
CSM_1.4	16.32	15.00	14.16	14.01
ECHAM4/OPYC3	16.19	15.62	14.97	14.38
GFDL-R30_c	16.17	15.60	14.86	14.52
HadCM3	16.32	15.53	14.87	13.74

CGCM2: Canadian Centre for Climate Modelling and Analysis; CSM_1.4: National Center for Atmospheric Research; ECHAM4/OPYC3: Max-Planck Institute for Center for Meteorology; GFDL-R30_c: Geophysical Fluid Dynamics Laboratory; HadCM3: Hadley Centre for Climate Prediction and Research.

Table 9-2.7 Sea-ice extent (10^6 km^2) in Summer (September) as projected by the five ACIA-designated models (International Arctic Science Committee, 2010)

Model	1981–2000	2011–2030	2041–2060	2071–2090
CGCM2	16.14	15.14	13.94	13.26
CSM_1.4	7.22	7.00	6.72	6.59
ECHAM4/OPYC3	7.02	6.03	4.06	2.68
GFDL-R30_c	7.28	5.91	4.33	2.91
HadCM3	7.41	6.22	5.12	3.22

CGCM2: Canadian Centre for Climate Modelling and Analysis; CSM_1.4: National Atmospheric Research; ECHAM4/OPYC3: Max-Planck Institute for Meteorology; GFDL-R30_c: Geophysical Fluid Dynamics Laboratory; HadCM3: Hadley Centre for Climate Prediction and Research.

Overall, the decrease in areal extent of sea ice projected by the five models for the northern hemisphere ranges between 12 and 46 % by the end of the 21st century, as shown in Table 9.2.8 (International Arctic Science Committee, 2010).

Four of the five ACIA-designated models project that the seasonal sea-ice zone is likely to increase in the future because sea-ice coverage will decrease more during summer than winter. This suggests that sea ice thickness is also likely to decrease because a single winter of sea-ice growth is an insufficient period to reach equilibrium thickness (International Arctic Science Committee, 2010).

Table 9-2.8 Changes in mean annual Northern Hemisphere sea-ice extent between 2000 and 2100 projected by the five ACIA-designated models (International Arctic Science Committee, 2010)

	Unadjusted Projections			Adjusted Projections		
	Ice Extent (10^6 km^2)		Change (%)	Ice Extent(106 km^2)		Change (%)
Model	**2000**	**2100**		**2000**	**2100**	
CGCM2	9.7	5.6	-42	12.3	6.6	-46
CSM_1.4	16.5	14.2	-14	12.3	10.8	-12
ECHAM4/OPYC3	11.9	8.9	-25	12.3	9.3	-24
GFDL-R30_c	11.9	8.5	-29	12.3	8.6	-30
HadCM3	12.8	9.4	-27	12.3	9.1	-26

In recent years, diminishing ice cover has occurred in the Canadian Arctic. While there have been some exceptions, ice is generally forming later and clearing earlier, and it is generally accepted that this trend will continue. Project decisions taken today will therefore need to account for the long-term effects of possible and or likely changes to the ice conditions along the shipping route and at the port site. While global temperatures may continue to rise, the current pattern of ice growth in the Arctic will remain relatively unchanged. Freezing degree days in the Arctic will be such that ice growth, while potentially diminished, will follow historical patterns. Simply put, winter ice will remain a challenge to navigation for all but the most capable vessels. Any changes in the ice regime will reduce the challenges of ice navigation; therefore the Project has been designed by making the conservative (cautionary) assumption that ice conditions will follow historical patterns.

Sea ice reduction could have a positive effect on navigation through the Northwest and Northeast Passages, and may increase commercial shipping, transportation of unprocessed mineral resources, and tourism (Arctic Council and International Arctic Science Committee, 2005). It is expected that the changes in sea ice cover due to climate change will not significantly affect the shipping operations in the Foxe Basin.

Tables 9-2.1 to 9-2.5 provide a general assessment of hazards that could affect the engineering structures in the Project. Table 9-2.6 provides other design measures that may be implemented to protect the Project structures from the impacts of construction, operations and potential changes to the climate. In general, conservative assumptions are used as the way to address potential effects of climate change.

Table 9-2.9 Design Measures for Project Structures used to Account for Climate Change

Project Structure	Design Measures
Milne Inlet Tote Road – Upgrades	No specific measures were taken into account for climate change beyond those for construction on permafrost
Milne Inlet Tote Road – Water Crossings	A 1:100 year storm event was used for design of all water crossings
Railway – Embankment	Embankment thickness and over-excavation depths in ice-rich materials increased based on a 50 % greater thickness of active layer
Railway – Water Crossings (Bridges)	Designed culverts and bridges to a higher return period of 1:200 (Dillon, 2008)
Railway – Auxiliary Facilities	Loading and unloading facilities and the workshop will be located on bedrock or piles to account for the increased thickness of the active layer. The unheated inspection shed will be sited on run of quarry rock fill. Telecommunication towers will be located on bedrock or piles into bedrock where possible; towers installed on thaw sensitive soils will be monitored for subsidence during thawing months; further, specific operating instructions will dictate how everyone is to act in the case of a tower failure; redundancy measures will be in place.
Port Facilities	Docks can account for the fluctuation in sea levels (higher or lower) due to climate change. Water depth at ports due to lower predicted water levels at Steensby Port will be sufficient for ships.
Open Pit Mine	Thermal Barrier on ice-rich overburden slopes should be of adequate thickness to account for increase to active layer thickness
Waste Rock Stockpile	Potentially-acid generating (PAG) rock will be buried sufficiently deep within the pile to account for increase in active layer thickness
Airstrips and Access Roads	Thermal barrier (non-frost/thaw sensitive fill) thickness increased to account for increases active layer depth
Building foundations	Ad freeze pile calculations to account for slightly warmer permafrost and deeper active layer. Thermal barriers and foundation pads thicker.

2.3 AUTHORS

Effects of the environment on the Project were prepared by Charlotte Dubec and Kevin Hawton, P.Eng. of Knight Piésold. Revision was made by Ramli Halim, P. Eng of Hatch and Larry LeDrew M. Sc., Sikumiut Environmental Management Ltd.

SECTION 3.0 - ACCIDENTS AND MALFUNCTIONS

Baffinland has an obligation to identify any foreseeable hazards that may arise from the Mary River Project and to assess the risk of harm arising from the identified hazards. The reasons for this arise from the following considerations:

- Concern for the health and safety of employees, contractors and visitors;
- Concerns for environmental protection;
- It makes good business sense and is cost effective; and
- So that Baffinland's duty of care for its employees and contractors can be undertaken, and so that health, safety and environmental legal requirements can be met.

Knowledge of hazards and the evaluation of associated risks are necessary for establishing health, safety and environmental objectives and targets, and for setting priorities to control the risks to employees and others. Hazard identification, risk assessment and control are an on-going process undertaken periodically throughout the Project life cycle, presented in Volume 10, Appendix 10A-2. This rigorous approach leads to the development and implementation of mitigation actions and procedures, and the development of adaptive management plans.

Despite this on-going effort, major accidents and malfunctions can occur through natural events, breakdown of mitigation measures, or human error. Although the likelihood or probability of such events is low, accidental events could have environmental, health or safety repercussions.

3.1 IDENTIFICATION OF RISKS AND METHODOLOGY

A list of potential malfunctions or accidents was developed from the following primary sources:

- Public concerns: expressed by local communities and other members of the public;
- Project personnel: all Project risks, including environment-related risks were developed and assessed as part of Project risk assessment exercises;
- Comparative projects: review of readily available Environmental Assessments issued recently for other large scale mineral projects; and
- Experience of personnel with other projects.

Only credible malfunctions and accidents with a reasonable probability of occurring have been assessed. For the purpose of this assessment, the severity of consequences is provided in Table 9-3.1 and the likelihood of occurrence is defined in Table 9-3.2. The level of risk is thus defined by consideration of the severity of the consequences and the likelihood of occurrence. The risk matrix used to define the risk associated with the potential accidents and malfunctions is presented in Table 9-3.3.

Despite the fact that all foreseeable precaution measures have been implemented, the consequences of their occurrences can entail the loss of human life or severe environmental damage. Table 9.3-4 presents a list of credible potential accident and malfunction scenarios for the Mary River Project. Risks were assessed based on operational controls implemented on the basis of best management practices as outlined in Baffinland's EHS Management System (refer to Volume 10 and Appendix 10A-2 for Hazard Identification and Risk Assessment Procedure) and the application of the management plans provided as appendices in Volume 10. The EPP for the Project provides a summary of the controls and procedures to be implemented.

Table 9-3.1 Consequence Severity

Consequence	Definition
Critical	*Major uncontrolled event or inefficiency with uncertain and perhaps prohibitively costly remediation*. Health and Safety: Fatality. Production: More than six month production loss or expenditure. Cost: >$500,000,000 damage or additional costs. Environmental Impact/Compliance: Very serious environmental impacts with impairment on landscape/ marinescape ecology. Long-term, widespread effects on significant environment. Corporate Image or Utility: Corporate image tarnished internationally. Community Affairs: Non compliance with existing community agreement. Extreme and widespread community concerns with international exposure/influence.
Major	Significant event or inefficiency that can be addressed but with great effort. Health and Safety: Lost-time injury(s) potentially resulting in permanent disability. Production: Three to six months production or expenditure. Cost: $100,000,000 to $500,000,000. Environmental Impact/Compliance: Serious environmental impacts with impairment on ecosystems. Relatively widespread long-term effects. Regulatory approval withdrawn for a few months. Corporate Image or Utility: Corporate image tarnished in North America. Community Affairs: High local community concerns with national exposure/influence
Moderate	Moderate event or inefficiency that might need physical attention and certainly engineering review. Health and Safety: Lost-time injury (no permanent disability). Production: One to three production loss or expenditure. Cost: $1,000,000 to $100,000,000 damage or additional costs. Environmental Impact/Compliance: Some impairment on ecosystem function. Displacement of species. Moderate short-term widespread effects. Regulatory orders with significant cost implications. Corporate Image or Utility: Corporate image tarnished in region. Community Affairs: Moderate local community concern with potential permanent damage to relations.
Minor	Minor incident or inefficiency that might require engineering review and is easily and predictably remediated. Health and Safety: Injury (no lost time). Production: Less than one month production loss or expenditure. Cost: $100,000 to $1,000,000 damage or additional costs. Environmental Impact/Compliance: Minor effects on biological or physical environment. Minor short-term damage to small areas. Corporate Image or Utility: Corporate image not affected, written complaint or concern dealt with internally. Community Affairs: Minimal local community concern with no lasting damage to relations.
Insignificant	Minor incident or inefficiency of little or no consequence. Health and Safety: No injury or lost time. Production: One to two weeks production loss or expenditure. Cost: <$100,000 damage or additional costs. Environmental Impact/Compliance: No lasting impacts. Low-level effects on biological or physical environment. Limited damage to minimal area of low significance. Corporate Image or Utility: Corporate image not affected or verbal complaint dealt with internally. Community Affairs: No community concern

Table 9-3.2 Likelihood of Accidents and Malfunctions

Likelihood	Description in Context of Full Operating Life of the Facility	Frequency
Almost Certain	Consequence expected to occur in most circumstances	High frequency of occurrence - occurs more than once per year
Likely	Consequence will probably occur in most circumstances	Event does occur, has a history, occurs once every 1 to 10 years
Possible	Consequence could occur at some time	Occurs once every 10 to 100 years
Unlikely	Consequence may occur at some time	Occurs once every 100 to 1,000 years
Rare	Consequence may occur at some time	Occurs once every 1,000 to 10,000 years

NOTE(S):
1. REFER TO VOLUME 10, APPENDIX 10A-2 STANDARD FOR HAZARD IDENTIFICATION AND RISK ASSESSMENT.

Table 9-3.3 Risk Matrix

	Likelihood				
Consequence	**Rare**	**Unlikely**	**Possible**	**Likely**	**Almost Certain**
Critical	Moderate	Moderate	High	Extreme	Extreme
Major	Low	Moderate	Moderate	High	Extreme
Moderate	Low	Moderate	Moderate	Moderate	High
Minor	Very Low	Low	Moderate	Moderate	Moderate
Insignificant	Very Low	Very Low	Low	Low	Moderate

Table 9-3.4 Major Accidents and Malfunctions Risk Summary

Project Sector	Issue of Concern	Consequence	Likelihood	Risk Rating
Mine Site	Open pit and waste rock stockpile – slope failure causing production delay or human injury	Major	Rare	Low
	Explosive accidents (accidental detonation of explosives) causing human injury or fatality	Major to Critical	Rare	Low - Moderate
	Hazardous material release resulting in contamination of environment	Minor	Unlikely	Low
	Truck accidents resulting in human injuries or fatalities	Major to Critical	Unlikely	Moderate

Table 9.3-4 Major Accidents and Malfunctions Risk Summary (Cont'd)

Project Sector	Issue of Concern	Consequence	Likelihood	Risk Rating
Mine Site	Open Pit flooding resulting in a production delay	Minor	Unlikely	Low
	Open Pit flooding resulting in a human injury	Major	Unlikely	Moderate
	Fire at the camp facilities and infrastructure resulting in human injuries or fatalities	Major to Critical	Unlikely	Moderate
	Failure of power supply resulting in human injuries or fatalities	Major to Critical	Rare	Low - Moderate
	Failure of WWTP resulting in environmental contamination	Minor	Unlikely	Low
	Contamination or interruption of water supply resulting in effects on human health	Moderate	Rare	Low
Tote Road	Road embankment failure/collapse of water crossing resulting in environmental degradation	Insignificant	Likely	Low
	Hazardous material release resulting in environmental contamination	Minor	Rare	Very Low
	Truck accident resulting in human injuries	Moderate	Likely	Moderate
	Collision with other users resulting in human injuries or fatalities	Major - Critical	Unlikely	Moderate
	Weather related strandings resulting in Human injuries	Major	Possible	Moderate
	Collision with wildlife Resulting in injury to Wildlife	Minor	Unlikely	Low
Railway	Road embankment failure/collapse of water crossing resulting in environmental degradation	Insignificant	Possible	Low
	Derailment resulting in human injuries or fatality	Major - Critical	Rare	Low - Moderate
	Tunnel collapse resulting in human injuries or fatality	Major - Critical	Rare	Low - Moderate
	Weather related strandings resulting in human injuries or fatality	Major - Critical	Rare	Low - Moderate
	Hazardous material release resulting in contamination of the environment	Minor	Rare	Very Low
	Collision with human resulting in human injury	Major	Rare	Low

Table 9.3-4 Major Accidents and Malfunctions Risk Summary (Cont'd)

Project Sector	Issue of Concern	Consequence	Likelihood	Risk Rating
Railway	Collision with wildlife Resulting in harm to wildlife	Minor	Unlikely	Low
Milne Port and Steensby Port	Diesel spill – ship to shore transfer resulting in contamination of the marine environment	Minor	Unlikely	Low
	Fire at the camp facilities and infrastructure resulting in human injuries or fatalities	Major - Critical	Unlikely	Moderate
	Failure of power supply resulting in human injuries or fatalities	Major - Critical	Rare	Moderate
	Failure of WWTP resulting in harm to human health or the environment	Minor	Unlikely	Low
	Contamination or interruption of water supply resulting in an effect on human health	Minor	Possible	Low
	Congestion at Port resulting in damage to vessels, possible spills, production delay	Minor	Unlikely	Low
	Hazardous material release resulting in environmental contamination	Minor	Unlikely	Low
	Ice accumulation at Port resulting in damage to port infrastructure and vessels, production delay	Insignificant	Likely	Low
	Introduction of invasive species (marine and terrestrial)	Minor	Likely	Low
Air traffic	Aircraft or helicopter crash resulting in human injuries or fatalities	Major - Critical	Rare	Low - Moderate
Shipping	Collision with marine mammals resulting in harm to marine mammals	Minor	Rare	Very Low
	Engine failure resulting in a delay in shipping	Insignificant	Possible	Moderate
	Ship grounding resulting in damage to ship or possible harm to aquatic life	Minor	Unlikely	Low
	Ice / ship interaction resulting in a delay or possible damage to vessel	Insignificant	Likely	Low
	Collision with other vessels resulting in damage to ship, possible harm to aquatic life	Moderate	Rare	Low

Table 9.3-4 Major Accidents and Malfunctions Risk Summary (Cont'd)

Project Sector	Issue of Concern	Consequence	Likelihood	Risk Rating
Shipping	Major diesel spill along the shipping route resulting in contamination of marine and coastal environment along shipping lane	Critical	Possible	High
NOTE(S): 1. ASSESSMENT IS BASED ON OPERATIONAL CONTROLS IMPLEMENTED ON THE BASIS OF BEST MANAGEMENT PRACTICES AS OUTLINED IN BAFFINLAND'S EHS MANAGEMENT SYSTEM (REFER TO VOLUME 10, AND APPENDIX 10A-2 FOR HAZARD IDENTIFICATION AND RISK ASSESSMENT PROCEDURE).				

The above hazard assessment framework was applied to the significance methodology described in Volume 2, Section 3, to evaluate the significance of residual effects of accidents and malfunctions, as follows (Table 9-3.5).

The major accidents and malfunctions identified are described in the subsequent sections, and an evaluation of significance is provided in Section 3.9.

Table 9-3.5 Ratings for Evaluating Significance of Residual Effects of Accidents and Malfunctions

Criteria	Classification	
Magnitude	Level I	An effect on the exposed indicator/VEC that results in a change that is not distinguishable from natural variation and is within regulated values Does not result in any human lost-time injury. Is equivalent to a Very Low to Low Risk Rating
	Level II	An effect that results in some exceedence of regulated values Results in a change that is measurable but allows recovery within one to two generations Results in human injury but no fatality Is equivalent to a Moderate Risk Rating
	Level III	An effect predicted to exceed regulated values and/or results in a reduced population size or other long-lasting effect on the subject of assessment Results in human fatality Is equivalent to a High to Extreme Risk Rating
Extent The physical extent of the effect, relative to study area boundaries	Level I	Confined to the LSA
	Level II	Beyond the LSA and within the RSA
	Level III	Beyond the RSA
Frequency How often the effect occurs	Level I	Rare - Occurs once every 1,000 to 10,000 years
	Level II	Unlikely - Occurs once every 100 to 1,000 years
	Level III	Possible – Occurs once every 10 to 100 years
	Level IV	Likely - Event may occur every 1 to 10 years
	Level V	High – occurs more than once per year

Table 9-3.5 Ratings for Evaluating Significance of Residual Effects of Accidents and Malfunctions (Cont'd)

Criteria	Classification	
Duration The length of time over which a Project effect will occur	Level I	Short term (effect lasts up to four years)
	Level II	Medium term (up to 25 years, for the life of the Project)
	Level III	Long term (beyond the life of the Project) or permanent
Reversibility The likelihood of the VEC to recover from the effect	Level I	Fully reversible
	Level II	Reversible with cost/effort
	Level III	Irreversible
Qualifiers		
Certainty Limitations in the overall understanding of the ecosystem and ability to predict future conditions	High	Baseline data are comprehensive; predictions are based on quantitative data; effect relationship is well understood
	Medium	Intermediate degree of confidence between high and low
	Low	Baseline data are limited; predictions are based on qualitative data; effect relationship is not well understood
Probability The likelihood that the predicted impact/residual effect will occur	Unlikely	Less than 20 % likelihood of occurrence
	Moderate	Between 20 and 60 % likelihood of occurrence
	Likely	Over 60 % likelihood of occurrence

3.2 MINE SITE

3.2.1 Open Pit Slope Failure or Waste Rock Stockpile Slope Failure

Open pits that are not properly designed and operated can be subject to erosion, pit wall failure and other slope stability incidents, causing hazards to workers or the environment. The floors of the pit might heave, but this is usually a localized event of low environmental significance. Two main sources of pit slope failure are overburden and bedrock instability. Overburden slope failure can lead to uncontrolled erosion, and bedrock instability can lead to pit wall collapse. The overburden slope angles will be conservatively designed to reduce the possibility of failure; thus, no significant environmental effects are anticipated. The bedrock slopes will also be conservatively designed, taking into account the geotechnical characteristics of the rock. Pit dewatering can also affect the stability of pit walls. This is not foreseen for the pit at Mary River, since the design and development will incorporate water diversions away from the pit perimeter wherever appropriate. Freeze-thaw processes acting on freshly exposed pit walls could potentially cause structural weaknesses that could lead to wall failure.

