Gahcho Kué Project

Environmental Impact Statement

Section 7

Key Line of Inquiry: Caribou

December 2010 09-1365-1004

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7 KEY LINE OF INQUIRY: CARIBOU

7.1 INTRODUCTION

7.1.1 Context

This section of the Environmental Impact Statement (EIS) for the Gahcho Kué Project (Project) consists solely of the key line of inquiry on caribou, specifically the barren-ground herds: Bathurst, Ahiak, and Beverly. In the *Terms of Reference for the Gahcho Kué Environmental Impact Statement* (Terms of Reference) issued on October 5, 2007, the Gahcho Kué Panel (2007) identified caribou as the single most valued component (VC) and provided the following rationale for a comprehensive assessment of the Project's impact on caribou:

> *"Caribou numbers decreased sharply in recent years and there seems to be consensus among Aboriginal groups that caribou are in poor health. Caribou are not only an important food source for traditional land users, they play an extremely important role in Aboriginal culture. Impacts on caribou are likely to result in corresponding economic, social, and cultural impacts. Threats to caribou are seen not just from the proposed development alone but cumulatively from all the diamond mines, mineral exploration, and other activities within their range."*

The Key Line of Inquiry: Caribou includes a detailed and comprehensive assessment of all Project effects on barren-ground caribou, including traditional and non-traditional uses of caribou. It also includes the specific effects that changes in caribou abundance and distribution would have on the social, cultural, and economic well-being of residents of the Mackenzie Valley.

All effects on caribou are assessed in detail in the Key Line of Inquiry: Caribou; however, the following subjects of note address issues that may overlap slightly with this key line of inquiry:

- Air Quality (Section 11.4);
- Mine Rock and Processed Kimberlite (Section 11.5);
- Vegetation (Section 11.7);
- Traffic and Road Issues (Section 11.8);
- Waste Management and Wildlife (Section 11.9);
- Climate Change Impacts (Section 11.13);
- Tourism Potential and Wilderness Character (Section 12.7.3);

- Proposed National Park (Section 12.7.4); and
- Culture, Heritage, and Archaeology (Section 12.7.5).

Where there is overlap between this key line of inquiry and a subject of note, information will be provided in both locations as required by the Terms of Reference. Nevertheless, the Key Line of Inquiry: Caribou contains the primary substantive analysis of the effects of the Project on caribou, including effects on the use of caribou.

7.1.2 Purpose and Scope

The purpose of the Key Line of Inquiry: Caribou is to meet the Terms of Reference issued by the Gahcho Kué Panel. The terms for this key line of inquiry are shown in Table 7.1-1. The entire Terms of Reference document is included in Appendix 1.I and the complete table of concordance for the EIS is in Appendix 1.II of Section 1, Introduction of the EIS.

This key line of inquiry includes an assessment of direct and indirect effects on all life stages of caribou herds within the study area. Caribou populations that may interact with the Project (based on overlap with annual home ranges) include the Bathurst, Ahiak, and Beverly herds. This assessment includes potential behavioural changes resulting from Project-related components and associated activities, including sensory disturbance, and effects on foraging, resting, and caribou movements within the study area.

The impact assessment will evaluate all Project phases, including construction (i.e., Kennady Lake dewatering), operation, and closure and reclamation (i.e., refilling and recovery of Kennedy Lake). Project-specific (incremental) and cumulative effects have been incorporated throughout this section. Given the size of the annual home ranges of the caribou herds, the effects from the Project must be considered in combination with other developments, activities, and natural factors that influence caribou within their seasonal ranges.

Information from other components of the EIS, including air quality, water quality, vegetation, and other wildlife, as well as information from existing diamond mines, is incorporated in the impact assessment for caribou. In addition, the potential socio-economic impacts resulting from changes to the caribou herds are summarized. More detailed information on the requirements of the EIS Terms of Reference for this key line of inquiry can be found in Table 7.1-1.

Table 7.1-1 Terms of Reference Pertaining to Caribou

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
3.1.3 Existing Environment: Caribou	Describe each herd and subspecies present, and for each describe:	
	- current population trends, including abundance, distribution, and demographic rates such as calf survival and adult mortality;	7.1.3.2, 7.1.3.3, 7.3.2.1, 7.3.3.1, 7.3.3.2
	- habitat requirements, including identifying areas of specific habitat use at different life stages (e.g., calving grounds, post calving, and summer ranges);	7.1.3.2, 7.3.3.1, 7.3.3.2
	- attributes of the seasonal habitats that relate to how caribou use them (e.g., insect relief, travel routes, forage);	7.3.3.1, 7.3.3.2
	- known population pressures, both natural and anthropogenic; and	7.3.3.2, 7.3.3.3
	- gaps in current knowledge of caribou such as assessing impacts from disturbance, harvesting, behaviour, or abundance.	7.3.3.2, 7.3.3.3
	Describe migratory routes, patterns, and timings in relation to the proposed Project activities including typical patterns and the range of known variation.	7.3.3.2, 7.3.3.1
	Describe traditional harvesting activities in relation to caribou.	7.3.3.3, 7.3.3.4
	Describe traditional values in the context of respect for caribou and how people should behave towards caribou.	7.3.3.3, 7.3.3.4
	Describe any known issues currently affecting caribou in the development area (e.g., contamination of food sources, parasites, disease).	7.3.3.2, 7.5.3.2
3.1.3 Existing Environment: Noise	Describe the existing noise, and for each describe:	
	- existing sources of noise in the project area; and	7.3.3.2
	- present noise in terms of frequency, duration, decibel levels throughout the year.	7.5.3.1, 7.5.3.2
4.1.1 Key Lines of Inquiry: Caribou	General requirements pertaining to caribou include:	
	- The EIS must detail any effects on caribou, as well as their significance and likelihood.	7.5, 7.6
	- The EIS must address how changes to abundance, health, distribution, and behaviour of caribou may affect the social, cultural, and economic well being of residents of the Mackenzie Valley, particularly Aboriginal communities in the regional study area. This must include an evaluation of possible contamination of country foods, and possible impacts on hunting.	7.5.4, 7.6.2, 7.5.5
	- Discrepancies exist between some impact predictions in previous diamond mine assessments and the real or perceived outcomes. The EIS needs to address this by explaining how it incorporated lessons learned. To this end, the developer is required to include a summary of caribou research and caribou related monitoring activities and their results for the potentially affected herds since the first diamond mine was permitted, to the extent that relevant information is publicly available.	7.3.3.2, 7.6, 7.8.2, 7.9

Table 7.1-1 Terms of Reference Pertaining to Caribou (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
4.1.1 Key Lines of Inquiry: Caribou (continued)	- The EIS must outline management options for dealing with impacts on caribou and related socio-economic impacts. For situations where the proposed development is predicted to be only one of many sources of impacts, direct or indirect, that combine in a cumulative manner, the EIS should outline what contributions this development can make to addressing a cumulative problem.	7.6, 7.8.2, 7.4.2
	- Observations from existing diamond mines must be used to establish how far from a mine site caribou show behavioural changes.	7.5, 7.6
	Specific requirements regarding caribou include:	
	- Information on all caribou herds with ranges that include the area of the proposed development, as well as the Tibbitt-to-Contwoyto Winter Road (including population size, demographics, trends, range use patterns, and condition).	7.3.3.1, 7.3.3.2, 7.5.1
	- A description of any life stages (including calving, post calving, overwintering, and migration) during which each herd may interact with the proposed development.	7.5.2, 7.5.3
	- An estimate of the amount (absolute and relative) of habitat loss, change, degradation, or effective habitat loss for each potentially affected herd for various life stages resulting from the development.	7.5.1, 7.5.2, 7.5.3, 7.5.4
	- An estimate of the existing habitat fragmentation at the landscape (seasonal range) and local (site) scale, the expected increase, and its possible effects on each potentially affected caribou herd for various life stages.	7.5.2
	- An analysis of ways the proposed development may influence the energy balance of caribou under different seasonal conditions and to what extent this may affect birth rates and calf survival. The analysis must include potential behavioural changes resulting from development components or associated activities, including sensory disturbance, effects on foraging, resting, and caribou movements within the development area. Moreover, the analysis must be broken down into disturbance from individual components, including construction and operation of the mine, traffic on the access route, as well as air traffic.	7.5.2, 7.5.3, 7.5.4, 7.6
	- The Identification of all possible sources for increased caribou mortality.	7.5, 7.6, 7.3.3.2, 7.4.2.1.2
	- Identification of all hazards to caribou within the development area and access routes, particularly Tibbitt-to-Contwoyto Winter Road crossings, as well as road crossings at the site and hazards that may be posed from mine rock and processed kimberlite containment facilities, materials used to build roads and berms, and the exposed lake bottom (e.g., contact with contaminated or hazardous materials).	7.3.3.2.4, 7.4.2, 7.4.2.1.1, 7.4.2.1.2, 7.7.2

Table 7.1-1 Terms of Reference Pertaining to Caribou (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
4.1.1 Key Lines of Inquiry: Caribou (continued	- The identification of all possible pathways for caribou exposure to contaminants, e.g., from exposure to dust or intake of contaminated forage (e.g. lichens affected by air pollution) or direct intake of tailings, as well as any measures or actions to be taken to minimize exposure. Include a description of any resulting caribou health issues (risk analyses) as well as an evaluation of potential avoidance of caribou as food source by Aboriginal communities.	7.3.3.2, 7.4.2, 7.4.2.1.1, 7.4.2.1.2, 7.5.3.1, 7.5.5.3
	- An identification of all potential changes to the predator-prey relationship of any potentially affected herd and how this may affect the herds.	7.4.2.1.2, 7.3.3.2.4
	- The identification of all components and associated activities of the development (including use of the Tibbitt-to-Contwoyto Winter Road) that may have an effect on caribou, regardless of whether they are in the developer's view significant or not.	7.3.3.2.4, 7.4.2, 7.4.2.1.1, 7.4.2.1.2, 7.5.2, 7.5.3, 7.5.4
	- The identification of all additive, multiplicative, or synergetic effects that may result from the components or activities associated with the proposed development. Determine the overall effect of all components of the development as a whole on caribou.	7.4.2, 7.5.2.2, 7.5.3.2, 7.5.4.2, 7.6
	- A description of any methods used to distinguish between impacts from development and natural variations in caribou numbers, health, or behaviour.	7.5.1, 7.5.4.1.1, 7.5.3.2.2
	- The identification of potential impacts on caribou from sources other than the proposed development, particularly those that may be influenced by the development. This must include an evaluation of any potential development related changes to harvest levels for each potentially affected caribou herd, e.g., by creating an access via the Mackay Lake road into an area previously inaccessible to vehicular traffic. Natural factors that increase the vulnerability of caribou must be considered as well.	7.4.2, 7.4.2.1.2, 7.5.2.1, 7.5.3.1
	- The identification of all cumulative effects of other past, current, or reasonably foreseeable future developments within the range of each potentially affected caribou herd in combination with individual components or activities of the proposed development and its effects on other environmental components, such as predators as well as the overall effect of the proposed development.	7.4.2, 7.5, 7.6
	- An outline of any potential measures or actions to minimize impacts, (e.g., various road bed designs). To the extent possible this should include an evaluation of any proposed mitigation against the measures implemented by previous diamond mine developments and a discussion of the likelihood of success for each measure.	7.4.2
	- An explanation of how any proposed mitigation measures, including plans for progressive reclamation, will contribute to the sustainability of the Bathurst caribou herd as well as other potentially affected herds.	7.4.2

Table 7.1-1 Terms of Reference Pertaining to Caribou (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
4.1.1 Key Lines of Inquiry: Caribou (continued)	- An outline of any adaptive management strategies (i.e., what management response will occur if adverse effects on caribou are detected) for any of the items listed above, as well as any plans for monitoring effects on caribou. Management strategies must be outlined where observed effects may be linked directly or indirectly to the proposed development.	7.4.2
7 (Table 7-1) Wildlife Issues	Remaining wildlife issues pertaining to caribou include:	
	- exposure to contaminants;	7.4.2.1.1, 7.4.2.1.2, 7.4.2, 7.5.2
	- impacts to already vulnerable populations;	7.5.4
	- effects on reproduction;	7.5.3.2, 7.5.4
	- cumulative impacts to population;	7.5.3.2, 7.5.4
	- impacts on caribou behaviour;	7.5.3.2, 7.5.3.1, 7.5.4
	- impacts of hazards on-site;	7.4.2.1.1, 7.4.2.1.2, 7.5.3.2.4
	- impacts on migration; and	7.5.2.2, 7.5.3,7.6.1.1, 7.6.2.1, 7.6.2.2
	- effects of tall waste pile on caribou and their predators.	7.3.3.2.4, 7.4.2
	Remaining wildlife issues pertaining to changing water levels include:	
	- drawdown impacts on habitat;	7.4.2
	- downstream impacts; and	7.4.2
	- wildlife impacts from freeze- and break-up timing changes.	7.4.2
	Remaining general wildlife issues include:	
	- waste management impacts.	7.3.3.2.4, 7.4.2