Stability analysis will be conducted during design and planning to determine overburden slope configurations that would achieve a desired safety factor for the ore and rock parameters. Bench heights, excavation and face angles, rock buttress, etc., will be based on the results of stability analysis. If erosion of the pit occurs during operation, measures such as rip-rapping or rock nailing will be taken. Rocks would be captured by the safety berms wherever necessary and practical. Geotechnical monitoring will be continuous during excavation with periodic monitoring during operation. Pit walls and overburden slopes will be visually inspected by the engineering staff and preventive measures implemented as appropriate. A geotechnical engineer or a professionally qualified engineer will visit the site periodically to assess the stability of the pit, identify any potential for safety hazards and take measures necessary to prevent or correction hazardous circumstances. If necessary, monitors will be installed to record ground-movements and temperatures and the results evaluated for redesign or modification of design.

There are no instances envisioned whereby instability of overburden or bedrock slopes could cause significant environmental consequences when proper design and monitoring are incorporated in the planning and operation of the pit. However, in case an accident or a malfunction of operation parameters should occur, proper safety procedures such as pit evacuation and implementation of emergency measures will be established to protect workers from injury and fatalities.

Failure could cause localized slope changes that would require subsequent reshaping to ensure long-term stability. In the unlikely instance that workers are injured by slope failure, emergency response procedures (to be developed in detail prior to commencement of operation) will be followed and technical and environmental preventative measures will be implemented immediately. With the control measures in place, the risk rating is considered low.

Waste rock is generated from stripping overburden and lower grade material from the mine to access the ore. The waste rock is trucked and placed in the stockpile. Several measures are undertaken to ensure stability of this pile:

- Final toe 100m from the final pit crest;
- 2:1 (H:V) overall slopes;
- 1.5:1 (H:V) individual lift slopes;
- 10m lifts, triple benching (30m benches);
- 15m berms between benches;
- 150m segments (5 benches); and
- Upper segment (above 680m elev.) toe moved back 120m away from crest of bottom segment (below 680m elev.).

Haulage ramps for the waste stockpile are similar in design to those in the pit, at 33m wide with 10 % grade. Final access ramps enter from the east and west sides of the pit, tying into the pit design.

Slope failure could cause localized changes that would require subsequent reshaping to ensure long-term stability. In the unlikely instance that workers are injured by slope failure, emergency response procedures, which will be followed and technical and environmental preventative measures will be implemented immediately. With the control measures in place, the risk rating is considered low.

3.2.2 Open Pit Flooding

During pit construction and operation, water will be collected in a sump structure at the lowest elevation and pumped to surface retention ponds prior to release. Throughout the lifetime of the mine, the pit will be entirely contained and surrounded in permafrost with the exception of an active layer of exposed overburden around the perimeter and a short distance into the exposed pit walls. Therefore the main source of sump water will be rain, snow melt and a small volume of runoff and seepage from the active layer. Because of the permafrost, there will be no sudden inflows of water due to release of groundwater from large fracture zones, voids or abandoned drill holes. Surface water inflows will be curtailed by a series of diversion ditches and swale structures around the perimeter. An extreme rainfall event during freshet, coupled with rapid flows from snow melt within and external to the pit, could potentially cause rapid accumulation of water that exceeds the sump capacity and begins to flood the pit. This scenario could be made worse by the potential failure of a water diversion berm around the pit perimeter. The consequence could include human injuries or production delays. The environmental consequence would include sudden filling and overflow of retention ponds.

Design and operational controls in place to minimize the consequences include:

- Emergency response procedures to be developed and reviewed prior to commencement of pit construction and operations to provide rapid response and evacuation as required to minimize the potential for human injuries;
- Ability to quickly mobilize and operate additional pumping systems and equipment in the event of rapid pit water inflows to the sump;
- Properly designed and constructed perimeter diversion ditches and swales in and around the pit; and
- Appropriately designed sump, pumping system and retention ponds with adequate holding capacity, especially during higher risk periods such as freshet.

The potential for human injury, environmental damage and production delays is unlikely and the risk rating is considered moderate because of the natural environment (i.e., permafrost conditions), engineered design features in and around the pit and the development of adequate emergency response procedures.

3.2.3 Explosives Accident

Explosives will be used during Construction and Operations Phases of the Project. Pre-packaged explosives will be used mainly during construction. During operations, ANFO and emulsions will be the main explosives used. A dedicated manufacturing and storage facility will be established on site to facilitate appropriate handling, use and management of explosives according to applicable regulations, including the *Explosives Use Act* and Regulations and the DFO Guidelines for the Use of Explosives in or near Canadian Fisheries Waters.

The components of ANFO and emulsion in isolation are not explosive, but they will explode if mixed in the correct proportions, confined appropriately and detonated with an external device. However, appropriate precautions will be taken to prevent accidental spill or release of the individual components and bulk explosives. An Explosives Management Plan will be adhered to by all workers (Volume 10, Appendix 10C-4). A blasting operations standard, a site-specific blasting plan for blasting near water and an Explosives Emergency Response plan will also be developed.

Handling of explosives will be done by licensed personnel only. Other workers will be restricted from access to explosives components, explosives or the facility. These precautions, in addition to adherence to applicable regulatory requirements, appropriate blasting design, monitoring, good housekeeping and management oversight, will reduce the possibilities of explosive incidents.

The potential exists, however, for accidents or malfunctions to occur. The associated concerns include:

- Hazard to human health - injury or fatality;
- Effect on environment - ammonia run-off, fuel spill, etc.;
- Wildlife and habitat disturbances; and
- Damage to property.

Although rare in occurrence, human error or unforeseen occurrences could also lead to accidents or malfunctions. In worst-case scenarios where injuries or damage to human, wildlife or property occur, established emergency procedures will be followed according to the explosive management plans mentioned above. With the control measures in place and handling restricted to licensed personnel, the risk rating is considered low to moderate.

3.2.4 Accidental Discharge of Hazardous Materials

Material Safety Data Sheet (MSDS) will be available on-site for all hazardous materials transported, handled and stored at all locations of the Project sites. Hazardous materials are stored in appropriate containers placed within a lined/impermeable secondary containment structure. Secondary containments are designed and dimensioned to contain spills and are equipped with sumps for recovery of liquids/runoff or contaminated materials. Detailed operating procedures have been developed for the handling, transportation, use and disposal of hazardous chemicals and wastes (refer to Environmental Protection Plan).

Fuel storage tanks are constructed within the confined of a secondary containment sized to retain 110 % of the content of the largest fuel tanks. Double wall ISO-containers are used for temporary storage. Temporary storage and refuelling stations are constructed on impermeable surfaces. The Waste Management Plan (SD-EMMP-004) describes the procedures in place for the handling of all waste materials while the Emergency Response and Spill Contingency Plan (Volume 3, Appendix 3B) details the response procedures to be followed in the event of a spill. The Steensby Port (SD-ERP-003) and the Milne Port OPEP details the procedures for fuel handling at the ports.

Despite the mitigation measures and management procedures Baffinland has implemented, a major, uncontrolled land-based spill of hazardous materials is unlikely but remains a possible event. If a spill occurs due to malfunction or accident, it will be contained within the secondary confinement and cleaned up rapidly. Given the adequate training that the employees will receive and the Emergency Response and Spill Contingency Plan, as well as the engineered controls, the environmental and safety risks of such an event are considered low.

This discussion applies to all areas of the Project where hazardous materials such as fuel and other chemicals are transported, stored and handled (Mine Site, ports and transportation).

3.2.5 Traffic Accident

Despite best efforts in operator training, truck and vehicle accidents are likely to occur during the construction phase, and to a lesser extent during the life of the Project. Accidents may be caused by human error, mechanical failure and/or extreme weather events. The consequences can range from minor to severe, depending on injuries or fatalities and the extent of environmental damage.

Baffinland will ensure that vehicle operators are appropriately trained and that regular maintenance is performed on all vehicles. The main camp will have a medical facility and medical staff to deal with injured personnel. In case of severe injuries, the worker will be stabilized at the clinic and evacuated off-site for medical treatment (refer to Health and Safety Management Plan, Volume 3, Appendix 3B).

Despite best efforts, traffic accidents, collisions with other vehicles or with wildlife are all likely events. With the control measures implemented, Baffinland considers the risk of these events resulting in serious human injury or environmental impairment as moderate.

3.2.6 Fire at the Camp Facilities and Infrastructure

A major fire in or near the camp accommodation complex has been considered. There could be many causes for such a fire including electrical or mechanical malfunction of equipment or infrastructure, the accidental ignition of various flammable/combustible materials that are stored and used throughout the camp, vehicular collisions with camp infrastructure and accidental detonation of explosives. Causes could include some combination of design flaws, systems malfunction, unintentional or irresponsible human behaviour, or improper following of established procedures due to training systems failure.

The design and operational controls in place to reduce the potential for accidental fire include:

- Design and construction of camp facilities and infrastructure in accordance with relevant building codes, fire regulations and other guidelines and regulations (refer to Volume 10, Section 3 Environmental Design Guidelines);
- Materials storage, management and handling processes and procedures, especially for fuel, hazardous materials and explosives;
- Regular inspections by trained and competent personnel of all camp facilities and infrastructure for fire code infractions;
- Proper training programs for functions that involve a potential for accidental fire;
- Adequate preventive maintenance programs for equipment, vehicles and camp infrastructure;
- Employee orientation and regular safety meetings that stress the need for fire safety and proper evacuation and response procedures;
- Establishing building facilities that can be heated using fuel oil rather than electrical power that would provide temporary shelter and heat in an emergency;
- Proper signage and fire suppression equipment available where required;
- Emergency response procedures to provide rapid response and evacuation capabilities; and
- Employees will be properly monitored for safe and responsible behaviour.

The potential for human injury and fatalities is considered to be unlikely; however, the risk rating is considered moderate because of engineered design features and the development and implementation of adequate emergency response procedures.

This discussion applies to Milne Port, the Mine Site, Steensby Port and temporary construction camps along the rail alignment where there is a risk of accidental fire.

3.2.7 Failure of the Camp Power Supply

The failure of the camp power supply could result in the failure of heating systems, potable water treatment plant, wastewater treatment plant and other key systems. The cause of the failure could be improper design of power generation plant and distribution system, insufficient maintenance, accidental fire, or damage due to human error. This could result in major inconvenience, discomfort and health and safety risks, especially during colder weather periods.

Design and operational controls will be implemented to minimize this potential occurrence. These include:

- Design and installation of the power supply and distribution system based on relevant electrical codes and regulations, including sufficient and functional backup systems that would heat key areas of the camp and generate power for necessary services;
- Regular testing of backup systems and inspections of all facilities and infrastructure for electrical and fire code infractions by trained and competent personnel;
- Proper training programs for functions related to power supply and generation;

- Adequate preventive maintenance programs; and
- Emergency response procedures to provide rapid response in the event of power failures and building facilities that can be heated using fuel oil rather than electrical power that would provide temporary shelter and heat in an emergency.

The potential for human injury and/or fatalities is considered **rare**; however, the risk rating is considered low to moderate because of the engineered design features/contingencies and the development and implementation of adequate emergency response procedures,

The above discussion applies to all camp sites including camps at Milne Port, Steensby Inlet and camps along the rail alignment where there is a risk of power failure.

3.2.8 Failure of the Wastewater Treatment Plant

The potential for a failure of the wastewater treatment facility (WWTF) was considered. Such a failure would result in effluent that does not meet discharge criteria and is potentially detrimental if released to the receiving environment. If the WWTF does not operate effectively, unsanitary and unhealthy conditions can result and can affect camp occupants. Causes for failure of the WWTF could include camp power failure, frozen discharge line, insufficient capacity in effluent storage ponds, insufficient capacity of system due to design failure, effluent upset conditions or operator error. Design and operational controls will be implemented to minimize risk associated with this potential scenario. These include:

- Adequate design of the WWTF based on predicted influent characteristics and variability;
- Sufficient volume capacity in effluent discharge ponds to ensure adequate capacity in the event of upset conditions;
- Proper training programs for work functions related to the WWTF;
- Daily monitoring program for early detection of operational problems and preventive maintenance program;
- Adequate electrical power backup systems in the event of power failure; and
- Prompt and adequate emergency spill response in the event of effluent or influent spill to the receiving environment.

The potential for human health problems or environmental impairment is considered to be unlikely; however, the risk rating is considered low in consideration of the engineered design features/contingencies and the development and implementation of adequate operational controls and emergency response procedures,

This discussion applies to all camp sites including camps at Milne Port, Steensby Inlet and along the rail alignment.

3.2.9 Contamination of the Water Supply

There is the potential for potable water supply to become contaminated at source or during the treatment and distribution process. Potable water contamination can result in adverse health outcomes for camp occupants. Potential for contamination at source (Camp Lake) could result from accidental release of deleterious substances to the lake due to fuel spill, contamination from accidental release of water from the east waste rock retention pond, or localized release of sediment to the lake during construction. Potable water contamination could also result from malfunction of the potable water treatment system or contamination within the distribution system.

Design and operational controls will be implemented to minimize risk associated with these potential scenarios that include:

- The potable water treatment, storage and distribution system will be adequately designed for the population of the Mine Site camp. Treatment processes will include filtration and UV disinfection. Operators will be adequately skilled and trained for the work they are performing. Preventative and routine maintenance and inspection programs will be implemented for the potable water treatment and distribution system.
- Camp Lake will be adequately protected from potential for contamination by ensuring that any upstream retention pond that holds runoff from the waste rock pile is large enough to hold the water until it is tested for appropriate drinking water criteria and released, even under high flow conditions. A treatment plant will be mobilized, if necessary, to treat water prior to release from the pond. Adequate protection measures including buffer zones and silt control measures will be implemented and enforced. An alternative potable water supply will be identified and used in the event of short-term water source contamination.
- A robust drinking-water sampling and monitoring program, modeled after similar programs in southern Canada, will be conducted to test raw and treated water from Camp Lake and from strategic points within the distribution system. The on-site environmental lab will have sufficient capacity to conduct limited testing for common bacteriological pathogens. This will provide rapid turn-around of results on a routine or emergency basis.
- A potable water emergency plan will be established. This could involve a combination of temporary use of alternative sources, boil-water orders and increased frequency of drinking water quality monitoring.
- Adequate electrical power backup systems.

The potential for human health problems due to contamination of potable water is considered to be rare; however, the risk rating is considered low in consideration of the engineered design features/contingencies and the development and implementation of adequate operational controls and emergency response procedures.

3.3 TOTE ROAD

3.3.1 Traffic Accidents and Release of Hazardous Materials

See discussion in Section 3.2.4.

3.3.2 Collision with Wildlife

Collision with wildlife is possible throughout the life of the Project. Baffinland's environmental induction program will focus on increasing the awareness of vehicle operators to the presence of wildlife, while the Terrestrial Environment Management Plan (Volume 10, Appendix 10D-11) outlines the actions implemented for their protection. Given the low number of animals anticipated to be killed by road traffic, the impact on the herds is considered low.

3.3.3 Road Embankment Failure and/or Collapse of a Water Crossing

A road embankment failure or the collapse of a bridge or culvert could result from an extreme precipitation event, extreme freshet events and/or the degradation of the ground due to the thawing of the soil/permafrost. Such events are difficult to predict and, depending on their timing, may result in stranding of vehicles and personnel, or human injuries. Despite the application of best engineering practice for the design of these structures and the routine inspection and maintenance of the roads, such events are likely to occur over the life of the Project. Given the effort place in design and maintenance, the risk rating is low.

3.3.4 Weather-related Strandings

Due to the inclement weather and rapidly changing difficult-to-predict conditions at the project site, there is the potential for personnel to be stranded in vehicles along roadways, along the rail alignment and when working on the land away from roadways. The result can be injury or fatalities due to exposure. There will be many controls in place to prevent or militate against this type of outcome including:

- Focus during employee induction and during safety meetings on the potential for weather-related hazards and potential incidents.
- The review of available weather information and predictions prior to working away from camp including satellite weather data available from Environment Canada website and real-time weather data available locally from the Mine Site, Milne Port and Steensby Inlet stations.
- Development and implementation of effective procedures for work away from camp, including proper clothing, survival packs, radio and telephone communications and use of vehicles in proper mechanical condition.

Based on the ambient and extreme weather conditions that occur at the Project site, the scenario of a weather stranding event is predicted to be possible. However, based on the robust operational and procedural controls and preventative measures, the overall risk rating is considered to be moderate.

3.4 RAILWAY OPERATION RELATED ACCIDENTS AND MALFUNCTION

The potential accidents on the Railway operation are related to:

- Road embankment failure and/or collapse of water crossing (discussed in Section 3.3.3);
- Derailment with associated release of hazardous materials (fuel);
- Collapse of the tunnel;
- Collision with wildlife;
- Injuries to traveling hunters (collision with human);
- Accidental release of hazardous material (discussed in Section 3.2.4); and
- Weather related strandings (discussed in Section 3.3.4).

The draft Railway Emergency Response Plan is presented in Volume 10, Appendix 10D-9 outlines the Baffinland's responses procedures for Railway emergencies.

Generally, rail is one of the safest means of transport; however, the potential exist that trains may derail. Minor derailments such as track jumping, or major derailments, which may be caused by misalignment of the Railway tracks, broken rail, malfunction of the switch mechanisms, failure of signals, spring thaws, failure of roadbed foundation, etc., may lead to injury or fatality. To prevent or minimize the possibility of derailments, the engineering design will take into account factors such as permafrost thickness and seasonal thawing of ice, rail alignment, efficient signalling, etc. Ballast material selection and thickness will be carefully engineered. Signal effectiveness will be constantly monitored and changes or adjustments made as quickly as possible. End-of-train detectors will detect whether cars have been uncoupled. Emergency response procedures will be implemented as soon as possible during accidental derailments.

The following discussion provides an overview of operational methods and techniques that will prevent or reduce any possibility of serious train accidents or malfunctions.

Safe use of the track will be controlled by a dispatcher, who will have oversight of all movements by giving specific and exclusive authority to vehicle and equipment operators to occupy a section of the track at a specific period. In "dark territory", where there are no fixed signals, fixed blocks will be established using wayside signs that will extend from one passing track to the next. Train crews will receive authority to occupy one or more blocks by radio in a standard-format transmission recorded by check marks on a pad form. This authority takes effect only after being repeated back to and verified by the dispatcher. Upon leaving the block, the crew will release it by a similar radio protocol. Work crews and road-rail (hi-rail) vehicles may occupy main tracks only if it will not prevent the use of other track segments. When trains have to pass, the Controller will order one onto a siding.

A Computer-Assisted Manual Block System (CAMBS) will give the Dispatcher information to help follow and implement specific sets of operating rules. The system will provide visual information on the status of the rail network and through its data base the dispatcher will be able to verify the current status of occupancy authorities on the track. The system is also able to check for any conflicts of the track occupancy and give warnings. This double safety feature, self-check and dispatcher oversight, will add particular safety to the operation and use of the Railway route.

Other safety systems will include track circuits for the detection of broken rails, installed at appropriate locations along the main line. A sleep mode activation system will be a standard feature of these circuits. The system will turn itself off during periods of inactivity and on once movement resumes. Activities will be transmitted to and displayed on the CAMBS terminal. The main line will be equipped with wayside detectors, strategically placed at mainline sidings, to monitor passing trains for defects such as hot wheels or bearings, or dragged objects and equipment. Information will be provided directly to the train, to a wayside signal system or to remote systems that are monitored by the dispatcher. A wheel impact detector (WILD site) will be used at the port terminal to detect defects such as flat spots. All information from the detectors and switches will be transmitted to the Control Centre and made accessible to the dispatcher, who will assess the information and provide required adjustments, warning or immediate maintenance request, etc., as the need may be.

Rock falls may be caused by the effects of wind, human or wildlife activity, etc. To prevent rock falls on the track, rock-fall detectors will be installed at appropriate locations along the route. The fall detector will warn the dispatcher, who will implement preventative action or initiate a control measures as soon as possible. The dispatcher will also monitor weather forecasts and adjust operations accordingly. In the event of a forecast of a severe storm, operations may be halted.

3.4.1 Train Derailment with Ore Cars or General Non-Hazardous Freight

Current project planning predicts that it will take six trains a day, 300 days a year, to move the ore to the port at Steensby Inlet. The inlet, 149 km to the southeast of the mine, offers a longer ice-free period, which will allow the mine to supply the port with ore for shipment 12-month a year. Trains carrying ore or other non-hazardous materials are not anticipated to derail, but if derailment occurs, it will delay scheduled shipment of ore. There will be no significant impact to the environment, since the ore contains no known toxic substances.