Table 7.1-1 Terms of Reference Pertaining to Caribou (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
3.2.7 Follow-up Programs	The EIS must include a description of any follow up programs, contingency plans, or adaptive management programs the developer proposes to employ before, during, and after the proposed development, for the purpose of recognizing and managing unpredicted problems. The EIS must explain how the developer proposes to verify impact predictions. The impact statement must also describe what alternative measures will be used in cases were a proposed mitigation measure does not produce the anticipated result.	7.10, Appendix 7.I
	The EIS must provide a review of relevant research, monitoring and follow up activities since the first diamond mine was permitted in the Slave Geological Province to the extent that the relevant information is publicly available. This review must focus on the verification of impact predictions and the effectiveness of mitigation measures proposed in previous diamond mine environmental impact assessments. In particular the developer must make every reasonable effort to verify and evaluate the effectiveness of any proposed mitigation measures that have been used, or are similar to those used at other diamond mining projects in the Mackenzie Valley.	7.3.3.2, 7.6, 7.8.2, 7.9
	The EIS must include a proposal of how monitoring activities at the Gahcho Kué diamond mine can be coordinated with monitoring programs at all other diamond mines in the Slave Geological Province to facilitate cumulative impact monitoring and management. This proposal must also consider reporting mechanisms that could inform future environmental assessments or impact reviews. The developer is not expected to design and set up an entire regional monitoring system, but is expected to describe its views on a potential system. The developer must also state its views on the separation between developer and government responsibilities.	7.10, Appendix 7.I

EIS = environmental impact statement.

7.1.3 Study Areas

7.1.3.1 General Location

The Project is situated north of the eastern arm of Great Slave Lake in the Northwest Territories (NWT) at Longitude 63° 26' North and Latitude 109° 12' West. The Project site is about 140 kilometres (km) northeast of the nearest community, Łutselk'e, and 280 km northeast of Yellowknife (Figure 7.1-1).

7.1.3.2 Study Area Selection

To assess the potential effects of the Project on caribou, it is necessary to define appropriate spatial boundaries. The study area for this key line of inquiry was identified in the Terms of Reference (Gahcho Kué Panel 2007) as follows:

> *"For potential impacts on caribou the geographical scope includes the potentially affected portion of the range of any herd that may be affected, including but not restricted to the vicinity of the mine site, the access road from Mackay Lake, and the Tibbitt to Contwoyto Road up to the start of the access road at Mackay Lake."*

For the Key Line of Inquiry: Caribou, the annual home range of each herd was used to define the study area for assessing effects from the Project. Using the annual home ranges to define study areas is appropriate because they include all of the natural factors, and human activities and developments that can produce cumulative effects on each caribou herd. Thus, the geographical scope of the study area for the Bathurst, Ahiak, and Beverly caribou herds goes beyond the requirements in the Terms of Reference. The intent was to capture the maximum spatial extent of effects from the Project and other developments on the potential affected caribou populations. In addition, the number and type of developments and activities varies among caribou populations.

For example, the Bathurst caribou annual home range includes the Project, four existing diamond mines (Snap Lake, Diavik, Ekati, and Jericho), and the Tibbitt-to-Contwoyto Winter Road (Figure 7.1-2). Several communities in the NWT are also within the Bathurst annual home range (e.g., Łutselk'e, Yellowknife, Behchokǫ̀, Whatì, Wekweètì, and Gamètì). The annual home range of the Ahiak herd includes the Project, three operating diamond mines (i.e., excludes Jericho), part of the Tibbitt-to-Contwoyto Winter Road, and is adjacent to the communities of Łutselk'e and Wekweètì (Figure 7.1-3). In contrast, the Beverly herd annual home range is adjacent to the Project and Łutselk'e, and does not overlap the four existing diamond mines or the Tibbitt-to-Contwoyto Winter Road (Figure 7.1-4).