In the rare event of such derailments, radio communication will be established immediately with all scheduled and non-scheduled trains to prevent any further collisions. Signs will be posted at determined locations to warn workers, incidental hunters, vehicles, etc., of the accident. Other emergency actions will be coordinated by the closest emergency response team. Based on the operational controls and emergency plans that will be in place, the risk of such an event is considered to be low to moderate.

3.4.2 Train Derailment with Fuel or Other Hazardous Materials

Derailment of a train carrying fuel or other hazardous materials is an infrequent occurrence. However, in the unlikely event that it does occur, the Emergency Response Plan will be implemented immediately and appropriate clean-up measures taken. It is unlikely that open water will be abundant on the Railway route, since waters and the ground will be frozen most of the year. Impact of fuel releases from train derailment would therefore be localized and contained by ice and snow, which will be cleaned up as quickly as possible. Radio communication will be established as soon as the spill is discovered to warn other rail users and provide an opportunity for a quick and uncomplicated clean-up.

Good maintenance of railway rolling stock as well as regular track inspection and maintenance are essential to reduce the risk of train accidents and derailment. The Railway Maintenance Management Plan and the Railway Emergency Response Plan present the management procedures that will be implemented in order to minimize the risks of train derailment and accidents.

A train derailment is considered a rare event. In the unlikely event that fuel or other hazardous materials come in contact with open water, the spill contingency plan will be implemented as soon as possible to contain and prevent the spread of material in water. Clean-up procedures will then be implemented by either the Project's emergency response team or an external team, depending on the severity of the spill. The risk is considered very low.

3.4.3 Train Collisions

The risk of accidental train collision with other trains, vehicles, human or wildlife leading to injury or mortality is low. With proper engineering, maintenance, inspection of warning signs and signals and adherence to speed limits, train collisions are unlikely.

The following safety measures will be enforced to reduce possibilities of accidents or malfunctions leading to collisions:

- Railway signals and gates at level/grade crossings;
- Train whistle or horn warning to warn wildlife, pedestrians and other trains and vehicles of the presence of a train; and
- Trackside signals to maintain distance between trains to prevent a head-on collision with another train or collision with other vehicles or wildlife.

With the control measures in place, collisions are considered an unlikely event and the risk is considered very low to low.

3.4.4 Injury to Passing Hunters at Steensby Inlet

Seasonal hunting of terrestrial and marine wildlife is one of the main land-use activities of Inuit in the Baffin Region. Hunters usually travel by boat or on snowmobiles to the Steensby area to hunt for caribou, seals, whale and other wildlife. To prevent accidental injury to passing hunters, community education and awareness programs will be established and presented in local communities to warn hunters of activities in the area. If possible, alternative hunting routes and trails will be established in consultation with the QIA, HTO, etc. Where such alternative routes are not possible or practical, localized exclusion zones will be developed with appropriate warning signs.

It is possible, though unlikely, that injuries may be caused to passing hunter(s) by a Project activity. Where such an injury occurs, the on-site emergency response team will be mobilized to assess the injury and implement response action as soon as possible. On-site medical services or evacuation to an external medical facility will be provided as required. Family members of the victim(s) will be contacted as soon as possible by an appropriate Project official to inform them of the incident. Appropriate counselling will be provided when necessary. With these control measures in place, the risk is considered low.

3.4.5 Collapse of the Railway Tunnel

A collapse in one of the tunnels is considered rare, given the application of best engineering design practices and construction standards used during design and construction. However, there is always the possibility of an unforeseen geological occurrence that would weaken the tunnel integrity and result in a rock slide/collapse of a portion of the tunnel wall resulting in human injuries or fatalities. If this were to occur, the slide/collapse area would be secured, the debris cleared when safe to do so and the tunnel repaired with adequate safety standards to prevent a second occurrence. This is considered an unlikely event, however; risk is considered low to moderate.

3.5 MILNE PORT AND STEENSBY PORT

For Milne Port, sea-lift and shipping will take place only during the open-water season. The most credible and likely accidents related to Milne Port activities are:

- Fuel spill during ship-to-shore transfer;
- Spill from over wintering fuel barge/vessel;
- Accidental release of hazardous substances (discussed in Section 3.2.4);
- Fire at the accommodation complex (discussed in Section 3.2.6);
- Failure of the power supply (discussed in Section 3.2.7);
- Failure of the wastewater treatment plant (discussed in Section 3.2.8);
- Contamination of the water supply (discussed in Section 3.2.9);
- Congestion at the port leading to a collision;
- Ice accumulation at the port;
- Introduction of invasive marine species; and
- Introduction of invasive terrestrial species.

3.5.1 Ship-to-shore Fuel Transfer

Fuel will be unloaded from tanker to shore by flexible hoses. For the early construction period, a fuel vessel/barge will overwinter in Steensby Inlet and will provide up to 20 ML of fuel storage. The distance between the receiving edge of the freight dock and the fuel tanker is about 400 m.

During ship-to-land fuel transfer at Milne Port and Steensby Port, minor accidental releases may occur occasionally in water and/or on land. Other oily discharges may also occur from bilge tanks, engines, mechanical parts and other devices on board. The accumulation of these minor spills may become a cause for concern if they are not quickly contained. Spills on land and ice are more readily contained than those in open water, since water can spread the spill quicker and cause immediate impacts to water quality and aquatic life. Snow and ice, on the other hand, will act to help contain the spill while clean-up action is implemented. Clean-up equipment will available at all times at both ports. An emergency and clean-up response team will implement the spill contingency plan as soon as possible. The shipping contractor will establish appropriate loading and off-loading procedures using the *Arctic Waters Pollution Prevention Act*, Arctic Shipping Pollution Prevention Regulation and the Regulation for the Prevention of Pollution from

Ships and Dangerous Chemicals to prevent or quickly contain any spills or releases of fuel during ship-to-land transfers.

Both ports are will have Transport Canada-approved Oil Pollution Emergency Plans (OPEPs) as required under the Oil Handling Facilities Regulations of the *Canada Shipping Act*; this Act also requires that every vessel have a Transport Canada-approved Shipboard Oil Pollution Emergency Plan (SOPEP) to address accidental releases of fuel. The OPEP for Milne Port is attached in Volume 3, Appendix 3B and the Steensby Port OPEP is attached in Volume 3, Appendix 3B.

The operations and response structure at the Port facilities have been designed for rapid response to a spill. All equipment and resources are strategically placed near the beach front, directly at the port operation site. Responders, workboats and other support equipment are on standby during all operations and will be on scene within one hour of a spill. Equipment and resources are required to contain and control diesel, up to the minimum spill size of 3.5 m^3, as determined in accordance with Section 2 of the Oil Handling Facilities Standards.

In the event of a spill, on-water recovery will be initiated immediately upon containment of free-floating product. The skimming capacities at the Port facilities are capable of recovery of several times the estimated spill volume.

The ports bulk fuel storage facilities will be equipped with appropriate spill response equipment, which provides *resident capability* for the response to spills in accordance with the scenarios developed under this Oil Pollution Emergency Plan. Containment and recovery equipment inventories exceed the facility category planning standards and are especially appropriate for the potential spill volumes as outlined in the scenarios contained in the OPEP. Routine training exercise will be carried out to assess the effectiveness of the spill response procedures; and improvements will be made as required.

Although a fuel spill is likely to happen over the life of the Project, spills resulting from the ship-to-shore transfer operation will quickly be contained and the environmental effects resulting from such an incident will not be significant. The risk is considered low.

3.5.2 Fuel Spill from Over Wintering Fuel Barge/Vessel

For the 2012-2013 winter, a 20 ML ice class fuel barge or vessel will be used for fuel storage at Steensby Inlet to provide the diesel fuel required to support early construction. This is a common practice used for site capture for Project undertaken in remote Arctic locations devoid of infrastructure.

The operation of this barge/vessel is regulated under the Canada Shipping Act. The barge/vessel operator will have its own SOPEP (reviewed and approved by Transport Canada) and will be ready to respond to any credible emergency scenarios that may arise on the barge/vessel.

This vessel will be capable of Arctic navigation and it will be positioned during the open water season. Once it is immobilized in the ice, there will be little movement except for tidal upswell. Collisions with other vessels are therefore unlikely. The only scenario that could result in a large spill are related to on-board operations of the vessels; the SOPEP will take this into consideration and will have detailed response procedures. The most likely spill scenario is thus from the ship-to-shore transfer of fuel as described in Section 3.5.1.

3.5.3 Ice Accumulation at the Port

Tide movement at the dock face will act to prevent ice accumulation to a certain extent, although a bumper of ice can develop around portions of the dock face. An icebreaking tug can maneuver close to the dock face after each vessel departure and before the next ship docks to reduce build-up.

The loaders will be designed with extension capability so that they can load some distance laterally from dockside should the vessels have to dock against an ice bumper.

Bubbler systems commonly provide enough up-welling circulation to reduce ice build-up within a confined area. Such a system could be adapted for use at the dock face. Generally, even at shallow water depths, the water is above freezing (around -2^{o} Celsius for salt water, depending on salinity) and its circulation can keep ice build-up to a minimum. Ice accumulation at the Ports is likely although the risks are predicted to be low.

Experience Elsewhere - To date, ice build-up at the dock has not been a problem experienced at Raglan with winter shipping (although they ship only four times a year, three during ice cover).

3.5.4 Congestion at the Port

A situation could arise in which several ships are waiting for unloading cargo or loading ore. Although planning and logistics will ensure that such events are rare, the probability of occurrence is likely. The probable accident associated with congestion is a collision or grounding of ship, especially during extreme weather events.

While an unlikely event, an accidental fuel spill could hypothetically occur as a result of collision or accident or while transferring fuel between tanker and shore base. The OPEPs address issues associated with minor spills resulting from the ship-to-shore transfer of fuel. A collision could result in a larger spill. Such a scenario is discussed in Section 3.7 (Major Diesel Spill at Port or Along the Shipping Lane). Throughout the life of the Project, it is expected that diesel fuel will be delivered to Milne Port or Steensby Port by 50 ML tankers only during the open-water season. Shipping of fuel in pack ice or under landfast ice conditions is not planned. The risk is considered low.

3.5.5 Introduction of Invasive Marine Species

Increased shipping activities could introduce invasive marine species in the northern Baffin Island area with ballast water or by physical attachment to ship hulls. The ability of introduced species to establish viable populations is determined in part by the physical and chemical conditions of the exchange site (CSAS, 2009).

Climate and water temperatures are prevailing barriers to colonization by invasive species. However, with climate change and the increase frequency of shipping, there is an increased possibility of introducing a species (biota) that can readily adapt to the prevalent conditions in Steensby Inlet or Milne Inlet. Such an invasive species would have to originate from a similar climatic region (average annual water temperatures of 2ºC) and could be a serious threat to native aquatic ecosystems. Although the likelihood of occurrence and the significance of the associated effects are impossible to predict, Baffinland will adopt best management practices in terms of ballast water management.

Ballast is water taken on to stabilize sea-going vessels by adding weight and maintaining draft (the depth a vessel sits in the water). Empty vessels take on much more ballast than a fully laden ship. For icebreakers, ballasting is used to keep the ice draft of the vessels constant and to stabilize the ship, thereby optimizing stresses in different loading conditions.

To reduce or eliminate the risk of invasive aquatic species and pathogens being introduced into Canadian waters, all ships will exchange ballast water in accordance with the *Ballast Water Control and Management Regulations* (Transport Canada, 2006a), which prescribe exchange of ballast water at sea in deep waters away from coastal zones. Ballast water will be exchanged in the mid-north Atlantic Ocean, which is part of the same ocean regime as Steensby Port. Upon arrival at the port, the ships will exchange ballast water for ore. During winter, full ballast is required to assist in icebreaking and so the entire amount of ballast water will be discharged at the ore dock. During summer, the ships may discharge ballast water along the shipping route before arriving at the dock (in such cases only a partial load of ballast in the order of 70,000 m^3 will be discharged at the ore dock). Baffinland is also committed to using an IMO and North American (Canadian) Coast Guard approved Ballast Water Treatment System to treat ballast water.

Ballast Water Management Plans are specific to individual ships. The Shipping and Marine Mammals Management Plan (Volume 10, Appendix 10D-10) outlines the major elements and requirements of a plan acceptable to Baffinland. In light of the ballast water management in place, the introduction of invasive species is unlikely and the risk is considered low.

Given the precaution taken, the introduction of invasive marine species is an unlikely event and the risk is considered low.

3.5.6 Introduction of Terrestrial Invasive Species

The delivery of material, equipment and freight to Steensby and Milne also introduces the potential for introduction of invasive vegetation species (e.g., dandelions) and terrestrial species (e.g., rodents) to the Arctic environment. Although climatic conditions at Milne Port and Steensby Port are expected to be the major barrier to the survival of introduced species, Baffinland will undertake routine inspection of storage sites. If a foreign species is detected, Baffinland will consult with Canada Custom and the Government of Nunavut DoE and take appropriate actions to remove/limit the spread of the species to Northern Baffin Island. The action taken will be species dependent.

3.6 SHIPPING RELATED ACCIDENTS AND MALFUNCTIONS

The potential accidents and malfunctions associated with shipping are:

- Collision with marine mammals;
- Ship engine failure at sea;
- Ship grounding;
- Ice /ship interaction;
- Collision with other vessels; and
- Major diesel spill at sea.

3.6.1 Collision with Marine Mammals

Collision of ships with marine mammals is considered highly unlikely, as there are very few reported cases. The consequence of such a collision would most likely be the death of the animal, which, although unfortunate, does not threaten the survival of the species.

The probability of collisions is considered in Volume 8, Section 5; however there is no reliable database available that could be used to arrive at a probability estimate for this highly unlikely event.

As a mitigation measure, Baffinland intends to post observers on the ore carriers to report sighting of sea mammals and provide guidance to the ship captain on avoidance. The event is considered rare and the risk is considered low.

3.6.2 Ship Engine Failure at Sea

Of all recorded incidents in 2010, 54 % of them involved propeller/rudder/engine troubles. Propeller/ rudder/engine issues have been the leading cause of marine incidents over the past ten years in Canada as well (TSB 2010).

Ship engine failure may be caused by malfunctioning of the engine system or systems connected to the engine. The quickest and safest way to resolve the problem is to repair the engine. Inability to repair the engine quickly may lead to drifting, which may eventually cause grounding (discussed below). Before any voyage, the engine system will be inspected to ensure that it is in good working condition. Repair and maintenance tools and equipment will be provided on each ship. Spare parts and if possible spare engines will be kept on board for potential engine failures.

Baffinland will have up to four dedicated ice breaking tug boats anchored at Steensby Inlet. A Baffinland tug boat or an international marine safety organization will be contact for assistance in case of unresolved engine failure along the Hudson Strait or in the Foxe Basin.

Although a ship engine failure is a possible event, the risk associated with such a failure is considered low.

3.6.3 Cargo Ship or Ore Carriers Grounding without Fuel Spill

Ship grounding is a marine accident that involves the submerging of ship, causing disturbance to seafloor and potential marine habitat and damage to the entire submerged ship or the part that is submerged. The bottom structure of the ship is often damaged, allowing water ingress and further damage. Grounding leads to financial difficulties and may also cause loss of human and marine life.

Some of the main causes of ship grounding include:

- Engine failure;
- Deviation from established shipping lanes;
- Inadequate training of crew;
- Malfunction of mechanical parts and/or engine;
- Extreme weather conditions; and
- Improper functioning of port facility.

The possibility of ship grounding will thus be prevented or minimized by properly engineered design, adherence to established shipping lanes (detailed bathymetry), employment of well-trained crew and following ship-specific operating procedures. As much as possible, port facilities will have dedicated personnel to direct incoming ships around any potential grounding locations.

Ship ground is a rare occurrence, when ships are designed properly and the ship operating procedures are followed by well-trained shipping crew. If grounding occurs, the established emergency response for each ship will be followed.

Cargo vessels and fuel tanker have anti-collision devices with alarms and radar to ensure that collisions are avoided. Marine heavy oil (MHO) used for powering the ship is stored within a double tank containment inside the ship (normally toward the stern), away from the hull. MHO storages are unlikely to be damaged by collision or grounding.

Ore carriers used by the Project, the dedicated fleet of icebreaking ore carriers and the chartered vessels likely to operate during the open-water season, will carry their own supply of MHO in an integral tank. While a collision or grounding of an ore carrier is possible, the subsequent potential release of MHO is not considered to be a credible spill scenario, since fuel is not contained next to the hull and therefore a breach of the tank is highly unlikely. The risk associated with such an event is considered very low.

3.6.4 Fuel Tanker Grounding or Collision Causing Fuel Spill

Shipping accidents in Canada are on the decline, with 2010 being a 36-year low in Canada for shipping accidents (Transportation Safety Board, 2010). Of the accidents that occur, ~90 % are shipping accidents and the remaining 10 % are accidents aboard the ship (TSB, 2010). The top three types of shipping accidents are groundings, fire/explosions and strikes.

Over the past ten years, few accidents have occurred within the Canadian Arctic waters and this will likely remain the case when compared to the other regions within Canada (TSB, 2010). While the potential for increased traffic in the Arctic is predicted due to climate change and variability, a large increase is not expected for many years to come (Analyse and Strategi, 2011). Given that detail bathymetry is currently ongoing, the defined shipping route will be in designed to maximize safety for the crew, the vessel and the cargo. As well, as technology progresses, more accurate navigational aid and technologies will be developed and will be implemented as necessary. The risk of a lost vessel is low for this project as the ore carriers will be designed to specifically handle the stresses of this harsh environment.

Of the incidents of oil spills less than 7 tonnes that occurred 1974 - 2010, the leading cause (40 %) was loading/unloading of oil, with the next leading cause (25 %) attributed to other/unknown (ITOPF, 2010). Groundings and hull failures each comprised of 3 % of the causes for oil spills (ITOPF, 2010). Of the incidents of oils spills (>700 tonnes) loading/unloading was again the leading cause at 35 %, followed by collisions at 29 % and groundings at 12 % (IOTPF, 2010). Modeling of oil spills at Milne and Steensby Port is discussed in Section 3.8.

Fuel will be delivered only during the open-water season. Large spills of diesel fuel may occur when a diesel fuel tanker is grounded. Such incidents are rare, but when they do occur immediate action is taken to salvage the ship and prevent uncontrolled flow of diesel. Each ship will have a proprietary general emergency plan based on to the International Safety Management Code (ISM Code) for the Safe Operation of Ships and for Pollution Prevention. The ISM Code is a management systems model designed to encourage safety and pollution prevention. Compliance with its provisions is mandatory for passenger and other ships. Emergency plans will be implemented as soon as possible to contain, clean up and salvage spills. Baffinland will be self-sufficient in terms of emergency response capability. The Canadian Coast Guard (CGC) and other regulatory agencies will be informed as soon as possible. Tankers will maintain a daily reporting routine to CGC and Baffinland when travelling through the north to inform tankers of other vessels in the area, a practice that will prevent or reduce possibilities of collision.

All tankers will have anti-collision devices with alarms and radar to ensure that collisions are avoided. Furthermore, marine heavy oil (MHO) used for powering the ship is stored within a double-hulled containment inside the ship. Fuel tanker grounding or collision causing a fuel spill is predicted as being unlikely with a low risk. Such an event would require that the vessel actually split and sink due to a major onboard explosion.

3.6.5 Ice / Ship Interaction

Dedicated ore carriers (160,000 to 190,000 DWT) will be designed for icebreaking capabilities. Ice / ship interaction is not expected to be a problem. Furthermore, two of the four tug boats anchored at Steensby Inlet will have icebreaking capabilities and will be available for rescue assistance through the Foxe Basin and Hudson Strait. The precautions taken for winter navigation are described in Section 3.2.2.5 of the Shipping and Marine Mammals Management Plan (Volume 10, Appendix 10D-10).

3.6.6 Collision with Other Vessels

Protocols are well established for commercial shipping in the Arctic. Several small fishing and harvesting vessels from both the LSA and the RSA frequent the coastal areas in the vicinity of both Milne and Steensby Ports.