LEGEND

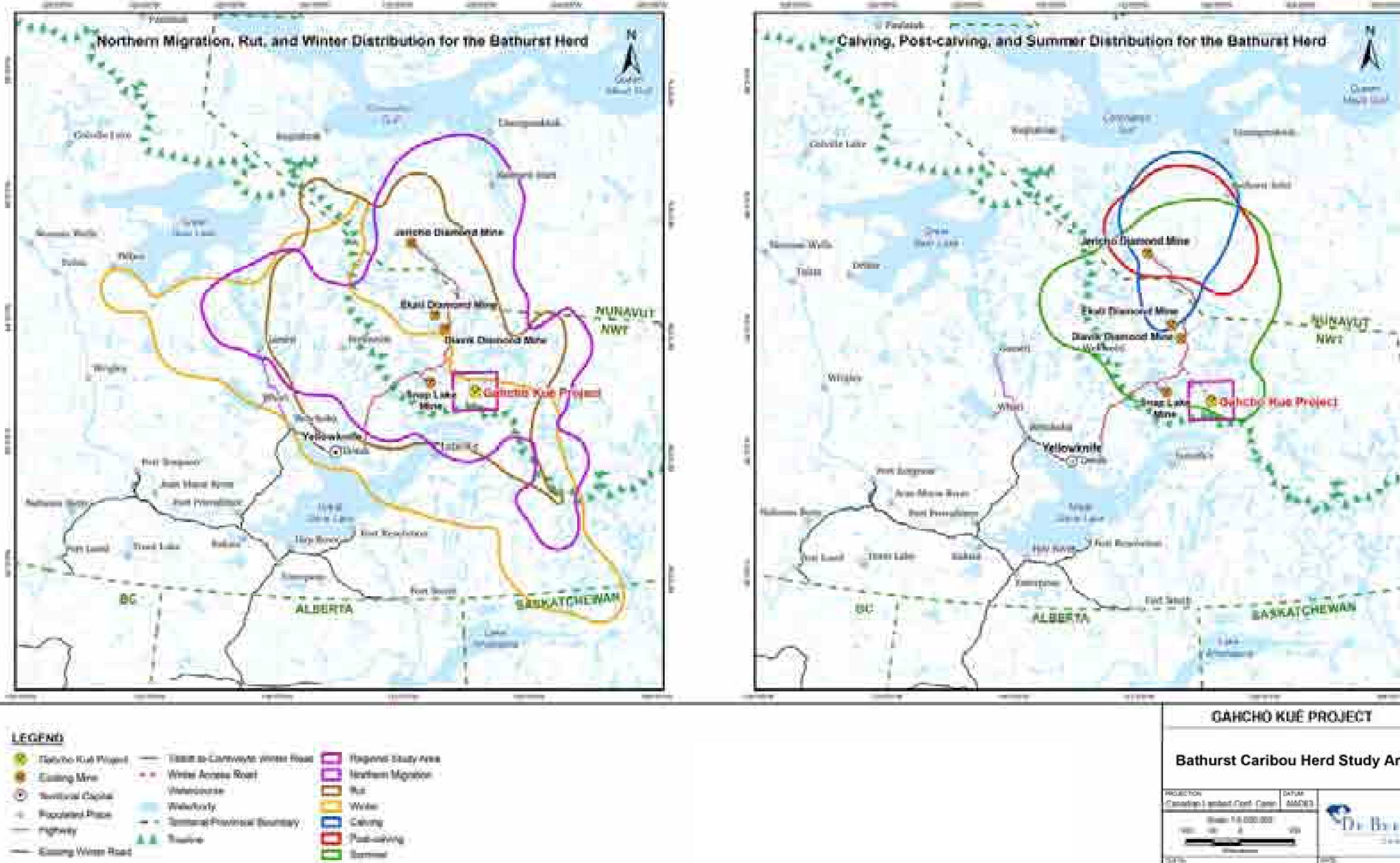
- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Location of the Gahcho Kué Project

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
FILE NO: B-Heritage-001-GIS		DATE: September 20, 2010
JOB NO: 09-1365-1004	REVISION NO: 0	**Figure 7.1-1**
OFFICE: GOLD-CAL	DRAWN: CW	CHECK: JB



NOTES
Base data source: The Atlas of Canada
Environment and Natural Resources, Government of Northwest Territories, 2007

GAHCHO KUÉ PROJECT

Bathurst Caribou Herd Study Area

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:8,000,000			
KLOI-07-054-GIS		DATE: December 7, 2010	
JOB NO: 09-1365-1004	REVISION NO: 0		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 7.1-2