For commercial ships, protocols and surveillance systems are well established to maintain communication with other vessels and avoid collision. For smaller vessels, the size of the ore carrier and their observation system should be adequate warn smaller craft of their presence. In addition, the Company will notify local communities when ships are expected to be in the area. There is a rare likelihood of collision with other vessels with a predicted very low risk.

3.7 AIR TRAFFIC

Air traffic emergencies were considered as a potential scenario for impacting personnel, aircraft and site infrastructure. The potential for aircraft incidents can occur anytime and anywhere. However, only incidents directly affecting the airport were considered. Incidents beyond its boundaries are covered in the Emergency Response and Spill Contingency Plan (Volume 3, Appendix 3B).

Air traffic incidents could result in failures to aircraft, infrastructure and personnel, significantly impacting the operation. The cause of these incidents could be:

- Aircraft incidents and accidents;
- Natural disasters;
- Bomb incidents;
- Hazardous material incidents;
- Structural fires; and
- Failure of power for movement area lighting.

Design and operational controls will be implemented to minimize this potential occurrence:

- Design will be based on Transport Canada Standards and Recommended Practices for designated aircraft use at the Mary River Project;
- Installation of visual aids for aircraft navigation;
- Installation and use of electronic and procedural approach aids;
- Adherence to the International Air Transport Association (IATA) standard for the air transportation of dangerous goods;
- Implementation of Mary River Project airport specific standard operating procedures; and
- Implementation and exercise of Mary River & Steensby emergency plans limiting the potential impacts of an incident.

Although the likelihood is rare, given the potential consequences of an aircraft crash for human injury and/or fatality, the risk is considered low to moderate. The potential of such an occurrence is reduced in consideration of the engineered design features, administrative and operational controls, and the implementation of the Emergency Response and Spill Contingency Plan (Volume 3, Appendix 3B).

The above discussion applies to all project airports including the Mine Site, Steensby Port and Milne Port.

3.8 MAJOR DIESEL SPILL AT PORT OR ALONG THE SHIPPING LANE

Catastrophic damage could possibly occur to a tanker delivering fuel, or to the fuel storage compartment of a bulk carrier. During the review of the DEIS, agencies requested that Baffinland endeavor to complete a more quantitative risk assessment of an oil spill along the shipping lane, and from the outcome, develop and assess a “worst-case scenario” spill event.

3.8.1 Worst-Case Scenario

In order to develop a credible “worst-case scenario” for an oil spill, a semi-quantitative approach was taken to risk assessment. We first considered the pattern of anticipated shipping that involves appreciable quantities of fuel, either as cargo or to propel the vessels.

During the 4-year construction phase, 13 fuel tankers will be arriving at Steensby Port carrying a total of 280 ML of fuel as cargo. During operations it is anticipated that 7 fuel tankers will be arriving per year for 20 years for a total of 140 transits. During the five years of decommissioning it is assumed that fuel delivery will be half of the volume delivered per year during operations. During construction 11 fuel tankers will be arriving at Milne Port carrying a total of 110 ML of fuel. Fuel tankers are assumed to carry 50 ML of fuel. Therefore over the life of the Project there are a total of 184 transits for fuel tankers which amounts to approximately 7,390 ML of fuel transported through the RSA.

During operations, 102 transits by ore carriers will occur per year. These vessels will carry ore as cargo, however each will carry a considerable quantity of fuel for the ship’s own engines. These ore carriers have a capacity of 6 ML of fuel, however as these vessel will be fueled in Rotterdam only, while they are in the RSA the amount of fuel in the ore carriers will average in the order of 3 ML. Over the 20 year operation phase, an estimated total of 6,120 ML of fuel will transit through the RSA in the ore carriers.

Various cargo vessels will supply the Project during Construction via both Milne and Steensby Ports, and during Operation and decommissioning via Steensby Port. They will only carry oil products as fuel for the vessel. The cargo vessels will be arriving from Canadian ports and are assumed to have a maximum capacity of 2 ML of fuel. A total of 175 transits by freight vessels will occur carrying approximately 350 ML of fuel transiting through the RSA.

The risk of an event is a combination of probability multiplied by consequences. The number of anticipated trips related to the Project can be used as an indicator of probability, i.e., the greater the number of trips, the higher the probability of a failure event. In a similar fashion, the total quantity of fuel transported per trip can serve as an indicator of potential consequences. There are, of course a myriad of other factors that will affect the risk of a marine oil spill, consequently this consideration is, at best “semi-quantitative”.

As shown in the Table 9-3.6 below, the largest number of trips associated with the Project will be by ore carriers, hence these vessels have a very high “probability Indicator” reflecting the fact that they represent a large portion of Project vessel traffic. This is offset by the “Consequences” Indicator which reflects the amount of fuel on board. As might be expected, the tankers contain the greatest quantity of fuel per trip and consequently pose the highest “Relative Risk” of a spill. Thus, a spill from a tanker is indicated as producing the most credible “worst-case scenario”.

Table 9-3.6 Relative Risk Value of a "Worst-case Spill Scenario" per Vessel Type

Vessel Type	Probability Indicator	Consequences Indicator	Relative Risk
	# trips (% total)	Volume of oil (MT) onboard	(PXC)/100
Tanker	184 (7.67)	50	3.83
Ore Carrier	2040 (85.03)	3	2.55
Cargo vessels	175 (7.29)	2	0.14
Totals	2399 (100)		

The total amount of fuel being carried by fuel tankers is greater than the total carried by ore carriers during the life of the Project (9,200 ML vs. 6,120 ML). The ore carriers will have their fuel compartments contained well within the vessel hull and removed by several layers from the ship's hull. The tankers will carry the oil in sub-divided cargo compartments along the body of the vessel (approximately 14). As such the fuel tankers will be carrying more fuel, which is contained in a larger area making it more susceptible to a spill occurring should the hull of the vessel be breached.

The most likely location of a credible worst-case spill scenario is along the southern shipping route. As mentioned, the northern shipping route will only receive 110 ML of fuel from 11 fuel tankers over the four year construction phase of the Project. No fuel tankers will be arriving at Milne Port during the operations phase. The southern shipping route will be well charted and equipped with both Nav Aids as well as aids to Navigation in order to reduce the risk of a spill.

As fuel tankers will only be arriving at Steensby Port during the open-water season, the credible worst-case spill scenario will occur during this period. A conservative estimate of 5 ML of fuel being spilled has been used in other models for the Project (Section 3.8.8). This represents 10 % of the total cargo of a fuel tanker. Based on a fuel tanker with 14 separated storage compartments, a spill of 5 ML represents a breach of two compartments with the release of 75 % of their contents.

3.8.2 Spill Modelling

Only three types of bulk fuels will be used by the Project. They are:

- Arctic diesel fuel for use by mobile equipment, power generators and locomotives;
- Jet A aviation fuel; and
- Marine diesel fuel for use by tugboats anchored at Steensby Inlet.

Gasoline used for powering miscellaneous small equipment (ATV, snowmobiles, small crafts) will be delivered in double wall ISO-containers. Thus the development of spill modeling was based on diesel fuel as the most commonly handled of the three types of bulk fuel to be transported to site.

Large diesel spill scenarios for both Milne Inlet and Steensby Inlet were modeled to predict the trajectory of a diesel spill and the coast line that could be impacted by such a spill. The purpose of this modeling was for estimating the marine and coastal areas potentially affected by such an event and the initial weathering fate of the diesel fuel.

3.8.3 Fate of Diesel Fuel – Natural Weathering Processes

- Diesel is lighter than water (specific gravity of 0.85 kg/L compared to 1.03 kg/L for seawater) and will initially form a thin layer on the surface. It will not pool, when spilled in a marine environment, as will crude oil, diesel fuel undergoes a series of physical and chemical changes, which together are termed oil weathering (NOAA, 2002).

- Evaporation: The most volatile compounds will quickly evaporate once exposed (API, 1999; ITOPF, 2002). Oil, with boiling points below 200°C, will typically evaporate in 24 hours, and the larger the surface area of the spill, the quicker the evaporation will occur. The conversion of liquid fuel to gaseous fuel typically occurs in first five days. Spills of refined products such as gasoline can evaporate on their own in hours while light crude products can lose anywhere from 20 % to 60 % of their volume in the first few day (API, 1999; ITOPF, 2002). Evaporation does increase viscosity and density of the remaining oil (ITOPF, 2002). In 18 hours, 37 % of an instantaneous release of approximately 16,000 L of diesel fuel evaporated under conditions of 10 knot winds and a water temperature similar to what could be expected during the open water shipping season. This process would be slowed in colder water and accelerated in higher winds.
- Emulsification: Wave action causes very small water droplets to mix with the fuel, which slows down other mixing processes. Emulsification typically occurs when winds exceed 7-10 knots. Emulsification are more likely to occur in oils that have a nickel/vanadium concentration greater than 15 ppm or an asphaltene content greater than 0.5 % (ITOPF, 2002). As the oil emulsifies, it takes on water until it reaches a stable state, which typically ranges from 70-80 % water (ITOPF, 2002). It is this product that is the red/brown product that is highly persistent and accumulates on shorelines and often referred to as mousse (API, 1999; ITOPF, 2002). The mousse is resilient to weathering effects. Once emulsification occurs, the result is typically a product that has a volume three times greater than the oil alone (ITOPF, 2002). If the mousse becomes extremely stable it is very difficult to break it back down to oil and water.
- Natural dispersion: Small droplets of fuel are mixed into the water, removing fuel from the surface (typically occurs during the first five days). Dispersion occurs as a result of the wind and waves causing turbulence. The rate of dispersion is largely dependent on the oil and the sea state (API, 1999; ITOPF, 2002). Dispersion is typically viewed as the sheen of oil present on surface water after a spill. Oil may disperse completely from the area in a few days given a moderate sea state (API, 1999; ITOPF, 2002). Dispersion is not uniform and once oil encounters an obstacle, such as shoreline, it will form a thicker sheen in that area (ITOPF, 2002). While greater dispersion may make cleanup efforts more difficult due to the size, a larger dispersion of oil increases various processes such as evaporation, dissolution, oxidation and biodegradation (API, 1999; ITOPF, 2002).
- Dissolution: a minor weathering process whereby water soluble components of the fuel are mixed into the water (typically occurs in the first five days). The rate at which dissolution occurs depends on water temperature, composition, spreading, turbulence, and degree of dispersion (API, 1999; ITOPF, 2002). Light hydrocarbon compounds are typically highly soluble and the most likely to be dissolved while heavier hydrocarbon compounds are typically insoluble (API, 1999; ITOPF, 2002). While the lighter compounds are more soluble they are also more volatile and as such more likely to evaporate at a rate of 10-10,000 times faster than dissolution (API, 1999; ITOPF, 2002). It is rare to see dissolved hydrocarbons in seawater exceed 1 ppm (ITOPF, 2002).
- Sedimentation: Heavier hydrocarbons (>1.025 g/mL) will sink in seawater and fuel may adhere to suspended particles in the water column (ITOPF, 2002). In turbulent waters with a high sediment load (4,000 mg/L), sedimentation can transfer oil through the water column in hours. Oil sedimentation along shorelines is not uniform and will vary depending on the sediment present and disturbance along the shoreline. In exposed, high energy shorelines, lots of sediment can join with the oil creating vast tar beaches (ITOPF, 2002). This oil mixture will sink once brought out into the ocean by storms, tides or currents. In sheltered shorelines where mud and marshes are common, oil sedimentation may remain

for an extended period of time (ITOPF, 2002). Sedimentation may also occur as a result of oil being ingested by zooplankton and eliminated as fecal matter (API, 1999; ITOPF, 2002). The fecal matter, along with fine sediment particles that have become contaminated, may become suspended in the water column after storms, turbulence and tidal rise and fall. This process is called clay-oil flocculation (ITOPF, 2002).

- Biodegradation: breakdown of fuel by microbes into other compounds and eventually into water and carbon dioxide. There are a wide range of these organisms and are more likely to be found in chronically polluted coastal areas (ITOPF 2002). Each organism only degrades a certain type of compound, and biodegradation can only occur along the oil/water interface (API 1999). Biodegradation slows down significantly once oil becomes a thicker layer and may potentially stop once sedimentation occurs as the organisms may be unable to receive sufficient nutrients and light (ITOPF 2002). This process occurs over weeks to years, depending on type of oil, temperature, nutrients present, oxygen and quantity of hydrocarbons spilled.

3.8.4 Mitigation Measures

Mitigation to address the potential for fuel spills includes ensuring shippers operate in compliance with the stringent regulations and guidelines established for the transport of fuel in Arctic waters north of 60º latitude. The following regulations and guidelines have been established under the *Canadian Shipping Act* and *Arctic Waters Pollution Prevention Act*:

- Guidelines for the Operation of Tankers and Barges in Canadian Arctic Waters (Interim): provide an increased standard of protection (above other Canadian waters) from oil spills. The guidelines address the construction of vessels, operation, crew training, required oil cleanup equipment and the need for an Emergency Response Plan approved by the Canadian Coast Guard (Transport Canada, 1997a).
- Arctic Waters Oil Transfer Guidelines: describe the approved procedures for transferring petroleum products in Arctic waters, including requirements for safety, fire fighting and emergency equipment, assessment of weather conditions, responsibilities, communication, emergency stop procedures and spill response equipment (Transport Canada, 1997b).
- Arctic Shipping Pollution Preventions Regulations: sets out shipping requirements through the Arctic, including vessel construction requirements.
- Arctic Waters Pollution Prevention Regulations: defines equipment standards, inspections transfer operations requirements and shipboard emergency plans.
- Oil Pollution Prevention Regulations: indicates liability associated with the deposit of waste in Arctic waters.
- Response Organizations and Oil Handling Regulations: oil tankers must engage a spill response organization if larger than 150 gross registered tonnage.

Vessels must also have on board an Oil Pollution Emergency Plan (SOPEP) and shipping companies are required to maintain an arrangement with a certified response organization, such as the Eastern Canada Response Corporation for eastern Canada. A typical Table of Content of a SOPEP is presented in Volume 10, Appendix 10D-10.1

3.8.5 Recovery Methods for Spills

At the DEIS PHC held in Igloolik (November 7, 2011), Environment Canada requested that Baffinland:

- Incorporate the knowledge gained from the National Energy Board "Spill Response Gap Study for the Canadian Beaufort Sea",
- Identify areas and times along each shipping route where accidents are more likely to occur, and
- Identify optimal times for bulk fuel shipments based on open water season and when/where conditions are most favorable for responding to an oil spill/environmental emergency.

The NEB report cited by Environment Canada (S.L. Ross Environmental Research Limited, 2011) covers the Beaufort Sea and the Davis Strait. The gap analysis looks at the time of the year when three types of response measures are effective for spill recovery on the basis of:

- Wind conditions;
- Wave conditions; and
- Visibility.

The response measures investigated are:

- In-situ burning;
- Containment and recovery; and
- Dispersant.

For the central Davis Strait, the report concludes that for the months of June, July, August and September, at least one method of response intervention is applicable 100 %, 100 %, 99 % and 95 % of the time respectively (on the basis of wind and wave data). The effectiveness of the recovery methods can drop to the low 80 % by November.

This confirms that the optimal months for fuel delivery are from June to September for the Davis Strait, which translate to the July to September period for the Foxe Basin as the ice free condition in that area start a bit later in the year.

In terms of "areas and times along each shipping route where accidents are more likely to occur", the very notion that accidents are predictable is a stretch of the imagination. Baffinland has launched an extensive program to establish the bathymetry along the shipping route. This information will be available by the time the ore carriers begin sailing through the Foxe Basin.

As stated above, the possibility of ship grounding will be prevented or minimized by properly engineered design, adherence to established shipping lanes (well-known bathymetry), employment of well-trained crew and following ship-specific operating procedures. As much as possible, port facilities will have dedicated personnel to direct incoming ships.

Ship ground is a rare occurrence, when ships are designed properly and the ship operating procedures are followed by well-trained shipping crew. If grounding occurs, established emergency response for each ship will be followed.

Cargo vessels and fuel tanker have anti-collision devices with alarms and radar to ensure that collisions are avoided. Marine heavy oil (MHO) used for powering the ship is stored within a double tank containment inside the ship (normally toward the stern), away from the hull. MHO storages are unlikely to be damaged by collision or grounding.

Ore carriers used by the Project, both the dedicated fleet of icebreaking ore carriers and chartered vessels that are likely to operate during the open-water season, will carry their own supply of MHO in an integral tank. While a collision or grounding of an ore carrier is possible, the subsequent potential release of MHO is not considered to be a credible spill scenario, since fuel is not contained next to the hull and therefore a breach of the tank is highly unlikely. The risk associated with such an event is considered very low.

3.8.6 Canadian Coast Guard (CCG) Response in the Arctic Region

A major commitment made by Baffinland is that the Company will be self-sufficient in terms of emergency response that deals with all events related to its operation. This will apply at the onset of the Operation. During construction, the EPCM contractor will maintain necessary equipment and trained personnel at the Steensby Port at all times to enable the Company to respond effectively to spills within close proximity to the port. Fuel shipments will be delivered during the open water period. All vessels transporting fuel to the site will be licensed to navigate in Canadian waters and therefore will have a Transport Canada approved SOPEP. As per the current situation/practice throughout the Arctic, until Baffinland's fleet is operational, Baffinland will rely on the assistance of the Canadian Coast Guard for search and rescue operations and assistance to respond to accidental events during ship transit to the port sites.

For information purposes, an update is presented on the CCG response capabilities in the Arctic Region.

The "*Central & Arctic Regional Response Plan (2008)"* and the "*Baffin Region, Nunavut Area Plan"* outline the Canadian Coast Guard's response capability for the Baffin region. This plan is a component of the *Canadian Coast Guard National Response Plan* (2008)*,* which is the responsibility of the Director Environmental Response, Ottawa. It establishes the framework and the procedures by which Central & Arctic Region will prepare for, assess, respond to and document actions taken in response to pollution incidents.

Arctic Community Packs (ACPs) are placed in northern communities for rapid (local) initial response. Canadian Coast Guard provides initial response training to members of the communities so that they may effectively deploy equipment in the ACPs in the event of a spill. Access (keys) for the ACPs have been given to community officials in most cases.

The inventory for each Canadian Coast Guard Arctic Community Pack location is listed in the Table 9-3.7. The program received funding under the Health of the Oceans Initiative and placement of ACPs at additional sites took place in 2009. A full review of each community through possible spill scenarios was undertaken and the equipment profiles at the existing Arctic Community Pack sites were changed to reflect characteristics of each community. The inventory at all communities is now site-specific and coincides with response strategies designed by the ER planning group. The locations of the additional Arctic Community Packs are: Baker Lake, Broughton Island (Qikiqtarjuaq), Chesterfield Inlet, Churchill, Pangnirtung, Tuktoyaktuk, Yellowknife, Hall Beach, Kimmirut and Iqaluit, the last three being along the proposed shipping route

Based on the findings of the review, inventories were adjusted by community and additional ACPs were delivered accordingly. For the most part, the single sea container approach has now been enhanced to contain three modules per community: one for boom, one for shoreline clean-up and one beach flush kit.

The approach is to provide the community with sufficient materials and training to ensure self-help capability for 48 hours and to ensure a timely initial response to spills less than 5 m^3. Following this initial response, should it be necessary, a cascading of resources from other CCG inventories would be initiated. The main base of operations with Environmental Response dedicated personnel is located in Hay River, Northwest Territories. This base is home to a Rapid Air Transportable (RAT) cache of equipment known as the

"RAT150". The RAT150T used in conjunction with the "Delta" (Δ) 1,000T meets planning standards for a 1,000 tonne (T) response. The equipment for the RAT150 meets pumping rates/capacities of 1,000T thresholds and is complimentary to the equipment held in the Δ 1,000T depots.

The response package, warehoused in Hay River, is maintained in 100 % readiness during the shipping season. The equipment is broken down and containerized so that it will fit through the smallest cargo door of any of the selected aircraft. Equipment is TDG compliant, palletized as appropriate and labeled for ease of selection and loading.

In combination with the RAT150T, equipment found in the Δ1,000T depots will be at a 1,000T capacity. Hence, the delta or "Δ" is the difference between the RAT150T and a full 1,000T. The Δ1,000T depots will have containerized heavier equipment (not suitable for air transport to smaller communities) augmenting the RAT150T to a 1,000T capacity, ready to be loaded on deck barge, Canadian Coast Guard icebreaker or freighter. While response personnel cascade in to the spill site, pre-identified local, CCG base and available ER personnel will mobilize to the centers and load the equipment on suitable marine transport.