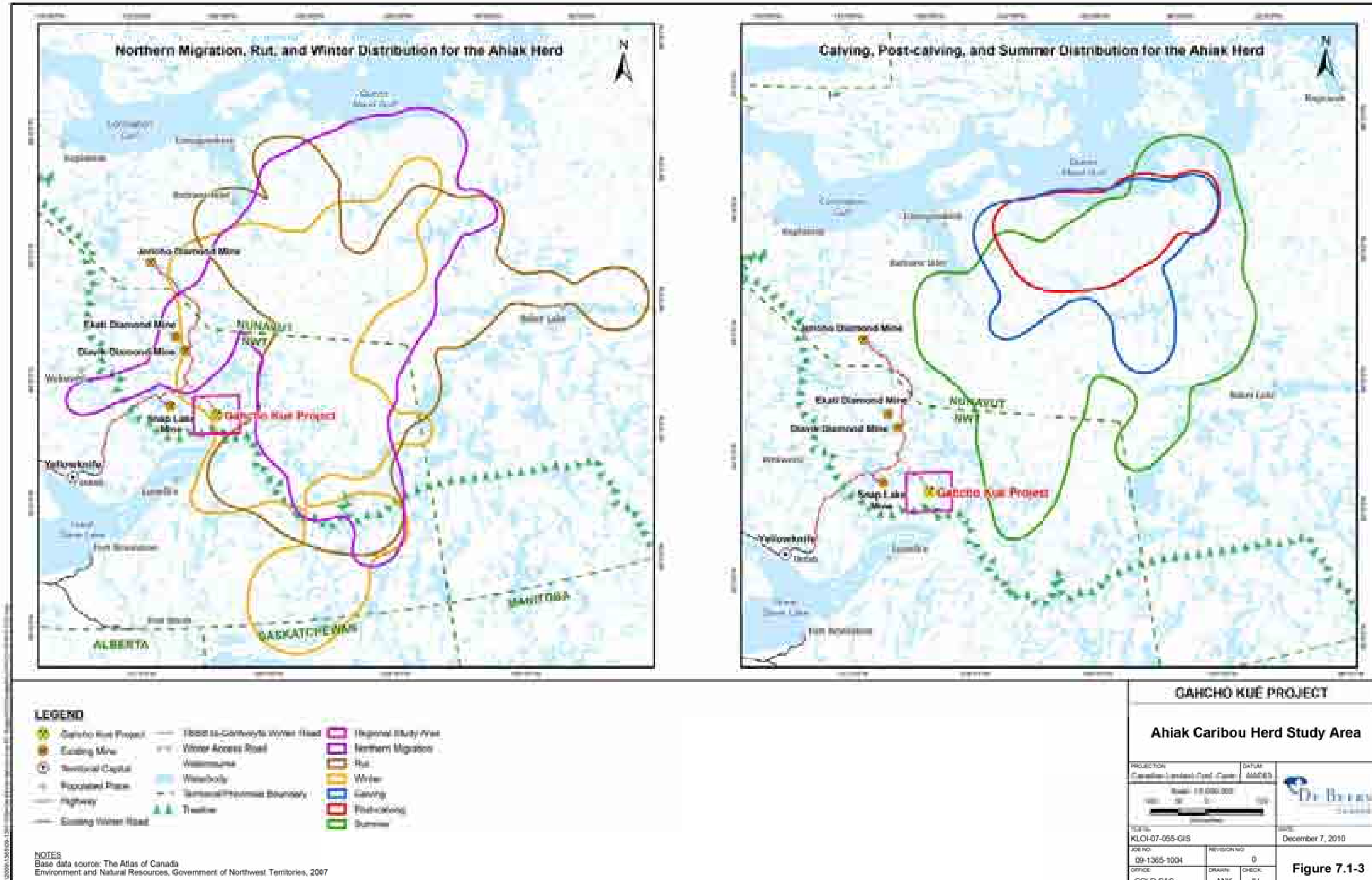
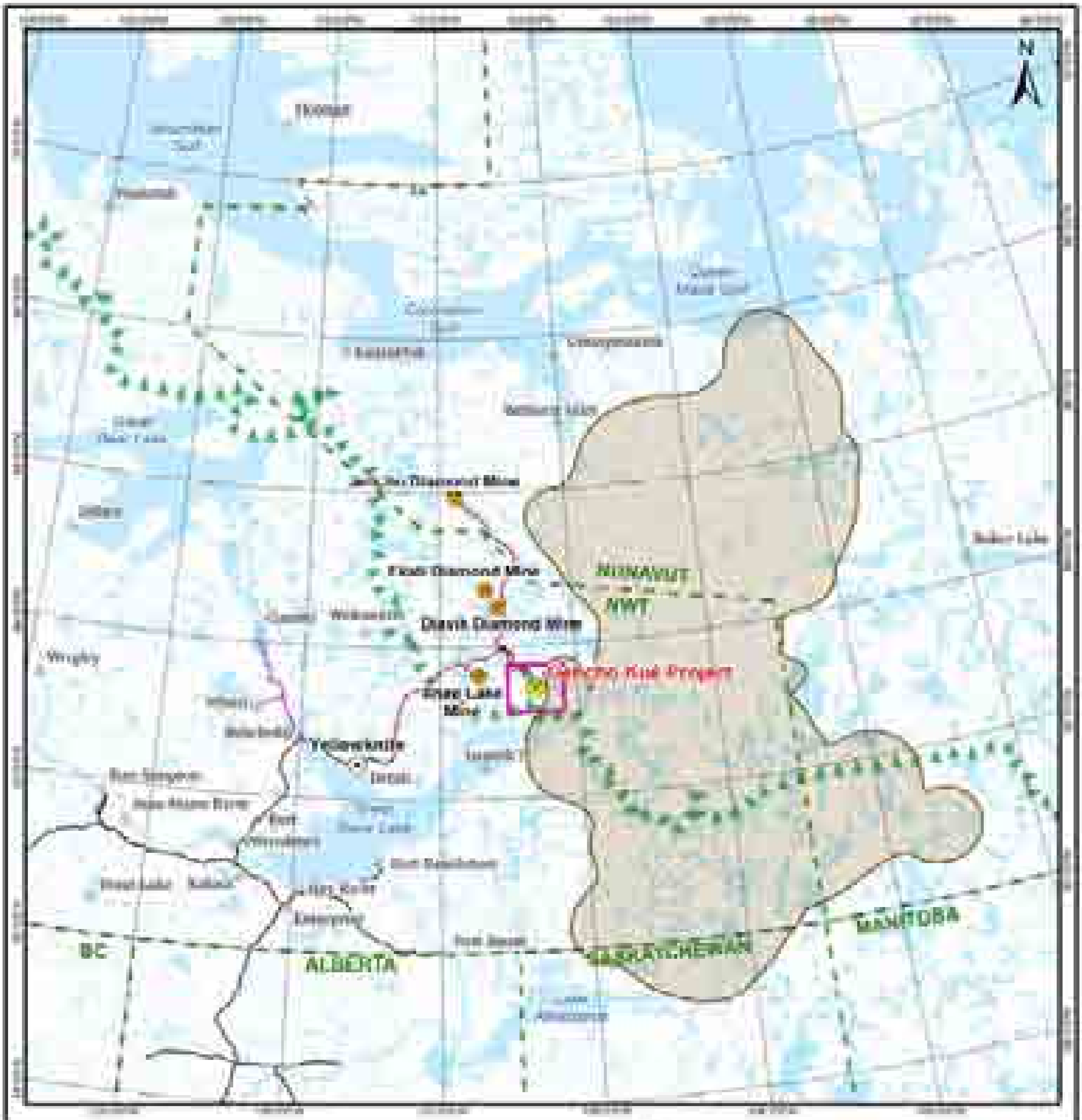

Northern Migration, Rut, and Winter Distribution for the Ahiak Herd
N
Jericho Diamond Mine
Ekati Diamond Mine
Diavik Diamond Mine
NUNAVUT
NWT
Gahcho Kué Project
Snap Lake Mine
Yellowknife
MANITOBA
SASKATCHEWAN
ALBERTA
Calving, Post-calving, and Summer Distribution for the Ahiak Herd
N
Jericho Diamond Mine
Ekati Diamond Mine
Diavik Diamond Mine
NUNAVUT
NWT
Snap Lake Mine
Gahcho Kué Project
Yellowknife
LEGEND
Existing Mine
Territorial Capital
Populated Place
Highway
Existing Winter Road
Winter Access Road
Watercourse
Waterbody
Territorial/Provincial Boundary
Treeline
Regional Study Area
Northern Migration
Rut
Winter
Calving
Post-calving
Summer
NOTES
Base data source: The Atlas of Canada
Environment and Natural Resources, Government of Northwest Territories, 2007
GAHCHO KUÉ PROJECT
Ahiak Caribou Herd Study Area
PROJECTION
DATUM
NAD83
KLOI-07-055-GIS
DATE
December 7, 2010
JOB NO.
09-1365-1004
REVISION NO.
0
OFFICE
GOLD-SAS
DRAWN
ANK
CHECK
JV

Figure 7.1-3



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt to Contwoyto Winter Road
- Winter Access Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Beverly Caribou Herd Study Area
- Regional Study Area

NOTES
Base data source: The Atlas of Canada
Derived from GNWT – ENR data

GAHCHO KUÉ PROJECT

Beverly Caribou Herd Study Area

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
TITLE No	KLOI-07-004-GIS
DATE	November 23, 2010
JOB NO	09-1365-1004
REVISION NO	4
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure: 7.1-4

Natural factors such as predation, insects, traditional and non-traditional harvesting, and habitat can also vary across the annual home ranges of the caribou herds. Thus, the annual home range provides an ecologically relevant spatial scale to assess the effects from the Project, other developments, and natural factors on caribou populations.