Three Δ1, 000T depots are strategically located in the northern communities of Tuktoyaktuk (Northwest Territories), Iqaluit (Nunavut) and in Churchill (Manitoba). For the purposes of response in Central & Arctic Region, Churchill is included in the Arctic Zone of operations despite it being south of 60° North Latitude because of the similarities in response characteristics it shares with northern locations.

3.8.6.1 CCG Expectations of Oil Handling Facilities (OHF) for Response

In most instances when a spill occurs, the initial report will trigger the mobilization of the facility response team. It is normal, in most cases, for oil handling facility personnel to be the initial responders.

Small Spills

For the purpose of the OHF Plan, a small spill is defined based on the maximum oil transfer rate of the oil handling facility (i.e., what level it is assigned under the *Canada Shipping Act, 2001),* which directly links to the minimum spill size to which it must be prepared to respond within one hour. Oil handling facilities are required to have the resources on site to contain a minimum-size spill within one hour and have the resources required to recover, or where the oil cannot be recovered the resources to control, a spill of a minimum spill size within six hours. Response organizations may be called upon to provide additional operational response capability at the discretion of the polluter.

Large Spills

For the purposes of the OHF plan, any spill above the facility's minimum spill size will be characterized as a large spill. Oil handling facility personnel are still expected to deploy their on-site equipment. Additional resources beyond the capability of the OHF will be requested from CCG, or in the case that CCG deems the OHF unable to adequately respond, they will dispatch resources accordingly.

Table 9-3.7 Canadian Coast Guard Arctic Community Pack Locations

Location	EQUIPMENT SUMMARY			
	Boom (24")	Skimmers	Boats	Storage
Arctic Bay (Ikpiarjuk)	3,650'	TDS-118	16' Aluminum	Open top Tank
Cambridge Bay (Ikaluktutiak)	1,350'	TDS-118	16' Aluminum	Open top Tank
Cape Dorset (Kinngait)	1500'	TDS-118	16' Aluminum	Open top Tank

Table 9-3.7 Canadian Coast Guard Arctic Community Pack Locations (Cont'd)

Location	EQUIPMENT SUMMARY			
	Boom (24")	Skimmers	Boats	Storage
Clyde River (Kangiqtugaapik)	4,500'	TDS-118	16' Aluminum	Open top Tank
Coppermine (Kugluktuk)	1,350'	TDS-118	16' Aluminum	Open top Tank
Coral Harbour (Salliq)	1,500'	TDS-118	16' Aluminum	Open top Tank
Gjoa Haven (Uqsuqtuuq)	1,350'	TDS-118	16' Aluminum	Open top Tank
Holman (Ulukhaktok)	1,500'	TDS-118	16' Aluminum	Open top Tank
Rankin Inlet (Kangiqsiniq)	2,200'	TDS-118	16' Aluminum	Open top Tank
Resolute (Qausuittuq)	1,350'	TDS-118	16' Aluminum	Open top Tank
Hay River FRU +	1,000'	-	37' Seatruck 42' Cutter	-

3.8.6.2 Recent Enhancements to the CCG Response Capability in the Arctic Region

In 2009, CCG – C&A ER received funding under the Health of the Oceans Initiative to proceed with this enhancement to their regional response capability. The equipment profiles at the existing Arctic Community Pack sites were changed to reflect characteristics of the community. The inventories at all communities are site-specific and coincide with response strategies designed by the ER planning group.

An overlay of the shipping route proposed for Steensby and Milne ports shows that community packs are now staged at almost all villages along the shipping route. In the Foxe Basin, community packs are situated at Hall Beach. Igloolik currently is not supported by a community pack. In Hudson Strait, community packs are staged at Cape Dorset and Kimmurit. The east coast of Baffin Island is supported by CCG with units placed at Pangnirtung, Qikiqtarjuaq and Clyde River. A major 1,000T capability is also located at Iqaluit.

The equipment profiles at the existing Arctic Community Pack sites were changed in 2009 to reflect characteristics and specific risks on an individual basis by community. The inventories at all communities are site-specific and coincide with response strategies designed by the ER planning group.

3.8.6.3 Interaction of CCG with Industry and Potential Polluters

The Canadian Coast Guard is the Lead Agency in responding to marine spills north of 60°. Baffinland initiated discussion with the CCG regarding their current policies and approach in dealing with industry in the region. It is Baffinland's understanding that the CCG's current levels of service in the Foxe Basin and Hudson Strait, as well as on the east coast of Baffin Island, is adequate for the current and probably the future needs of the region.

Activity in the context of the Mary River Project would undoubtedly represent an increase of shipping volumes, but CCG sees spill risk centered around the diesel fuel deliveries. From an environmental response standpoint, CCG would respond in an efficient manner with current resource levels.

3.8.7 Potential Effects of a "Worst-Case" Spill Scenario

Impacts to Biota - Lower Trophic Levels and Fish

The introduction of diesel fuel into the marine environment could have a harmful effect on plankton, benthos and fish. In open water, toxicology issues would likely focus on acute toxicity within the first few days after a spill. Acute toxicity appears to be related to the Water Soluble Fraction of the fuel (McCarthy *et al*., 1985; Yapa and Shen, 1994) and due to the concentration of aromatic constituents, rather than the aliphatic compounds (Doeffer, 1992). Lethal concentrations of WSF vary between species, life cycle stages (eggs and larval stages are most sensitive) and physical environment parameters (water temperature).

In the event of a surface spill during fuel transfer, plankton living in the surface waters at the spill site would be particularly vulnerable because they would be exposed to the highest concentrations of WSF constituents. Organisms or certain life history stages of organisms with no or limited locomotory abilities (fish eggs, larvae and benthic invertebrates) would also be vulnerable. In contrast, adult fish would be less vulnerable because they are generally able to avoid spills by swimming away.

Craddock (1977) provided a summary of acutely lethal concentration (standardized for a continuous 96-hour exposure) ranges for the water soluble fraction of diesel fuel for a variety of marine biota as follows: fin fish, 5-50 mg/L; larvae and eggs, 0.1-1 mg/L; pelagic crustacean 1-10 mg/L; benthic crustacean 1-10 mg/L; gastropods 10-100 mg/L; bivalves, 5-500 mg/L; other benthic invertebrates, 1-10 mg/L.

Chronic exposure for these species will rely heavily on the substrate along the shorelines. In areas of low disturbance, contaminated sediments can rest for an extended period of time, and should these contaminants end up underneath a mussel bed, this would create a direct route into the food chain (Peterson *et al*., 2003). The sediment filtering benthics are typically slow at metabolizing hydrocarbon compounds allowing for high concentrations of hydrocarbons to occur (Neff, 1988; Peterson *et al*., 2003). Benthic invertebrates have been shown to have a quick uptake of these compounds, some as fast as 5 to 30 mg/g dry weight during the initial uptake following a spill (Teal and Howarth, 1984). These benthics also make up the diet of many larger animals such as walrus and King and Common eider. Chronic exposure of hydrocarbons to benthic invertebrates has been shown to decrease biodiversity, reduce population numbers, slower growth rates and slower assimilation rates (Teal and Howarth, 1984).

From this information, any spill that resulted in WSF concentrations greater than about 0.1 mg/L would be of concern if it occurred at a time when larval fish or eggs were present. This would likely have no acute lethal effects to juvenile and adult fish because it is below the reported lethal range of concentrations (5-50 mg/L) for fin fish. Also, it is highly unlikely that fish would be exposed to that concentration for 96 hours, the duration of exposure at which acute lethal concentrations are determined. Most activity that could result in an accidental introduction of diesel into the marine environment during the bulk sampling program would occur during August, when most fish species are not spawning, however large numbers may be present during in-peak migration during this time (Appendix 9C). Arctic char spawn during fall, but this takes place in fresh water and, consequently, their eggs (the more sensitive stages) would not be exposed to a fuel spill into the marine environment.

There may be acute lethal effects to some plankton groups in the initial spill area because the expected initial WSF concentration may fall within the reported range of lethal values (1-10 mg/L). However, the WSF concentration is expected to be quickly diluted, resulting in exposure to acutely lethal concentrations for only a short period. Plankton in the initial spill area would quickly re-establish potentially within two weeks (US EPA, 1980; Silva *et al*., 1997). It is expected that such a short-term reduction in zooplankton abundance over a small area would not have substantial effects to other ecosystem components. Similarly, the introduction of low concentrations of weathered oil to the sediment over most of the affected area would have little effect to benthic biota.

In addition to toxicity issues, the introduction of diesel or Jet A fuel could negatively impact domestic fisheries by tainting fish targeted for human consumption. Arctic char exposed to crude oil in a laboratory setting quickly accumulated an oily off-flavour. This eventually cleared, but much more slowly than it was acquired (Lockhart *et al*., 2002). Results of those experiments suggest that exposure of fish of edible size to concentrations of oil around 3 mg/L for periods of a few hours would be of concern for tainting. However, the small area affected and short duration of exposure at the concentrations described in our example indicates that tainting would be a much localized problem. Sport and domestic fishing for Arctic char occurs in the Robertson River entering into Koluktoo Bay and throughout most coastal areas of Milne Inlet and Eclipse Sound. Fuel from an accidental spill of the size discussed here is expected to disperse over an area within the bulbous head of Milne Inlet and would not reach Koluktoo Bay or areas farther from the head of Milne Inlet. Although anadromous char can move large distances from their overwintering stream while feeding in coastal marine environments, they return to their natal streams during August and September to spawn and overwinter in fresh-water areas. Consequently, it is thought that the only char in the immediate vicinity during August and September and susceptible to tainting are those fish that would move into Phillips Creek. While fish are expected to use Phillips Creek during summer, no fish have been captured as part of the Project's baseline studies. The capture of tainted fish in the area could be avoided by closing the affected area to fishing.

3.8.7.1 Impact on Seabirds

Seabirds are likely to interact with a spill through a variety of ways. Seabirds are the marine organisms the most affected by a spill due to the fact that they spend an appreciable portion of time in the water (Lock *et al*., 1994; Chardine 1992). Birds are vulnerable to oil exposure through contamination of their plumage and through the ingestion of oil contaminated food. Oiled plumage can result in the loss of insulative capacity leading to hypothermia or loss of buoyancy, which in turn could result in drowning. Ingestion of oil can lead to changes in physiology, internal tissue damage or death. Seabirds that are more susceptible to oiling (i.e., alcids, common eiders and gulls) include those that spend a large portion of time on the water, are weak flyers that prefer to dive, have flightless feather-moulting stages, dive for food, and roost on the water at night (Lock *et al.,* 1994; Piatt *et al.,* 1985). All seabirds are considered to be highly sensitive to oiling.

While nest and chicks would not be directly affected from the spill, they would be indirectly affected through various means. The largest cause of indirect impacts to chicks and eggs are the parent seabird becoming fouled by the spill (Eppley and Rubega, 1990). This can result in direct mortality for the seabird or it has been shown to cause a disruption in the natural parent behaviour of seabirds (Eppley and Rubega, 1990). This breakdown is potentially caused by seabirds being delayed in returning to their nest thereby creating a large window where the chick is unprotected from both the elements and predators. Oiled adults can leave oil stains on incubating eggs and this can induce mortalities.

A dozen sites in Foxe Basin and Hudson Strait have been identified as Important Bird Areas (IBA) (Appendix 9C). These sites also include marine habitat such as coastline, open sea, and polynya-shore lead habitat. Of these 12 sites, the 30 km swath that represents the likely boundaries of a major spill encroaches upon two (North Spice Island and Foxe Basin Islands), and as such these seabird colonies at these two IBAs are at a high risk of being exposed to a spill. A spill event near Hantzsch Island and Digges Sound would also put seabirds at a high risk of exposure due to the fact that a large thick-billed murre colony is present and these seabirds undergo a flightless, marine migration. Seabirds from other IBAs are considered to be at low risk of exposure due to the distance of the proposed shipping route and 30 km swath from the shore colonies (Appendix 9C).

Major seabird and waterfowl colonies are located on Bylot Island, but neither large colonies nor large feeding flocks were seen during aerial surveys conducted in the Milne Inlet area during the middle and end of the breeding season in 2006 (Volume 6, Appendix 6E). Only a few Thick-billed Murres, as well as Glaucous Gulls, Herring Gulls and Iceland Gulls were seen using the area and two small colonies (less than 20 breeding pairs each) were also located on the cliffs along the shoreline. An accidental spill would have no effect on birds nesting and feeding in the vicinity of Bylot Island, but could have some effect on the small number of seabirds and other birds in the immediate vicinity of Milne Inlet.

3.8.7.2 Impact on Marine Mammals

Whales are generally not at great risk to fuel spills because they rely on a layer of blubber for insulation and oiling of the skin does not appear to have adverse thermoregulatory effects (Kooyman *et al*., 1976; Kooyman *et al.*, 1977; Geraci, 1990; St. Aubin, 1990). There is a possibility that baleen of bowhead whales could be contaminated, thereby reducing filtration efficiency, though these effects are expected to be minimal and reversible (Geraci, 1990). There is no irrefutable evidence that links fuel spills with cetacean mortalities.

Seals can be sensitive to exposure to oil at certain times during their life history, particularly during their annual moult or pupping periods (Dickens *et al*., 1990). A number of sublethal effects of oil exposure or the consumption of oil-contaminated prey has been documented for seals, including changes in behaviour and physiology, but there is little evidence to irrevocably link seal mortalities to oil exposure. Similarly, polar bears can be affected by the consumption of oil-contaminated prey, direct ingestion due to cleaning oil from their fur, of suffer from adverse effect thermal insulation (Dickens *et al*., 1990).

Quantities of hydrocarbons can attach to the fur, thereby reducing swimming speed and mobility in the water (St. Aubin, 1988). Young seals may be more vulnerable to this effect as it has been noted before that a fouled coat has stuck flippers on the side of their bodies causing them to be unable to swim. It is thought that adults would be strong enough to avoid this affect. A build-up of hydrocarbons may limit the movement of more delicate structures such as eyelids and vibrissae (St. Aubin, 1988).

The 30 km swath overlaps with known terrestrial walrus haulouts. If the spill reach the shore of these haulout sites, walrus will be at an increased risk of being exposed. As well walrus have the potential to be exposed to chronic exposure due to foraging of contaminated benthic invertebrates. The benthic invertebrates living in an exposed shoreline would come into contact with the spill via direct contact and ingestions of oil attached to sediments. Any buildup of hydrocarbons within the benthic invertebrates would be taken in by foraging walrus thus creating a pathway for increased hydrocarbon intake. As well, due to the fact that walrus lack a significant coat of fur there is an increase possibility that lesions will develop as a result of contact with oil (St. Aubin, 1988).

During August and September, when shipping is expected to occur, narwhal, bowhead, ringed seals and harp seals are common in the waters of Milne Inlet and Eclipse Sound. Narwhal routinely move to the head of Milne Inlet, but bowheads and harp seals tend to remain in waters north of Koluktoo Bay. Ringed seals are likely present near the head of Milne Inlet through the summer. If it is assumed that the trajectory of a 10,000 L spill is 10 km^2, the area affected would include about a third of the marine area between the head of Milne Inlet and Koluktoo Bay. Under such a scenario, it is doubtful that bowhead or harp seals would be exposed to the slick. Narwhal and ringed seals may be within the area, but exposure would be short-term because of anticipated rapid dilution of the fuel and because general disturbance associated with the clean-up operations would likely cause animals to leave the area.

3.8.8 Large Spill Modeling - Establishing the Size and Trajectory of the Spill

The starting point for modeling a spill scenario is to establish the type of product and a credible volume. Only two types of fuels will be delivered in bulk, Arctic diesel and Jet A fuel. The spill scenario therefore assumed a total cargo volume of 50 ML (50 million litres or 5,000 m^3) of Arctic diesel fuel coming through the sea lane and to port.

Ship-to-shore transfer operations are not causes of major spills. Since these operations are closely monitored, spills rarely exceed 5 m^3, which is the basis for the development of the Milne Port and Steensby Port OPEPs (Volume 3, Appendix 3B). Due to rapid deployment of spill containment equipment, such spills are too small to be used in predicting the trajectory of a larger spill that could result from a catastrophic event.

For modeling purposes, the total amount of 50 ML spilled is judged to be too large a spill and not a credible amount. Instead, three possible 'modes' of release or of estimating the amount were put forward:

- For a hypothetical fuel transfer loss at the port, assuming a 3 ML/h transfer rate (equates to about 16.7 h where the entire offloading might be typically expected to take about 24 h), there would be potential release of 50,000 L/min. Assuming a period of 10 minutes before the spill is stopped, this would represent a spill volume of 0.5ML. Clearly the assumed time before spill stoppage is a key factor.
- If one assumes fourteen tanker compartments and complete loss of one, this would release 3.6 ML. Again, the number of compartments damaged is a factor.
- Historical spill statistics can also be considered. Some research/review (e.g., McKenna and McClintock, 2005) indicates spill amount is best expressed as a proportion of fuel transported, with 5 % a most likely estimate, and 10 % a conservative one: 10 % yields 5 ML.

From this work-up, it was assumed that 5 ML was a worst-case amount worth carrying forward. It was felt that the Port sites (either Steensby or Milne) were reasonable locations to take for the spill, as they match the first scenario above and could be considered possible even for the second.

The analysis of open-water scenarios was accomplished by making use of a numerical computer model developed by AMEC to predict the behaviour of fuel on the sea surface and determine probabilistic spill trajectories. The model simulates the two-dimensional motion of a surface slick transported under the joint influence of wind-driven surface currents and residual currents. The processes of evaporation and vertical dispersion are simulated to estimate the volume loss of fuel from the surface slick. Individual trajectories evolve under the influence of a deterministic time-series of winds (hourly) and current vectors until such time as the trajectory terminates ashore or on an external boundary to the model grid, the trajectory has drifted for more than 30 days, or until the slick volume drops to less than 5 % of its initial volume.

The advection or transport of spilled fuel on the sea surface was modeled using a *30-year time-series of gridded winds* from the NCEP/NCAR reanalysis project selected for use. These data are near-surface modeled winds and were determined to be the best comparable winds to the nearby Milne or Steensby stations from 2006 to 2010. The NCAR/NCEP winds long time-series length provides good statistical reliability in the predicted spill probability distributions. Several wind speed and direction sensitivity runs were also conducted to allow for discrepancies between the measured site and 30-year wind distributions.

The results of this modeling are fuel spill distribution probability maps for Milne Port and Steensby Port, developed by superimposing all possible spill trajectories, for a given month, over the 30-year distribution of selected wind data. The results of this modeling are presented in Appendix 9A for Milne Inlet and 9B for Steensby Inlet.

3.8.9 Spill Modelling at Milne Port (Appendix 9A)

Milne Inlet is divided into six geographical regions and for each monthly spill scenario a companion set of shore impact statistics are calculated to report the percent of trajectories impacting the shoreline and the earliest times to impact in any of the regions.

It is predicted that 90-97 % of all trajectories will reach shore in the port site area within about 4 km at the head of Milne Inlet in as soon as 30 minutes and on average in four hours, with an associated small amount of fuel weathering. Between 3 and 10 % of the time trajectories might be expected to first contact shore another 6 km farther out in the reach of the inlet leading to Cape Kwaunang. First impacts for shores in Koluktoo Bay, the Bruce Head region on the Borden Peninsula, and the southern tip of Stephens Island are much less likely, occurring less than 1 % of the time. Due to the short times to shore for most of the trajectories, weathering of the fuel is correspondingly low. In the Milne Port Area an average about 4 to 5 % of fuel is weathered due to evaporation or dispersion into the water column before any fuel reaches shore. This amount increases to 10 to 16 % for trajectories reaching Cape Kwaunang and about 15 to 50 % for trajectories north of there.

The collection of spill probability plots and shore impact statistics define the probable distribution of any hypothetical, uncontained and unmanaged spill for the Project domain of operations in Milne Inlet for the open-water season.

An important observation is that the trajectory model predicts the times and paths taken to first reach a shoreline in the inlet. More detailed characterization of the weathering fate of the spill, slick size and amounts of fuel remaining on the surface and ashore, e.g., after initial shoreline contact, is better afforded with the OILMAP software. To this end, several scenarios for a range of wind conditions likely to be encountered in Milne Inlet are considered.

Appendix 9A presents the spill modeling report for Milne Port.

3.8.10 Spill Modelling at Steensby Port (Appendix 9B)

The results are fuel spill distribution probability maps of Steensby Inlet developed by superimposing all possible spill trajectories, for a given month, over the 30-year distribution of the selected wind data. Steensby Inlet is divided into 10 geographical regions and for each monthly spill scenario a comparison of shore impact statistics are calculated to report the percent of trajectories impacting the shoreline and the earliest times to impact in any of the regions.

The vast majority of trajectories, 86 %, reach shore in the port site area, as soon as 15 minutes and on average in two hours. Just over 9 % of trajectories end on the western side of Steensby Inlet, about 12 to 20 km away. Times to shore are as early as 7 hours, 29 hours on average and up to 150 hours (6 days), where 54 % of the fuel is estimated to be remaining.

Other regions farther in the inlet are reached, though generally less than 1 % of the time. The Rocky East region is reached as soon as six hours and 56 hours on average. The Coastal Plain West is reached as soon as seven hours and 29 hours on average. The Inlet Islands are reached as soon as 18 hours and 56 hours on average. Koch Island, with one trajectory, at the mouth of Steensby Inlet, is reached in just over two days. To the north, the Rocky Northeast region is reached as soon as 34 hours and 52 hours on average. The Lagoon Complex to the head of the inlet is reached within 52 hours and 66 hours on average.

The collection of spill probability plots and shore impact statistics presented in the modeling report (Appendix 9A) define the probable distribution of any hypothetical uncontained and unmanaged spill for the Project domain of operations in Steensby Inlet for the open-water season.

A qualitative assessment of shoreline fuel retention has also been prepared, based on a review of the modeling results and an understanding of the shoreline habitats. The initial modeling results suggest that the impact to shoreline resources would be comparatively short-term (days to weeks), largely because of the volatile nature of diesel fuel. Shorelines close to the port location have fine sediment matrix in the immediate subsurface, this will limit fuel penetration and overall retention. Stranded fuel would continue to evaporate on the beaches.

Key macrobiota on these shorelines include salt marshes and rockweed. Salt marshes are in the upper intertidal and supratidal zones and are vulnerable to fuel contact. The substrate is typically fine-grained sediment and organics, which have low permeability so that significant volumetric retention will not be expected; however, diesel sticks to organics, so some residual fuel may be incorporated into the organic substrate. It is likely that salt marshes close to the spill site would experience a combination of lethal effects and some sublethal effects. New plants shoots would be expected during the spring melt so it is unlikely that most effects would be limited to a single generation. The estimated duration of impact would be weeks to months with normal growth rates returning the following spring; some marsh areas very close to the spill site could have reduced growth rates for longer periods of time.

Rockweed occurs in the lower intertidal and shallow subtidal. Rockweed would only be exposed during spring tides, so it is not vulnerable at any time. There are likely to be a combination of lethal and sublethal affects for rockweed located within 5 km of the spill location. The life stages of rockweed in this region are unknown but the extensive occurrence along the shore probably represents first-year growth; it also occurs offshore, where it is vulnerable to contact with sheens. As such, it is likely that effects of a diesel spill on rockweed would be limited to a single generation and that rockweed growth at breakup during the following year would be normal. The effect of a spill on rockweed is likely to be moderate (weeks to months).

3.8.11 Generic Spill Scenario along the Shipping Lane (Appendix 9C)

Baffinland commissioned a study by Coastal & Ocean Resources Inc. (CORI) on the Coastal Sensitivity of Proposed Port and Shipping Routes for the Mary River Project (Appendix 9C). This study considers the potential for open water diesel spill associated with fuel shipment to the Project. The assessment examines potential environmental sensitivity associated with the Project shipping routes.

A rationale was developed for the key elements of a spill scenario. Thus a set of reasonable assumptions have been postulated as comprising the spill features. These include:

- A worst-case spill of 5 ML of diesel (assume ADIOS2 “diesel [Canada]” fuel type NOAA, 2010);
- The spill occurs along the shipping lane;
- The spill will be largely confined to a 15 km swath on each side of the shipping lane;
- Slick areas are in the order of 18 km^2 after one day and 70 km^2 after seven days;

- Shorelines within 15 km of the shipping lane may be contacted by the spill; if they are contacted, it is likely that worst-case contact would be less than 100km);
- In general, diesel slicks are thin (approximately 1-10 microns) so that should shoreline contact occur, loading levels are low;
- Shorelines outside of 15 km from the shipping lanes are unlikely to be contacted;
- A spill would be most toxic, shortly after the spill, before weathering has taken place; locations more distant from the center of the shipping lane would experience lower toxicity levels;
- Spill scenarios assume no mitigation; in some locations, particularly near the port sites, there is good potential for mitigation; and
- Diesel persistence is relatively short – generally a matter of days and at worst-case one to two weeks.

The southern shipping route enters eastern Hudson Strait, passes close to the community of Cape Dorset and turns northward in Foxe Basin, passing 15 km offshore from Prince Charles Island and into Steensby Inlet. There are approximately 900 km of shoreline within the 30 km swath along the shipping route, of which 500 km (56 %) is located in the Steensby Inlet area. Much of the proposed southern route passes well offshore from Foxe Basin shorelines.

For a worst-case spill scenario anticipated to occur along the shipping route, the exact location of this spill scenario is difficult to determine. Conceivably, areas where navigation hazards exist would make the vessel more vulnerable. Examples of such hazards include narrow passages, shallow waters, areas of high currents and areas prone to bad weather. These types of hazards are present along the western and eastern end of Hudson Strait as well as the northern portion of Foxe Basin as the vessels approach Steensby Inlet. Shoals are known to be present approaching Steensby Inlet and as such extra precaution will be required.

Significant bird colonies and bird usage occurs along the shorelines of Foxe Basin and Hudson Strait and the area includes 12 designated Important Bird Areas. These sites also include marine habitat such as coastline, open sea, and polynya-shore lead habitat. Although these areas are generally more than 15 km from the proposed shipping route, birds do forage offshore to considerable distance and may be vulnerable to open-water spills. North Spicer Island and Foxe Basin Islands are key bird areas and a worst-case spill scenario could reach these islands. As such the colonies of seabirds present on these islands would be considered a high risk. A spill near Hantzsch Island and Digges Sound would also be considered a high risk for seabirds and the flightless, marine migration that occurs near these locations (Appendix 9C). Seabirds from the other IBAs are considered to be at low risk due to the distance of the proposed shipping route from the shore colonies. Impacts on seabirds as a result of a spill event are discussed in Section 3.8.7.2.

Known populations of bearded seal, ringed seal and walrus occur along the southern shipping route. Bowhead and beluga whales are known to occur within the southern shipping route; however their presence is limited during the summer months. These marine mammal species may be present during a spill event depending on the location. Walruses are the most likely to come into contact with a spill should the spill occur near known walrus haulout sites (Volume 8 Section 5.7.2.2). As such walruses are considered to be a moderate risk (Appendix 9C). Overall little to no direct marine mammal mortality is anticipated due to a spill event. Likely effects include consumption of oil-contaminated prey, changes in behaviour and changes in physiology due to fouling. As such the other marine species are considered to be a low risk (Appendix 9C). Impacts on marine mammals are described in Section 3.8.7.3.

Estuarine habitats include salt marsh that is an important feeding habitat of geese and also co-occurs with many anadromous Arctic char streams. Estuaries in Steensby Inlet and northern Foxe Basin are within 15 km of the shipping route, so have the potential to be contacted in a worst-case, open-water spill. Due to the oleophillic nature of salt marshes, and due to the fact that they occur in low-energy environments, they are regarded as sensitive to spills. Due to the potential for the spill reaching estuaries, Arctic char are considered to be low to moderate risk (Appendix 9C).

Fuscus seaweed is prevalent along the Steensby Inlet shoreline. This species has experience mortality and damage as a result of other spills, and such similar affects are anticipated should a spill reach the shoreline. Since *Fucus* is in the lower intertidal it would come into direct contact with surface slicks only at low tide and this could cause mortality and damage, but only to shorelines contacted by fuel (e.g., less than a few tens of kilometers). Since *Fucus* is widely distributed along the shore (CORI 2008a) and within the subtidal (CORI 2008b) recovery potential is considered good. Dispersed fuel within the water column may cause damage but since the effect is likely to be short, recovery potential is considered good. Impacts on biota such as zooplankton and fish are described in Section 3.8.7.1.

3.9 RESIDUAL EFFECTS SUMMARY

This Section presents potential accidents and malfunctions, mitigation measures and the residual effects assessment for the major accident and malfunctions presented in Table 9-3.2. Potential accidents and malfunctions that were assigned a "very low" risk rating were not carried forward into the assessment of significance. This includes:

- Explosives accidents;
- Fires;
- Failure/interruption of Power supply or WWTP;
- Contamination or interruption of water supply;
- Weather related strandings on the Milne Inlet Tote Road, Railway or construction access road;
- Collisions with wildlife;
- Railway derailment (without hazardous material release);
- Railway tunnel collapse; and
- Aircraft crash.

The exception is that the issue of potential introduction of invasive species at the port sites, raised as an issue of particular concern by local communities, was carried forth into the assessment of significance though it was assigned a "very low" risk rating.

Table 9-3.8 summarizes the ratings assigned to the significance criteria of residual effects associated with each effect discussed below. The confidence level assigned to the predictions is summarized in Table 9-3.9.

Safety is of paramount importance, and human injury (occupational or to bystanders) is a serious occurrence. Human fatality is considered a significant event. Therefore, it is recognized that a collision (of a truck or train) with a person, while considered an unlikely event, is potentially significant if human fatality were to occur. This potential effect was therefore rated as Significant and adverse.

Table 9-3.8 Residual Effects Assessment Summary – Major Accidents and Malfunctions

Effect			Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Affected Receptors**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
Mine Site - Open pit and waste rock stockpile slope failure	**Negative** Environmental degradation, Human injury	Landforms, water and sediment quality, vegetation, Humans	**Level II,** potentially **Level III** if human fatality occurred	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant
Mine Site – Hazardous material release	**Negative**	Soils, vegetation; Terrestrial wildlife and habitat; Surface water and sediment quality; Freshwater biota	**Level II:** Effect results in some exceedence of regulated values	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant
Mine Site/Tote Road - Truck accident	**Negative** Human injury; equipment damage	Human health and well-being/ Humans	**Level I, Level II or Level III** depending on whether human injury or fatality may occur	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Significant, if human fatality occurred
Mine Site – Open pit flooding	**Negative** Environmental degradation, potential human injury, production delay	Surface water and sediment quality; Humans	**Level II:** Human injury is possible	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant

Table 9-3.8 Residual Effects Assessment Summary – Major Accidents and Malfunctions (Cont'd)

Effect			Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Affected Receptors**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
Tote Road – Road embankment failure/collapse of water crossing	**Negative** Environmental degradation	Landforms, soil and permafrost; water quantity; surface water and sediment quality; Freshwater biota	**Level II:** Effect results in some exceedence of regulated values	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant
Tote Road – Hazardous material release	**Negative** Environmental degradation	Soil; Vegetation; Terrestrial wildlife and habitat; Surface water and sediment quality; Freshwater biota	**Level II:** Effect results in some exceedence of regulated values	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant
Tote Road or Railway – Collision with human	**Negative** Human injury	Humans	**Level II to Level III**: may result in injury or fatality	**N/A**	**Level I:** Infrequent	**Level I:** short term	**Level III**: irreversible	Significant, if human fatality occurred
Railway – Embankment failure/collapse of water crossing	**Negative** Environmental degradation	Landforms, soil and permafrost; water quantity; surface water and sediment quality; Freshwater biota	**Level II:** Effect results in some exceedence of regulated values	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant

Table 9-3.8 Residual Effects Assessment Summary – Major Accidents and Malfunctions (Cont'd)

Effect			Residual Effect Evaluation Criteria					Significance
Effect	**Direction & Nature of Effect**	**Affected Receptors**	**Magnitude / Complexity**	**Geographical Extent**	**Frequency**	**Duration**	**Reversibility**	**Rated Significance of Residual Effect**
Railway – Hazardous material release	**Negative** Environmental degradation	Soil; Vegetation; Terrestrial wildlife and habitat; Surface water and sediment quality; Freshwater biota	**Level II:** Effect results in some exceedence of regulated values	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level I:** short term	**Level II:** reversible with cost/effort	Not Significant
Port Site(s) – Diesel spill during ship to shore transfer	**Negative** Environmental degradation	Marine water and sediment quality; Marine habitat and biota; Marine mammals; seabirds	**Level III**: An effect predicted to exceed regulated values and/or result in a reduced population size or other long-lasting effect on the subject of assessment	**Level II**: Beyond the LSA and within the RSA	**Level I:** Infrequent	**Level I:** short term (immediate response will occur, to contain spill and avoid long-term persistent effects	**Level II**: reversible with cost/effort	Not Significant
Shipping – Diesel spill along shipping route	**Negative** Environmental degradation	Marine water and sediment quality; Marine habitat and biota; Marine mammals; seabirds	**Level II: marine water and sediment quality;** marine mammals **Level III**: seabirds (result in a reduced population size)	**Level III**: may extend beyond the RSA (depending upon ship location)	**Level I:** Infrequent	**Level I**: Short term effect based on timely response to spill event and volatility of diesel fuel	**Level II**: reversible with cost/effort	Significant

Table 9-3.9 Significance of Residual Effects from Accidents and Malfunctions

Key Issue	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
Mine Site: Open pit and waste rock stockpile slope failure	N	2	N/A	N/A
Mine Site: Hazardous material release	N	2	N/A	N/A
Mine Site: Truck accident	N	2	N/A	N/A
Mine Site: Open pit flooding	N	2	N/A	N/A
Tote Road: Road embankment failure/collapse of water crossing	N	2	N/A	N/A
Tote Road: Hazardous material release	N	2	N/A	N/A
Tote Road: Truck accident	N	2	N/A	N/A
Tote Road or Railway: Collision with human	S	2	1	2
Railway: Embankment failure/collapse of water crossing	N	2	N/A	N/A
Railway: Hazardous material release	N	2	N/A	N/A
Port Site(s): Diesel spill during ship to shore transfer	N	2	N/A	N/A
Shipping: Diesel spill along shipping route	S	2	1	2

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

A significant effect identified is the potential for a large fuel spill to occur along the shipping route. While unlikely to occur and depending upon location and other factors such as weather, a diesel spill by a tanker in the open water could result in a moderate magnitude effect to most marine environmental components and a high magnitude effect to seabirds. A large spill, depending upon the location and sensitivity of the area, could have a large extent (Level II or possibly Level III) but effects are short lived due to the volatility of the diesel fuel (Level I duration). For light diesel fuel, the effects are reversible.

3.10 AUTHORS

The accidents and malfunctions assessment was prepared by Fernand Beaulac of FMB Management Services, with inputs from John McClintock of AMEC, John Harper, Ph.D. of Coastal and Ocean Resources Inc. and Trevor Ford of Sikumiut Environmental Management Ltd. Review and edits were carried out by Larry LeDrew of Sikumiut Environmental Management Ltd. and Richard Cook of Knight Piésold Ltd.

SECTION 4.0 - TRANSBOUNDARY EFFECTS ASSESSMENT

4.1 INTRODUCTION

Over the past decade and beyond, a variety of international, bilateral and national laws, guidelines and institutions have adopted requirements that a transboundary impact assessment be conducted prior to making decisions on projects or activities with transboundary implications (Bruch *et al*., 2007). In Nunavut, consideration of transboundary effects is required by NIRB and the Board provides general direction to proponents regarding transboundary impacts in its minimum EIS Requirements for a Part 5 Review, including Item 10 which states:

> *Where relevant, an EIS must include an assessment of all significant adverse ecosystemic or socio-economic trans-boundary effects.*

The above requirement is also reflected in Section 1.3.10 of the EIS Guidelines provided to Baffinland for the preparation of the EIS.

Transboundary effects are defined by NIRB in its Guide 2 – Guide to Terminology and Definitions (NIRB, 2007) as:

> *Environmental effects/impacts which occur across provincial, territorial, or international boundaries.*

4.2 BOUNDARIES

The transboundary effects assessment is intended to consider the extent of effects that may occur outside of the NSA. There are two jurisdictional boundaries that border the Qikiqtani region of Nunavut. To the south of Baffin Island and across Hudson Strait is the Nunavik Inuit Settlement Area, which forms part of northern Quebec. To the east of Baffin Island and across Davis Strait is Greenland.

4.3 RELEVANT INTERNATIONAL AGREEMENTS

Canada has international agreements in place and joint efforts under way in the following areas that are relevant to development of the Mary River Project:

- Arctic Environment Protection Strategy;
- Polar Bear Conservation;
- Exchange of Information Related to Energy Project;
- Co-operation on Oil Spill Preparedness and Response; and
- Marine Mammals Conservation and Management.

4.3.1 Arctic Environment Protection Strategy - 1991

This Strategy represents the culmination of the co-operative efforts of the eight Arctic countries: Canada, Denmark, Finland, Iceland, Norway, Sweden, Union of Soviet Socialist Republics (Russia) and United States of America.

The eight Arctic countries were assisted in the preparation of the Strategy by the following observers: Inuit Circumpolar Conference, Nordic Saami Council, USSR Association of Small Peoples of the North, Federal Republic of Germany, Poland, United Kingdom, United Nations Economic Commission for Europe, United Nations Environment Program and the International Arctic Science Committee.

The objectives of this strategy are to:

- Protect the Arctic, including humans;
- Provide for the protection, enhancement and restoration of environmental quality and the sustainable utilization of natural resources including their use by the local populations and indigenous people of the Arctic;
- Recognize to the extent possible, seek to accommodate the traditional and cultural needs, values and practices of the indigenous people as determined by themselves related to the protection of the Arctic;
- Review regularly the state of the Arctic environment; and
- Identify, reduce and, as a final goal, eliminate pollution in the Arctic.

The link to the Arctic Council is www.Arctic-council.org.

4.3.2 Polar Bear Conservation

A Memorandum of Understanding (MOU, 2009) between Canada, Nunavut and Greenland outlines activities aimed at polar bear conservation (http://pbsg.npolar.no/export/sites/pbsg/en/docs/GN-MOU-PB.pdf). The MOU notes the different responsibilities of Nunavut and Canada in the areas of leadership, research, management authority and the establishment of protected areas for wildlife species, in co-operation with territorial and provincial governments and wildlife management Boards in the territories. For example, across the north, there are national parks, national wildlife areas, migratory bird sanctuaries and provincial and territorial parks that protect some terrestrial habitat.

4.3.3 Exchange of Information Related to Energy Project - Canada-Greenland Collaboration

This June 2010 Memorandum of Understanding (MOU), based on a marine cooperative agreement between the two countries dating from 1983, call for the participants to exchange information on specific energy projects, developments in their energy markets, the energy policy context within which they operate and their respective regulatory requirements, regulatory oversight approaches, regulatory processes, guidelines and best practices.

4.3.4 Collaboration on Oil Spill Preparedness and Spill Response

Since 1983, Canada has had an agreement with the Kingdom of Denmark related to collaboration with regards to oil spill preparedness and spill response in the Arctic (http://www.treaty-accord.gc.ca/text-texte.asp?id=101893&bprint=true).

4.3.5 Canada-Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga

This joint commission provides international oversight on the national management practices affecting these two species. Canada has also Observer Government status at meetings of the North American Marine Mammal Commission (NAMMCO) and the International Whaling Commission (IWC) and contributes to the work of scientific committees of these three marine mammal commissions.

4.4 DEFINITION AND APPROACH

A transboundary environmental effect can occur when animals move across jurisdictional boundaries or when project activities themselves, or their zone of influence, cross jurisdictional boundaries. The focus of Baffinland's transboundary effects assessment is on the latter, as effects on migratory VECs occurring within Nunavut are considered and fully assessed in the component-specific effects assessments (Volumes 4 through 8) as well as the cumulative effect assessment (Section 1).

In accordance with the definition and guidance provided by NIRB, the transboundary effects assessment for the Mary River Project addresses effects from its activities that occur across provincial, territorial and international boundaries. The Project, including the proposed Canadian shipping route, is located entirely within the Nunavut Settlement Area (NSA) and therefore little potential exists for it to result in effects beyond the NSA. Nevertheless, some residual environmental effects directly linked to the activities associated with the Project, could, as a consequence of a large zone of influence, result in transboundary effects as described below.

The NIRB Guidelines also require that due consideration be given to effects of the Project in combination with the effects of other projects located outside of NSA. This consideration represents a refinement of the Project cumulative effects assessment (Section 1).