7.1.3.3 Caribou Study Area

The following annual home range of each herd was used to define the Caribou Study Area for assessing effects of the Project to each caribou population:

- annual home range of the Bathurst herd (309,000 square kilometres [km^2]) (Figure 7.1-2);
- annual home range of the Ahiak herd (345,000 km^2) (Figure 7.1-3); and
- annual home range of the Beverly herd (282,000 km^2) (Figure 7.1-4).

The annual (and seasonal) range(s) for each caribou herd were calculated using satellite collar data (courtesy of Government of Northwest Territories (GNWT) Department of the Environment and Natural Resources [ENR],) and a 95 percent (%) kernel density (i.e., probability density) estimate. Range estimates for the Bathurst herd included satellite locations from January 1996 through October 2007. Estimates for the Ahiak and Beverly herds were generated from data collected from January 2001 through October 2007, and from January 1995 through October 2007, respectively.

7.1.4 Content

There are two main components to this key line of inquiry. It begins with Section 7.2, Summary, which provides an overall picture of caribou in the context of the Project and summarizes the results of this key line of inquiry, using language for a broader audience. It emphasizes the way that Project activities cause changes (e.g., noise, dust) that may lead to biological and socio-economic effects.

This summary is followed by details of the effects analysis and assessment related to caribou. The headings that follow the Summary are arranged according to the sequence of steps in the assessment. The following briefly describes the content under each heading of this key line of inquiry.

- **Existing Environment** summarizes baseline information on caribou herds with annual or seasonal home ranges that may overlap with the Project beginning with the general environmental setting in which the

Project occurs, followed by methods used to collect baseline data, and the baseline results for caribou (Section 7.3).

- **Pathway Analysis** identifies all potential pathways by which the Project could affect caribou and traditional and non-traditional uses of caribou, and provides a screening level assessment of each pathway after applying environmental design features and mitigation that reduce or eliminate Project-related effects (Section 7.4).
- **Effects on the Caribou Population** presents the methods and results of the analysis of effects from the Project, and other human developments and activities (e.g., harvesting) and natural factors on caribou population size and distribution, including effects from changes in habitat quantity and quality, behaviour and movement, and survival and reproduction (Section 7.5).
- **Related Effects on People** presents the results of the analysis of effects on people that flow from effects of the Project on caribou, including access to caribou, availability of caribou, and effects on human health (Section 7.5).
- **Residual Effects Summary** summarizes the effects on caribou and people that are predicted to remain after all environmental design features and mitigation to eliminate or reduce negative effects have been incorporated into the Project design (Section 7.6).
- **Residual Impact Classification** describes methods used to classify residual effects, and summarizes the classification results.
- **Environmental Significance** considers the overall impact from the Project, and other human developments and activities, and the environmental significance of the impact on caribou (Section 7.8).
- **Uncertainty** discusses sources of uncertainty surrounding the predictions of impacts to caribou (Section 7.9).
- **Monitoring and Follow-up** describes recommended monitoring programs, contingency plans, or adaptive management strategies related to caribou (Section 7.10).
- **References** lists all documents and other material used in the preparation of this chapter (Section 7.11).
- **Glossary, Abbreviations, Acronyms, and Units** explains the meaning of scientific, technical, or other uncommon terms used in this chapter. In addition, acronyms, abbreviations, and abbreviated units are defined (Section 7.12).

7.2 SUMMARY

The proposed Gahcho Kué Project (Project) is a diamond mine located at Kennady Lake, a headwater lake of the Lockhart River watershed in the NWT. Kennady Lake is about 280 km northeast of Yellowknife, and 140 km northeast of the Dene Community of Łutselk'e on the eastern arm of Great Slave Lake. The Project is 84 km east of the Snap Lake Mine, the only other active mine in the Lockhart River watershed. The Diavik Diamond Mine and Ekati Diamond Mine are located about 127 and 158 km northeast of Kennady Lake, respectively, in the Coppermine River watershed.

This section of the Environmental Impact Statement (EIS) addresses the Projects predicted direct and indirect effects on all life stages of caribou within their seasonal ranges, specifically the barren-ground Bathurst, Ahiak, and Beverly herds. It includes an assessment of potential behavioural changes resulting from Project-related components and associated activities, including sensory disturbance, and effects on foraging, resting, and caribou movements within the seasonal ranges. It also includes the specific effects that changes in caribou abundance and distribution would have on the social, cultural, and economic well-being of residents of the Mackenzie Valley.

The impact assessment evaluates all Project phases, including construction (i.e., Kennady Lake dewatering), operation, and closure and reclamation (i.e., refilling and recovery of Kennedy Lake). Project-specific (incremental) and cumulative effects have been incorporated throughout this section. Given the size of the annual ranges of the three caribou herds, the effects from the Project must be considered in combination with other developments, activities, and natural factors that influence caribou within their seasonal ranges. The annual home range of the Ahiak herd is about 345,000 square kilometres (km^2), the Bathurst herd range is 309,000 km^2, and the Beverly herd home range is 282,000 km^2. Within these overlapping ranges are located four existing diamond mines (Snap Lake, Diavik, Ekati, and Jericho), and the Tibbitt-to-Contwoyto Winter Road. Several communities in the NWT are also located within the overlapping annual ranges (e.g., Łutselk'e, Yellowknife, Behchokǫ̀, Whatì, Wekweètì, and Gamètì).

The migratory movements of the three caribou herds can extend over much of the NWT, Nunavut, and northern Saskatchewan, where many communities rely on caribou as an important natural resource. Satellite collar data from 1996 to 2009 showed that of the barren-ground caribou herds, the Bathurst herd has the greatest likelihood of interacting with the Project, followed by the Ahiak herd. The likelihood of large numbers of animals from the Beverly herd interacting with the Project was predicted to be too low to have detectable effects on the herd. Much of what is currently known of the population ecology of caribou in NWT is based on research on the Bathurst herd. Potential effects predicted for the Bathurst herd were anticipated to be representative and provide conservative estimates of effects for the adjacent, more easterly distributed Ahiak herd.