As a general approach, the environmental effects assessment undertaken for each VEC and VSEC has included a detailed consideration of the full effect of each identified interaction, including any possible instances where the zone of influence associated with the interaction extends beyond the boundary of the NSA. Additionally, the cumulative effects assessment includes a consideration, where applicable, of other projects or categories of projects/activities that are located outside of the NSA and which might potentially act in combination with the effects of the Project.

4.5 ASSESSMENT

Tables 9-4.1 and 9-4.2 present overviews respectively of the VSECs and VECs that have been considered in this EIS. The tables identify potential environmental effects that might have a transboundary component (either direct or cumulative) and identifies where this has been considered within the EIS.

In general, the Project configuration is such that there are few potential transboundary issues. This is not surprising, given the geographic location of the Mary River Project and the limited range of any possible or detectable biophysical effects.

As shown in Tables 9-4.1 and 9-4.2, the existing environmental assessment has already incorporated transboundary considerations into the evaluation. Where assessment boundaries are less than the full range, e.g., of a migratory species, the calculated effect will be conservatively estimated. Where the effects predictions are population-based, the reference population is usually far smaller than the total population of the affected species; thus the predictions will over-state any transboundary effect. In cases where species of concern have been considered, the evaluation has included relevant factors affecting the subject population, including transboundary factors. In this manner, the consideration of all such VECs has encompassed transboundary effects assessment. Within the tables, the term “subsumed” has been used to refer to this treatment of a VEC within the EIS.

A limited number of interactions require supplemental consideration in order to satisfy the NIRB Guideline requirement for consideration of transboundary effects. Where such consideration is required, the discussion is presented in this chapter. Five VECs and six VSECs are identified for transboundary interactions. Two of the VSECs have the potential for direct effects (demographics and substance abuse-transport). The remaining issues are all cumulative in nature. In no case, however is there a potentially significant negative residual environmental effect. Within the cumulative effects assessment (Section 1), consideration has been given to significant negative interactions that occur between a VEC and other projects or activities, including those outside Nunavut.

The discussion presented under each VEC and VSEC assessment chapter has, for every identified issue, incorporated a consideration of transboundary effects. Additionally, supplemental text has been provided below with respect to three issues:

- Shipping;
- Climate change/air quality; and
- Demographic change.

4.5.1 Shipping

There are two shipping destinations on Baffin Island: Milne Inlet on the north coast and Steensby Inlet on the south coast. The Milne Inlet site will occasionally receive oversized equipment for the Project by way of sea-lift during the open-water season. Milne Inlet is accessed through Davis Strait, which connects the North Atlantic Ocean with Baffin Bay and is 320 km wide at its narrowest point. Given the width of Davis Strait and Baffin Bay, and that shipping along this route will occur infrequently during the open-water period, there are no anticipated transboundary effects from shipping activities within Nunavut.

The viability of the Project relies on the year-round supply of iron ore to customers, which requires that ore be shipped from Steensby Inlet year-round. A Project-dedicated fleet of icebreaking ore carriers will transport ore to market during ice-cover months and will be supplemented by chartered ships during the open-water season. All ships will operate in accordance with the *Canadian Shipping Act* and the *Arctic Waters Pollution Prevention Act*, thus mitigating transboundary concerns related to sewage, solid waste disposal and ballast water management. All ships will have prevention and response equipment for accidental spills and will have in place a Shipboard Oil Pollution Emergency Plan.

Ships entering and leaving Steensby Port will navigate through Hudson Strait and Foxe Basin. While Foxe Basin is entirely within Nunavut, jurisdiction over development activities in Hudson Strait is divided geographically between Nunavut and the Nunavik Inuit Settlement Area of northern Quebec. The planned shipping route is located entirely on the Nunavut side of Hudson Strait, which is 65 km wide at its narrowest point and up to up 230 km wide in other parts. The central channel of Hudson Strait ranges in depth from 300 to 400 m. The analysis undertaken to predict the zone of influence of the largest ship used for the Project was presented in the marine mammal impact assessment (Volume 8). Given the width of Hudson Strait compared with the zone of influence of Project ships, no transboundary impacts are anticipated from shipping activities within Nunavut.

Baffinland acknowledges that in rare circumstances, depending on ice conditions, icebreakers may have to navigate Hudson Strait using a more southerly route for safety purposes. Hudson Strait is a well established shipping route. There are established shipping lanes for community resupply accessing the communities of Hall Beach, Igloolik, Cape Dorset and Kimmirut. In addition, the *MV Arctic* has been providing winter ore transport through Hudson Strait to support mining operations at the Raglan Mine (Deception Bay in northern Quebec) for a number of years. During that time no adverse effects on marine mammals have been documented. This is consistent with Baffinland's finding that no transboundary impacts will occur from shipping activities in Nunavut through Hudson Strait.

During the DEIS review meetings held in Iqaluit, it was agreed by Baffinland that the effects assessment will include an overview consideration of effects extending into Davis Strait and northern Labrador Sea regarding marine mammals and birds based on the zone of influence of the vessels and the receiving environment. As well, Baffinland agreed to review the range of interactions with marine mammals including those that could affect marine mammals to the west of Hudson Strait and provide rationale for not extending boundaries of zone of influence. This consideration was to include a discussion on the interactions along the shipping route including migrating marine mammals within Hudson Strait. These commitments are addressed for marine mammals in Volume 8, Section 5.14 (Indirect Effects on Marine Mammals in areas beyond RSA) and Section 5.15 (Effects of Shipping on Marine Mammals in Davis Strait and the Northern Labrador Sea). A consideration of seabird interactions extending into Davis Strait and northern Labrador Sea is provided in Volume 6, Section 4.9 (Thick Billed Murres), Section 4.12.1 (General Mitigation), Section 4.12.3 (Important Habitat Areas) and Section 4.12.4 (Seabirds and Seabird Colonies). In general, the level of interaction is rated as low and hence potential effects are few and are limited to unplanned events.

4.5.2 Climate Change/Air Quality

The assessment of effects on air quality, presented in Volume 5, shows that residual effects will not extend beyond 1.5 km from the Project site. As a result, and given the location of the Project, no transboundary air quality effects are possible.

The Project will emit greenhouse gases into the atmosphere, as diesel generators are the only current viable and available source of energy. Greenhouse gas emissions contribute to global warming, an issue of concern that crosses all borders and affects all jurisdictions, particularly circumpolar countries. Baffinland acknowledges that greenhouse gas emissions are a broad scale transboundary issue for which there is no viable alternative in Nunavut. At the Project level, Baffinland will report annually on performance indicators, including energy use and emissions management. The report will help to show Nunavummiut and other Canadians the Company's current performance and how it can be improved. Baffinland will also explore ways of conserving energy as the Project moves through development and will adapt accordingly.

4.5.3 Demographic Change

The potential for adverse residual transboundary socio-economic effects has been considered. The residual adverse effects relevant to the LSA are considered for their potential to affect other regions outside the RSA. The only potential effect relates to in-migration leading to demographic changes.

The Project is expected to draw workers from across Canada. Workers hired from outside of Nunavut will be provided with transportation to and from Project sites from one or more southern points of origin. Demographic changes in communities in the south as a result of the Project will not be discernible, and therefore, no adverse effect will arise from this interaction.

4.6 CONCLUSION

Baffinland has given due consideration to the potential for transboundary effects associated with the Project. This consideration has included:

- Any residual effects of the Project which have the potential to occur outside of the NSA; and
- Any (cumulative) effects that result from interactions between the Project effects and effects of other projects located outside Nunavut.

Baffinland has examined each of the VECs and VSECs and assessed the potential for these transboundary effects. Specifically, Baffinland has considered effects associated with marine shipping on marine mammals and migratory birds.

There will be a minor, "*not significant*" negative residual environmental effect of the Project on greenhouse gas emissions. With respect to all the VECs and VSECs examined, Baffinland has determined that there will not be any negative residual transboundary environmental effects.

4.7 AUTHORS

The transboundary effects assessment was prepared by Tobin Seagel of Knight Piésold, with contributions from Anne O'Toole and Warren Bernhardt of North/South Consultants.

Table 9-4.1 Summary of Project Transboundary Effects Assessment - VSECs

VSEC	Potential Effect	Transboundary Relevance	Type of Effect	Assessment Approach
Communities				
Population Demographics	Migration of non-Inuit Project employees into the North Baffin LSA Migration of non-Inuit into North Baffin for indirect jobs Inter-community Inuit migration	Yes	Direct	Subsumed + Section 9.4.5.3
	Out-Migration from the North Baffin			
Education and Training	Improved life skills amongst many LSA residents	No	n/a	n/a
	Incentives related to school attendance and success	No	n/a	n/a
	Opportunities to gain skills	No	n/a	n/a
Human health and well-being, including local food security	Changes in parenting	No	n/a	n/a
	Increase household income and food security	No	n/a	n/a
	Absence from community during work rotation	No	n/a	n/a
Substance Abuse	Transport of substances through Project sites	Yes	Direct	Subsumed
	Affordability of substances	No	n/a	
	Attitudes towards substances and addictions	No	n/a	
Community infrastructure and public service	Competition for skilled workers	Yes	Cumulative	Subsumed
	Labour force capacity	Yes	Cumulative	Subsumed
Governance and leadership	IIBA Agreement with QIA	No	n/a	n/a
Economics and Employment				
Livelihood and employment	Creation of Jobs in the LSA	Yes	Cumulative	Subsumed
	Employment of LSA Residents	Yes	Cumulative	Subsumed
	Job Progression and Career Advancement – New career paths	No	n/a	n/a
Economic development and self-reliance	Land	No	n/a	n/a
	People	No	n/a	n/a
	Community Economy	No	n/a	n/a
	Territorial Economy	Yes	Cumulative	Subsumed
Contracting and business opportunities	Expanded market —business services to Project	Yes	Cumulative	Subsumed
	Expanded market —consumer goods and services		Cumulative	Subsumed

Table 9-4.2 Summary of Project Transboundary Effects Assessment - VECs

VEC	Potential Effect	Transboundary Relevance	Type of Effect	Assessment Approach
Landforms, Soil and Permafrost	Local subsidence	No	n/a	n/a
Climate Change	Contribution to greenhouse gas emissions	Yes	Cumulative	Subsumed + Section 9.4.5.2
Air Quality	Degradation of ambient air quality - long range transport	Yes	Cumulative	Subsumed + Section 9.4.5.2
Noise and Vibration	Sensory effect on wildlife	No	n/a	n/a
Freshwater Aquatic Ecosystem Fish and Fish Habitat				
Philips Creek km 32 Lake	Reduction in downstream discharge volume	No	n/a	n/a
Milne Port Watersheds	Change in drainage patterns	No	n/a	n/a
Katiktok Lake	Volume reduction	No	n/a	n/a
Mine Site Watersheds	Change in drainage patterns	No	n/a	n/a
Streams and Rivers	Changes in Flows	No	n/a	n/a
Camp Lake	Changes in lake volume	No	n/a	n/a
Sheardown Lake	Changes in lake volume	No	n/a	n/a
Ravn Camp Lake Withdrawal	Changes in lake volume	No	n/a	n/a
Cockburn Lake Withdrawal	Changes in lake volume	No	n/a	n/a
3 km Lake	Changes in lake volume	No	n/a	n/a
10 km Lake	Changes in lake volume	No	n/a	n/a
Steensby watersheds	Changes in drainage patterns	No	n/a	n/a
Water Quality				
Surface water freshwater quality	Deterioration of surface runoff - negative effects on receiving water quality	No	n/a	n/a
Treated Effluent Quality	Un treated effluent discharge to freshwater lakes or river	No	n/a	n/a
	Contaminated Runoff, Elevated TSS	No	n/a	n/a
	Spills	No	n/a	n/a

Table 9-4.2 Summary of Project Transboundary Effects Assessment – VECs (Cont'd)

VEC	Potential Effect	Transboundary Relevance	Type of Effect	Assessment Approach
Fish & Fish Habitat				
Freshwater fish, fish habitat and other aquatic organisms	Loss of Habitat (all areas within LSA)	No	n/a	n/a
	Movement (all areas within LSA)			
	Mortality (all areas within LSA)			
	Health (all areas within LSA)			
Vegetation		No	n/a	n/a
Caribou	Loss of Habitat	No	n/a	n/a
	Mortality			
	Movement			
	Health			
1) Migratory birds 2) Peregrine falcons 3) Snow geese 4) Common eiders 5) King eiders 6) Red-throated loons 7) Thick billed murres	Direct Habitat Loss	Yes	Cumulative	Subsumed
	Indirect Habitat Loss		Cumulative	Subsumed
	Indirect Habitat Loss		Cumulative	Subsumed
	Indirect Habitat Loss		Cumulative	Subsumed
	Health & Mortality		Cumulative	Subsumed
Marine water and sediment quality	Discharge of runoff	No	n/a	n/a
	Discharge of treated effluent	No	n/a	n/a
	Ship-to-shore spills	No	n/a	n/a
Sea seabed sediments quality	Discharges from Ships	No	n/a	n/a
Invasive Species	Ballast water	Yes	Cumulative	Subsumed
Marine and coastal physical habitat		No	n/a	n/a
Marine fish and invertebrates		No	n/a	n/a
Marine mammals Polar bears, ringed seals, bearded seals, bowhead whales, walrus beluga whales, narwhals	Habitat	Yes	Cumulative	Subsumed
	Movement			
	Mortality			
	Health			

NOTE(S):
1. SUBSUMED = THE TRANSBOUNDARY ASSESSMENT IS INCLUDED WITHIN THE SUBJECT – SPECIFIC EFFECTS ASSESSMENT.

SECTION 5.0 - NAVIGATION OF WATERWAYS

5.1 INTRODUCTION

5.1.1 Purpose

This section assesses the effects of the Project on marine and freshwater navigation as required by federal legislation administered by the Navigable Waters Protection Program (NWPP) of Transport Canada under the *Navigable Waters Protection Act* (NWPA). The scope of the assessment includes any Project infrastructure or activities that directly affect both marine and freshwater waterways within the Nunavut Settlement Area. These waterways include the:

- Proposed northern shipping route corridors through Baffin Bay, Pond Inlet, Eclipse Sound and Milne Inlet;
- Head of Milne Inlet where dock facilities are proposed;
- Stream and river crossings on the Milne Inlet Tote Road alignment (subject to existing approvals under the NWPA);
- Stream, river and lake crossings on the Railway alignment;
- Proposed southern shipping route corridors through Hudson Strait, Foxe Basin and Steensby Inlet; and
- Portion of Steensby Inlet where dock facilities and causeway are proposed.

NIRB (2009) identified the following requirements related to navigation in the Guidelines:

- Potential impacts to the navigability of watercourses from proposed crossings;
- Acknowledge the requirement to provide formal applications to the Navigable Waters Protection Program (NWPP) for works in navigable waters;
- Description of the proposed shipping routes for open-water and year-round operations, navigational aids and other marine traffic using these routes;
- Description of the proposed land-based or sea-based navigational aids at the port sites;
- Potential impacts on local harvesting activities in freezing water seasons by Project shipping, and interference with offshore fisheries/boating in open-water season at both Milne Inlet and Steensby Inlet, as well as on shipping routes;
- Measures to mitigate potential impacts to the safety of persons traveling by snowmobiles, sledges and boats along Project shipping routes; and
- Consider the following source documents including the Navigable Waters Protection Act, (1985), Navigable Waters Bridges Regulations (Transport Canada, 2006b), and Navigable Waters Works Regulations (Transport Canada, 2011).

5.1.2 Relevant Legislation

Construction, operation, maintenance and removal of temporary or permanent Project infrastructure below the high-water mark in the waterways listed above will comply with the NWPA.

The purpose of the NWPA is to protect the public right of navigation in Canadian navigable waters. Navigable waters include all bodies of water with the potential of being navigated by any type of floating vessel for transportation, recreation or commerce**.** The NWPA prohibits the construction of temporary or permanent works in Canadian navigable waters and interference to navigation unless approved by the Minister of Transport or if the works are determined to be minor. Prohibitions include any bridge, boom, dam, wharf, dock, pier, pipe or cable.

Shipping will operate in accordance with two primary legal instruments regulating ship traffic in the Canadian Arctic: the *Canada Shipping Act*, the *Arctic Waters Pollution Prevention Act* and their associated regulations.

5.1.3 NWPA Related Consultation

Transport Canada staff visited the Mary River Project site during the summer of 2008 and provided preliminary feedback concerning the requirements for NWPA approval based on the level of Project design information provided at the time. The Project infrastructure identified as requiring NWPA approval was limited to four crossings along the Milne Inlet Tote Road (CV128, CV217, BG017 and CV223 – shown on Figure 3-2.2 in Volume 3) and the two major crossings along the Railway at the Ravn River and Cockburn Lake (shown on Figure 3-2.4 in Volume 3).

5.2 MILNE PORT

5.2.1 Baseline Conditions

The Government of Nunavut, industrial outposts such as mines, and communities throughout Nunavut use sea-lifts to transport and re-supply goods. Sea-lifts are a vital link for all Nunavut communities and outposts, as they are the most economical means of transporting bulk goods including construction material, vehicles, heavy equipment, housewares and non-perishable items. Sea-lifts most commonly take place in the open-water season (4-5 months per year); though on occasion they take place in winter, when icebreaking activities are required.

Marine transport and shipping data was compiled from INNAV data summarizing marine traffic in Eclipse Sound, Baffin Bay and Milne Inlet from 2002 to 2010 (Table 9-1.1).

The Canadian Coast Guard (CCG) carries out icebreaking to allow commercial vessels to move efficiently and safely through ice-covered waters. The CCG also carries out northern resupply, transporting dry cargo and fuel during the annual resupply of northern settlements and government sites when commercial operators cannot. In addition, the CCG is involved in search and rescue, environmental response to ship-sourced spills and maritime security. The dock at the decommissioned Nanisivik mine is used by the CCG for training purposes.

There is an increasing trend in use of the Northwest Passage by private and commercial vessels. Seven vessels cleared customs in Inuvik in 2009, and eighteen as of September 20, 2010. The increasing trend is largely the result of climate change making the passage more open and accessible. Most of these vessels likely pass through Lancaster Sound into Baffin Bay and do not enter the waters of Eclipse Sound and Pond Inlet.

Based on the available data, marine traffic in the Pond Inlet - Eclipse Sound - Milne Inlet areas consists of community sea-lifts to Pond Inlet, Inuit hunters in small boats, and to lesser extent, Arctic cruises and other tourism activities (often supported by Inuit small craft). Aside from community sea-lift to Pond Inlet, little commercial shipping occurs within these waters.

Figure 4-10.4 (Volume 4) shows the travel route information collected during workshops conducted in Arctic Bay, Clyde River, Hall Beach, Igloolik and Pond Inlet during 2008. These routes are used throughout the year to access hunting and fishing areas, gather carving stone, for other traditional use activities and as highways between communities. Considerable travel by Inuit occurs by snowmobile when the area of Pond Inlet - Eclipse Sound - Milne Inlet is encased in landfast ice. Travel by small craft occurs during the brief open-water season (late July through early October). Inuit hunters access the Milne Inlet beach area for camping and to store boats during hunting trips inland by all-terrain vehicle (ATV). Most of the camping (and beaching of small craft) occurs to the eastern end of the head of Milne Inlet. Phillips Creek, which flows into the head of Milne Inlet, is not normally navigated by Inuit hunters, although they reportedly store boats inside the sand spit at the mouth as a safe harbour before venturing inland.

5.2.2 Proposed Works

A temporary floating dock will be constructed at Milne Port at the location shown on Figure 3-2.1 in Volume 3. The floating dock will be deployed as required to receive fuel and freight deliveries and will be stored on shore during the winter.

At the onset of the Project, much of the construction material and supplies, fuel and mining equipment will be received at Milne Port during the open-water season. Up to 23 resupply vessels will dock at the peak in Year 2 of construction. Vessel docking will be assisted by harbour tugs and lines personnel on the dock, as required.

5.2.3 Potential Effects and Mitigation

Collisions at Sea and Increased Navigation Risk

The marine shipping required for the Project has the potential to affect other ship activity, use by small watercraft and travel routes over ice along the proposed shipping corridors or in association with ship operations in and around Milne Port. The potential effects of marine shipping on navigation include:

- Risk of collision between cargo ships and other commercial marine traffic; and
- Increased navigation risk to small vessels by having to alter their normal course around the cargo ships, or tugs.