Barren-ground caribou have an important social, cultural, and economic value for the people and communities living in the Canadian Arctic. Aboriginal people have a strong connection with caribou, and rely on the animals for food, clothing, and cultural wellness. Caribou also influence the landscape through their movements and foraging, and provide food resources for predators and scavengers such as wolves, grizzly bears, wolverines, and foxes. The Bathurst, Ahiak, and Beverly herds are currently listed as *sensitive* by the Working Group on General Status of NWT Species; however, they are not listed federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Historic movements (or migrations) of barren-ground caribou were identified based on trails that scar the landscape. Landscape scarring indicative of historic caribou water crossing was documented near both Kennady Lake and Lake N16 in the Local Study Area (LSA). Although it was not possible to determine how frequently caribou preferred to use these crossings, their presence suggests that large numbers of caribou moved through the LSA in the past.

The Project is located in the midst of a broad area through which caribou migrate northward in spring and southward in fall. Barren-ground caribou generally first appear near the Project area in late April and early May, and depending on the year, are present in widely varying numbers during the summer herd dispersal period. The timing of fall movements towards wintering grounds also varied among years; however, field surveys completed from 1999 to 2005 indicated that caribou were usually present in the area in late September or early October. The Project is not located near the calving grounds of the Bathurst, Beverly, or Ahiak caribou herds.

Pathway analysis identified and assessed the issues and linkages between caribou and the Project components and activities. It was determined that five pathways were likely or highly likely to lead to negative residual effects on caribou and human use of caribou:

- direct loss and fragmentation of habitat from the physical footprint may alter caribou movement and behaviour.
- winter road footprint decreases habitat quantity and may cause fragmentation, which can alter caribou movement and behaviour.
- dust deposition may cover vegetation and change the amount of different quality habitat, and alter caribou movement and behaviour.

- sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats around developments, and alters movement and behaviour, which can influence survival and reproduction.
- vehicles on the Winter Access Road and Tibbitt-to-Contwoyto Winter Road changes the amount of different quality habitats, and alters movement and behaviour, which can influence survival and reproduction.

The total area of the Project footprint (comprised of mine and infrastructure [853 ha], and adjacent unaltered shallow and deep waters [382]), is estimated to be 1,235 ha; this footprint area represents 4.4% of the baseline Local Study Area (LSA). Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA. All other habitat types decreased less than 0.4% relative to their abundance in the LSA.

Comparison of 2010 baseline and predicted Project landscapes indicated that habitat-specific incremental changes from the Project footprint were less than 0.1% per seasonal range (i.e., spring and fall migration areas, and winter and summer ranges) for the Bathurst and Ahiak herds. For many habitats, the local change from the Project relative to the seasonal range of the herd was so small that it was not measurable (i.e., <0.01%). For other habitats, the decrease in availability ranged from 0.01% to 0.1%. The cumulative decrease in the area of habitats within caribou seasonal ranges from reference conditions to future landscapes was estimated to be less than 0.4% for any given habitat (excluding burns).

For the Bathurst and Ahiak herds, the cumulative direct disturbance to each seasonal range from the Project and other previous, existing and future developments in the area is predicted to be less than or equal to 1.7% relative to reference conditions. This change is well below the 40% threshold value identified by numerous studies for habitat loss as being associated with declines in bird and mammal species. Research has shown that when disturbance cover exceeds 40%, the configuration of the landscape can change and the influences of habitat fragmentation on populations of wildlife become apparent.

The pathways for effects from changes in habitat quality, movement, and behaviour include influences from dust deposition, noise, and the presence of vehicles and Project infrastructure. Sources of dust deposition can include blasting activities, haul roads, the processing plant, activities at mine pits, waste rock and processed kimberlite piles, and vehicle traffic along the Winter Access Road. Air quality modelling predicts that most Project-related dust deposition is associated with the mine pits and haul roads, but that the maximum predicted dust deposition rate would occur within 100 m of the Project footprint. Noise will be generated by mobile and stationary mining equipment, blasting, and aircraft. In general, it is predicted that noise attenuation to background levels will occur at distances about 3.5 km from the mining operation.

The combination of direct (physical footprint) and indirect (noise, dust, and other sensory disturbances) effects can create a zone of influence (ZOI) around a mine site that can change the behaviour and occurrence of caribou. Studies around some of the nearby established diamond mines have shown that caribou are more likely to occur further from the mine than closer to it. The ZOI varies in size among mines and between years, but appears to range from about 10 km to 30 km from a mine site. The ZOI appears to be larger for mines with a large footprint and higher levels of activity, and smaller for smaller mines. The ZOI for the Project is predicted to be about 15 km around the Project.

In addition, incremental local and regional effects from the Project, roads and other developments can accumulate together to influence the quality of available habitat and the number of animals that the landscape can support (i.e., carrying capacity). Models showed that the majority of preferred habitats (i.e., good and high quality habitats) lost to development occurred prior to 2000, and that cumulative effects peaked in 2006. In 2006, 7.3% or less of preferred habitats per seasonal home range of Bathurst caribou was affected by development when compared to pre-disturbance (reference) conditions. As a result of a decline in the number of active exploration sites on the landscape the area of preferred habitats increased from 2006 to 2010 (up to 3.3% gain). Cumulative changes from reference conditions through to a scenario with the Project and Taltson Hydroelectric Expansion Project were similar to changes observed for the time period prior to 2006. Similar trends were observed for preferred habitats per Ahiak seasonal range. Analyses showed that cumulative impacts on habitat were low in magnitude.

During the two-year construction period, up to 25 trucks are anticipated to be on the Winter Access Road in a 24 hour period (1,500 to 2,000 trucks per year per 12 week period). Traffic is anticipated to decrease to 14 trucks and three trucks per 24 hour period on the Winter Access Road during operations and initial closure (two year period), respectively. Analysis of predicted sound levels show that while noise will be generated along the Winter Access Road, the expected levels are within relevant criteria established for remote areas. This change in habitat suitability is periodic as winter roads are in operation for an average of eight to 12 weeks each year. Noise from the Winter Access Road is predicted to diminish to background levels within 3 km, based on traffic volume during the construction period, and within 500 m during the operation phase. Although there is potential for trucks passing by a location along the Winter Access Road to alter caribou movement and behaviour, the potential effects will be limited to the seasonal use of the Winter Access Road, and should be within the range of baseline conditions.