Mitigation of these potential effects is best achieved by adopting best industry practices and ensuring compliance with relevant legislation to reduce the risk of collisions. Mitigation to address the potential effects of icebreaking activities on sea ice conditions and travel routes is addressed in Volume 4, Section 10.

The temporary infrastructure required for the Milne Port will temporarily change the existing coastline with the floating dock that extends approximately 200 m from the shoreline when deployed. The port docks and associated land-based infrastructure will make a portion of the beach unavailable for beaching small craft in this area, although the two primary use areas (for camping to the east of the port and for safe harbour/storage of small craft to the west within the mouth of Phillips Creek) will remain available for use.

Interference with Coastline Navigation

The potential effects of port infrastructure and operations on coastline navigation include:

- Increased navigation risk to small vessels by having to alter their normal course around ports;
- Increased navigation risk to small vessels resulting from port induced alterations to current, wind and ice conditions;
- Risk of collision between small vessels and cargo ships and tugs; and
- Risk of collision between small vessels and port infrastructure.

Mitigation of these potential effects is best achieved by adopting best industry practices and undertaking appropriate consultation with user groups to communicate potential risks. Navigation aids are not expected to be required, but might be specified by Transport Canada.

5.3 MILNE INLET TOTE ROAD

5.3.1 Baseline Conditions

The 100 km Milne Inlet Tote Road was upgraded in 2007 and 2008 from a winter road to an all-season road adequate for transporting equipment and ore using 45-t trucks. The upgraded road follows the original 1960s alignment.

The Tote Road passes through the Phillips Creek Valley, an inland travel route for Inuit hunters and people travelling between communities. Most travel occurs in winter by snowmobile, but as described in Section 5.2, some hunters travel up the valley, including along the road, by ATV in summer. No navigation of Phillips Creek or the surrounding waterways is known to occur.

5.3.2 Proposed Works

The Milne Inlet Tote Road was upgraded in 2007 and 2008. No further work is proposed at stream crossings along the road, except for ongoing maintenance.

5.3.3 Potential Effects and Proposed Mitigation

The existing navigable crossings are subject to existing NWPA approvals. No new effects or additional mitigation is proposed.

5.4 RAILWAY

5.4.1 Baseline Conditions

No infrastructure exists where the Railway will be constructed. The waterways at two crossings have been deemed navigable by Transport Canada: the Ravn River crossing at kilometre post 35 (kp-35) and the Cockburn Lake crossing at kp-95 (measured from the Mine Site). The locations are shown on Figure 3-2.4, Volume 3.

Land use studies have suggested that inland travel associated with hunting, and mostly by snowmobile. At the Ravn River crossing, most travel routes are along the length of the river. There is an existing Inuit crossing of the Ravn River (5 km upstream of the proposed Ravn River Bridge), called Iparqak Ford on government topographic maps. This crossing is located near to Pingimajuq Ridge, a historic meeting place of Inuit from Pond Inlet, Clyde River and Igloolik, located several kilometres from the Railway alignment. Pingimajuq Ridge was a feature identified by the Pisiksik Working Group during the Mary River Inuit Knowledge Study. It is not expected that small craft would be used on the Ravn River, a very large river system that eventually drains into the western side of Steensby Inlet.

The Cockburn Lake crossing is on the Cockburn River system that flows into Steensby Inlet at Ikpikitturjuaq Bay, immediately north of Steensby Port. It is thought that Cockburn Lake may be accessible from the coast by smaller boats, although navigation of the Cockburn River system was not identified in the land use portion of the Mary River Inuit Knowledge Study.

The Railway involves a number of encroachments of small lakes and ponds, shown on the plan and profile drawings of the railway in Volume 3, Appendix 3E. The lakes are theoretically navigable since they will support a small craft, but they are generally isolated from each other and from waters that are used for navigation.

5.4.2 Proposed Works

Locations of the large road bridge over the Ravn River is shown on Figure 3-2.6 (Volume 3) and the large Railway bridge on Figure 3-2.7 (Volume 3). Bridge design drawings are provided in Volume 3, Appendix 3E. Both are large structures, with greater than 1.5 m clearance above the Q2 high water mark.

5.4.3 Potential Effects and Proposed Mitigation

Two bridges on the Railway alignment, at Ravn River and Cockburn River, are quite large and are not expected to impede navigation in the unlikely event that a person attempts to navigate these waterways.

Detailed bridge drawings will be formally submitted to Transport Canada for review. Drawings will include the watercourse name and number (if applicable), crossing width, height to the bridge measured from the high water mark, bankfull depth, longitude and latitude.

Temporary closures of watercourses would occur due to potential safety concerns associated with operation of heavy equipment and other construction activities. During these periods, navigability would be limited or prohibited.

5.5 STEENSBY PORT

5.5.1 Baseline Conditions

Steensby Port, though removed from the communities of Igloolik and Hall Beach, is used to a limited degree. Historically, Steensby Inlet was used by Inuit to access inland areas to hunt caribou during summer months.

Contemporary navigation is expected to be limited to local hunting in small craft (up to 6 m). An older cabin located along a sandy section of shoreline at the Port Site is in disrepair and will be compensated for by Baffinland through the Inuit Impact and Benefit Agreement (IIBA). Other land use includes accessing a lake from Ikpikitturjuaq Bay for char fishing.

5.5.2 Proposed Works

A dedicated fleet of icebreaking cape-size ore carriers will transport most of the ore from Steensby Port to market, supplemented by the use of chartered ships during the open-water season. A 150 m by 100 m freight dock, an L-shaped 700 m by 30 m ore loading dock, a 200 m bridge between Baffin Island and a small offshore islet and two temporary docks will be constructed at the Steensby Port (see Figure 3-2.9 in Volume 3). Their combined footprint will cover maximum area of 8 ha. The ore dock will receive an average of 12 ore carriers per month on a year-round basis and up to 17 vessels per month in open-water season, when non-icebreaking ships will be chartered to ship additional ore. The dock has been designed to accommodate cape-size ore loading carriers with a draft of 20 m. Vessel docking will by harbour tugs and lines personnel on the docks.

Design drawings for the ore dock, freight dock, bridge and construction docks are provided in Volume 3, Appendix 3F.

5.5.3 Potential Effects and Proposed Mitigation

Collisions at Sea and Increased Navigation Risk

The marine shipping required for the Project has the potential to affect other ship activity, use by small watercraft, and travel routes over ice along the proposed shipping corridors or in association with ship operations in and around Steensby Port. In addition to large ore carrier ships several other types of vessels are proposed including tugs and other smaller cargo vessels.

The potential effects of marine shipping on navigation include:

- Risk of collision between ore ships and other commercial traffic; and
- Increased navigation risk to small vessels by having to alter their normal course around ore ships, cargo ships or tugs.

Mitigation is best achieved by adopting best industry practices and ensuring compliance with relevant legislation. Mitigation to address the potential effects of icebreaking activities on sea ice conditions and travel routes is addressed in Volume 4, Section 10.

The dock infrastructure required for Steensby Port will change the existing coastline through construction of permanent docks that extend several hundred metres from the shoreline. The docks and land-based infrastructure will make a portion of the beach unavailable for beaching small craft in this area, although the primary use area of Ikpikitturjuaq Bay will remain unaffected. The area where the older cabin is located will no longer be available for use.

Interference with Coastline Navigation

The potential effects of port infrastructure and operations on coastline navigation include:

- Increased navigation risk to small vessels by altering their normal course around ports;
- Increased navigation risk to small vessels resulting from alterations to current, wind and ice conditions;
- Risk of collision between small vessels and ore ships, cargo ships and tugs; and
- Risk of collision between small vessels and port infrastructure.

Mitigation is best achieved by adopting best industry practices and undertaking appropriate consultation with user groups to communicate potential risks. Navigation aids are not expected to be required, but might be specified by Transport Canada.

5.6 POTENTIAL RESIDUAL EFFECTS AND SIGNIFICANCE

The Project requires marine shipping, two ports sites with dock infrastructure, and several large bridges. Coastal waterways are used by small watercraft during the open-water season. There is limited or no current historical use of the inland waterways by watercraft for navigational purposes. In consideration these factors and mitigation, no significant potential adverse residual effects are expected. Any interruption in navigability due to construction or maintenance of bridges or dock infrastructure will be temporary. Bridges constructed over navigable waters will be built with sufficient freeboard to ensure crossings do not impede navigability.

5.7 AUTHORS

The navigability assessment was prepared by Oscar Gustafson, R.P.Bio., and Richard Cook, B.Sc., of Knight Piésold.

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SECTION 7.0 - DEFINITIONS AND ABBREVIATIONS

7.1 GLOSSARY

Access road	A road providing a way into or out of a particular area or site.
Adverse effect	Effects from a new development that could impair or damage the environment. Mitigation is used to reduce or eliminate adverse effects.
Aggregate	Crushed rock from quarries as well as sand and gravel from borrow sources.
Airstrip	A runway without normal air base or airport facilities.
Archaeological site	1. A place that was used by people hundreds or thousands of years ago and where the remains of their existence can still be found. Scientists can study the place and look at the items left behind to learn who the people were and how they lived. 2. Archaeology is the study of past human cultures.
Baseline	1. A line serving as a basis; especially: one of known measure or position used (as in surveying or navigation) to calculate or locate something 2. A usually initial set of critical observations or data used for comparison or a control 3. A starting point.
Beluga whales	A toothed whale (Delphinapterus leucas) of Arctic and sub Arctic waters having a fusiform body that is about 10 to 15 feet (3.0 to 5.0 meters) long and white when mature.
Bowhead whales	A baleen whale (Balaena mysticetus) of Arctic and subArctic seas.
Crusher	A machine for crushing rock or other materials. Used to reduce materials such as ore, coal, stone and slag to particle sizes that are convenient for their intended uses.
Culvert	A drain set at a right angle to cross the long axis of a body, often a large pipe used to allow water to pass under a road.
Cumulative effects	"…the impact on the environment that results from the incremental effects of a development when added to other past, present and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (NIRB, 2009)
Deadweight Tons (DWT)	A long ton used in indicating a ship's gross capacity.
Decommissioning	Closing the mine forever. As the act of permanently closing and removing the production facilities at a mine site.
Deposit	Place where there are enough rich rocks to start a mine. A natural occurrence of a useful mineral, or an ore, in sufficient extent or degree of concentration to invite exploitation.

Deposit No. 1 - Nuluujaak Mountain	Nuluujaak Mountain is also known as Deposit No. 1.
Dock	1. A wharf or platform for the loading or unloading of materials from a ship. 2. A landing place or moorage for boats.
Effect	The outcome or effects from something that has happened. The effects can be good or bad, depending on who or what was involved.
Emissions	Human made waste sent into the air, water or land.
Environmental assessment (used interchangeably with 'environmental effects assessment', see below)	1. An assessment of the effects caused by a development activity such as mining. 2. Looking at a proposed development to make sure there are no bad changes to the land, water, air or living things.
Environmental effect	Any change to the environment, whether bad or helpful, that wholly or partially results from an organisation's activities, products or services.
Environmental impact statement	A document outlining the environmental effects of the project on the environment prepared by the proponent of a project and presented to decision makers and the public.
Environmental Management System (EMS)	An Environmental Management System (EMS) is a framework developed by an organization to help improve its environmental performance by taking environmental considerations into account when making decisions and managing risks.
Environmental monitoring	Testing of the animals, air, soil, water and other things in the environment that happens on a regular basis to see if the environment is being damaged by a specific activity such as oil exploration. Special scientific equipment is used.
Exploration	The whole range of activity from searching for and developing mineral deposits.
Explosives	Any rapidly combustive or expanding substance. The energy released during this rapid combustion or expansion can be used to break rock.
Feasibility	Checking whether something is capable of being done or carried out.
Fresh water	Water found in lakes, rivers and streams that has little salt in it.
Fuel storage	A place or space for storing fuel. Fuel storage often refers to diesel and gasoline storage, which may occur in bulk storage.
Geochemical	Related to the chemicals that make up rocks, minerals, soils, water and the air. "Geo" means Earth. Geochemistry is the study of chemical properties of and chemical changes in rocks and other parts of the Earth.
Harvest	The reduction of wildlife into possession, it includes hunting, trapping, fishing, netting, egging, picking, collecting, gathering, spearing, killing, capturing or taking by any means.

Icebreaker	A ship equipped (as with a reinforced bow) to make and maintain a channel through ice.
Inuit Impact and Benefit Agreement (IIBA)	Contractual agreements under negotiation between the Proponent and Inuit groups. The intent of these agreements is to make it possible to develop the Project in a way that respects Inuit rights and culture, provides socioeconomic benefits to nearby Inuit communities and addresses negative environmental, economic, and social impacts
Incinerator	A furnace or a container for incinerating waste materials.
Infrastructure	Physical improvements to support mining, such as buildings, gas pipes, water lines, sewage and water systems, telephone cables and reservoirs. It may also include roads, railways, airports, bridges and electrical cables.
Iron	A heavy ductile magnetic metallic mineral that is silver-white in pure form but rusts easily.
Marine	Having to do with the ocean and salt water. Marine animals are animals that live in the ocean.
Marine mammal	Mammals that normally spend most of their time in the ocean. Examples are whales, seals and walrus.
Mary River	Nuluujaak Mountain (Deposit #1)
Mary River Project	Name for Baffinland Iron Mines Corporation's iron ore development on Baffin Island.
Metal	1. A solid mineral element that is able to conduct heat and electricity and is pliable under heat or pressure. Common metals include bronze, copper and iron. 2. Most metals are hard and shiny and are mined from the earth. After the rocks containing the metal are crushed, the metal is removed and used to make many different things. There are many kinds of metal. Gold and silver are commonly used to make jewellery; iron and steel are used to build cars and ships; and metals like aluminum are used to make drink cans, aircraft and doors.
Milne Inlet camp and port	The Milne Inlet camp will operate only during the construction phase of the Mary River Project, with a total population of 100 people. It will be connected to the Mary River site by a tote road, on which materials and supplies will travel.
Milne Inlet Tote Road	A road connecting the Mary River site to Milne Inlet that will be used to move materials and supplies. It will be during both the construction and operations phases of the Mary River Project.
Mine	1. Excavation in the earth from which ores and minerals are extracted. 2. A place where they find rich rocks and dig them out of the earth.
Mine life	The length of time a mine is or could be in production.

Mineral	A substance that occurs naturally in the Earth; a substance obtained by mining.
Monitoring	1. To study and measure the level of a substance, or a condition or a situation over a period of time. Monitoring is often used to provide information on wildlife populations so that steps can be taken to reduce or limit the harmful effects of human activity on the animals. 2. Keeping track of changes that are happening to the land, water, air or living things.
No net loss	Replace habitat you take from the fish with new habitat. A term found in Canada's Fisheries Act; it requires fish habitat replacement on a project-by-project basis.1
Nuluujaak	Nuluujaak Mountain (Deposit No. 1)
Oil	1. Any of various thick, viscous, usually inflammable liquids insoluble in water but soluble in organic solvents, obtained from animal, plant or mineral sources. 2. Petroleum. 3. A petroleum derivative, such as a machine oil or lubricant. 4. A substance with an oily consistency. 5. Black liquid from the ground.
Open pit mine	A mine working or excavation open to the surface, used to recover mineral reserves near surface.
Permafrost	Ground that is always frozen.
Permitting process	A process in which an applicant requests and acquires a permit from a regulatory agency.
Potable water	Water suitable for drinking.
Production	1. Bring out of ore by physical effort. 2. Total output especially of a mining industry.
Progressive reclamation	A type of reclamation that is done during the construction and operation phases of a mine prior to final closure.
Project proposal	A written paper that explains why a project should go ahead, when it should start and finish, how it should be done, what will be done, how much it will cost and who will do the work. A proposal is a plan to do something, building a new school for example. The proposal is read by a group of people who will decide whether to allow the project.
Project schedule	A schedule wherein activities are assigned a duration and sequenced in a logical order.
Railway	A permanent road having a line of rails fixed to ties and laid on a roadbed and providing a track for cars or equipment drawn by locomotives or propelled by self-contained motors.
Reclamation	Restoration of disturbed and/or mined land to its original contour, use, or condition. Fixing the land after a development is done there.
Environmental Health and Safety (EHS) Management System	A set of rules, procedures and information flows used to achieve results to satisfy the needs of environmental protection, safety and health.

Sewage	Sewage is made of solid human waste and urine, chemicals and other things normally collected in honey buckets, toilets, or septic tanks. Sewage contains a great deal of organic material.
Ship track	Place in landfast ice where a ship has passed.
Shipping route	Any of the lines of travel followed by merchant sea vessels.
Socio-economic environment	What life is like for the community or person. Includes economic activity, social relations, well-being and culture.
Steel	An alloy of iron, which is mostly pure iron combined with some other elements, such as carbon.
Steensby port	Port site for the Mary River Project that will be connected by a rail line to the Mary River site.
Stockpile	An accumulation of rock gathered or piled in one area.
Surface water	Water on top of the ground.
Sustainable development	Development that helps us now but will not hurt future generations; Where development meets the needs of the present generations without compromising the ability of future generations to meet their own needs.
Terrestrial	Related to the land and not the water. Caribou are terrestrial animals because they live on land; as opposed to fish who live in the water and are aquatic.
Toxicity	1. Related to how toxic or poisonous a substance is to a living thing. 2. The ability for a material to cause adverse effects in a living organism.
Traditional or Inuit knowledge	Aboriginal (including Inuit) knowledge about the people, the land, water, living things and the culture.
Tug boats	A strongly built powerful boat used for towing and pushing barges and assisting larger ships in and out of a dock safely.
Tunnel	A covered passageway; a horizontal passageway through or under an obstruction.
Walrus	A large, gregarious marine mammal of Arctic waters that is related to the seals and has long ivory tusks, a tough wrinkled hide and stiff whiskers and that feeds mainly on bivalve mollusks.
Waste rock	Left over rock after work is done.
Waste water treatment facility	Something that is built, installed, or established to improve the quality of water that has been used (as in a manufacturing process or sewage).

7.2 ABBREVIATIONS

AANDC	Aboriginal Affairs and Northern Development Canada
ACIA	Arctic Climate Impact Assessment
ACP	Arctic Community Packs

ANFO	Ammonium Nitrate Fuel Oil
ATV	All Terrain Vehicle
BIM	Baffinland Iron Mines (Corporation)
BMP	Best Management Practice
CCG	Canadian Coast Guard
CCME	Canadian Council of Ministers for the Environment
CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Agency
DEW	Distant Early Warning
DFO	Department of Fisheries and Oceans
DND	Department of National Defense
DWT	Deadweight Tonnage
EHS	Environmental, Health and Safety
EIS	Environmental Impact Statement
EPP	Environmental Protection Plan
ER	Emergency Response
GHG	Greenhouse Gas
GN	Government of Nunavut
HRMP	Human Resources Management Plan
HTO	Hunters and Trappers' Organization
IATA	International Air Transport Association
IBA	Impacts Benefit Agreement
INNAV	Canadian Coast Guard Marine Communications, Traffic Services Program
IPCC	International Panel on Climate Change
LSA	Local Study Area
MHO	Marine Heavy Oil
MOU	Memorandum of Understanding
MSDS	Material Safety Data Sheet
NAMMCO	Northern Atlantic Marine Mammal Commission
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NGMP	Nunavut General Monitoring Program
NIRB	Nunavut Impact Review Board
NLCA	Nunavut Land Claims Agreement
NLUP	Nunavut Land Use Plan
NOAA	National Oceanic and Atmospheric Administration
NPC	Nunavut Planning Commission
NSA	Nunavut Settlement Area
NTI	Nunavut Tunngvik Incorporated
NWPA	Navigational Waters Protection Act
NWPP	Navigational Waters Protection Program
OHF	Oil Handling Facility
OPEP	Oil Pollution Emergency Plan
PAG	Potentially Acid Generating
PDA	Project Development Area

QIA	Qikiqtani Inuit Association
RCMP	Royal Canadian Mounted Police
RDA	Regional Development Area
RSA	Regional Study Area
SOPEP	Shipboard Oil Pollution Emergency Plan
TSS	Total Suspended Solid(s)
UV	Ultraviolet
VC	Valued Component
VEC	Valued Ecosystem Component
VSEC	Valued Socio-Economic Component
WSF	Water Soluble Fraction
WWTF	Wastewater Treatment Facility
ZOI	Zone of Influence