Another objective of the effects analysis was to assess the ‘energy’ implications of cumulative encounters with developments during the post-calving and rut seasons on autumn body weight in female caribou, and ultimately, on their fecundity. Fecundity is defined as the likelihood of a female becoming pregnant and successfully producing a calf in spring. Based on the previously published literature, it was determined that one disturbance event (i.e., one encounter with a ZOI) could excite an animal and result in the expenditure of 47 grams of stored energy reserves (or 575 milliJoules), whereas one day of intense insect harassment could result in weight loss of 148 grams. For a summer with average insect harassment levels, almost 500 disturbance events would be required before a female lost sufficient weight to result in failed reproduction the following year. However, a spatial examination of satellite collar data and caribou paths from 1996 to 2009 showed that caribou encounter relatively few ZOIs during summer and fall movements. With the application of the Project and reasonably foreseeable developments to the present landscape, a typical caribou may encounter approximately 19 disturbance events during summer to fall movements (which can be over 1,000 km in total length).

The combined influences of the stressors of habitat loss and energetic costs were added to population models that considered the historically wide swings in numbers (cycles) of caribou described in traditional knowledge (TK) and previously completed scientific studies. Models projected population sizes over 30-year simulations and showed that cumulative impacts may be moderate in magnitude. Population projections were reduced by 12.2% with the application of the Project, and previous, existing and reasonably foreseeable developments relative to reference conditions. Most of this impact may be related to changes in behaviour and reductions in calf production through sensory disturbance from human development. Population models showed that the incremental effects from the Project and a potential future project (Taltson Hydroelectric Expansion Project) decreased abundance projections by only 1.5%. Hunting pressure and insect harassment that result in changes to survival and fecundity rates had stronger effects on the likelihood of persistence of the caribou herd.

The Winter Access Road and the Tibbitt-to-Contwoyto Winter Road may increase access to caribou when the winter roads are in operation (approximately eight to 12 weeks each year). De Beers will have a no firearms and no hunting policy for staff and contractors on-site. Thus, during the winter road season, people at site will not benefit from increased access to the region for the harvesting of caribou.

The number of caribou harvested in the region from improved access due to the Winter Access Road for the Project is predicted to be within the range of current baseline conditions.

The duration of incremental and cumulative impacts from the Project on caribou populations and distribution, and traditional and non-traditional use of caribou for the majority of pathways is anticipated to be reversible over the long term (27 to 32 years [approximately two caribou life spans]). The duration of impacts associated with the Winter Access Road is expected to be reversible within the medium term (five years after initial closure). Direct disturbance to habitats within the development footprint are expected to be irreversible within the temporal boundary of the assessment. There is a moderate degree of uncertainty associated with these predictions, which is primarily related to the duration of impacts and the variability inherent to long-term predictions in ecological systems. Confidence in the predictions is based on the consistent low effect sizes (i.e., magnitudes of change) that were determined from the incremental and cumulative effects analyses for habitat quantity and quality, energetics, vital rates, and population trajectories.

The weight of evidence from the analysis of the primary pathways predicts that the incremental and cumulative impacts from the Project and other developments should not have a significant negative influence on the resilience and persistence of caribou populations. Most of the incremental and cumulative impacts were predicted to be negligible to low in magnitude and reversible. The persistence of caribou herds during large fluctuations in population size indicates that the species has the capability to adapt to different disturbances and environmental selection pressures. Migration routes, and survival and reproduction rates appear to have the flexibility to respond to changes through time and across the landscape. This resilience in caribou populations suggests that the impacts from the Project and other developments should be reversible and not significantly affect the future persistence of caribou populations. Subsequently, cumulative impacts from development also are not predicted to have a significant adverse affect on continued opportunities for use of caribou by people that value the animals as part of their culture and livelihood.

7.3 EXISTING ENVIRONMENT

7.3.1 General Setting

The Project is located at Kennady Lake (63^{o} 26’ North; 109^{o} 12’ West), a headwater lake of the Lockhart River watershed in the NWT. Kennady Lake is about 280 km northeast of Yellowknife, and 140 km northeast of the Dene Community of Łutselk’e on the eastern arm of Great Slave Lake. The Project is 84 km east of the Snap Lake Mine, the only other active mine in the Lockhart River watershed. The Diavik Diamond Mine and Ekati Diamond Mine are located about 127 and 158 km northeast of Kennady Lake, respectively, in the Coppermine River watershed.

The Regional Study Area (RSA) (Figure 7.3-1), approximately 5,700 km^2 in size, was defined to capture the regional-scale direct and indirect effects of the Project on VCs or populations with wide distributions. The Project is within the transition zone between the tundra and the treeline, and species that are characteristic of both ecozones may occur within the RSA. Shrubs of willow and birch occur in drainages, and in some areas may reach over 2 metres (m) in height. Heath tundra covers most upland areas, and conifer stands occur in patchy distribution above the treeline, in lowland sheltered areas, and riparian habitats. Conifer stands are found within the RSA as far north as Kirk Lake. An extensive esker system (linear structures of loose sand and gravel, formed by glacial rivers) stretches from Margaret Lake in the northwest, across the northern portion of the RSA, and beyond the eastern boundary. Numerous smaller esker complexes and glaciofluvial deposits such as kames and drumlins are scattered throughout the RSA. Habitat types within the RSA were based on the broad-scale Ecological Landscape Classification (ELC) developed by Matthews et al. (2001) for the Slave Geological Province (SGP) (Section 11.7).

The Local Study Area (LSA) encompasses the Project, which includes the proposed development of the anticipated core Project footprint, the airstrip, roads and related infrastructure. The LSA is approximately 200 km^2, centred on Kennady Lake. The LSA was designed to assess direct effects from the Project footprint (e.g., habitat loss) and small-scale indirect effects on individuals from Project activities (e.g., changes in forage quality resulting from dust deposition). The LSA contains habitat that is characteristic of regional habitat conditions; however, the terrain is less varied within the LSA compared to the RSA. The LSA habitat is characterized primarily by low relief with rolling hills, boulder fields, and a few bedrock outcrops. The dominant waterbodies are Kennady Lake, Lake N16, and Lake X6. Water covers 20% to 30% of the LSA, and a major esker complex stretches across the southern portion. Small conifer stands are located in the southern portion of the LSA. Habitat types within the LSA were based on the broad-scale ELC developed by Matthews et al. (2001) for the SGP and finer-scale ecosystem units (Section 11.7).

The Project is accessed in the winter by a 120-km-long Winter Access Road that extends from the Tibbitt-to-Contwoyto Winter Road at MacKay Lake, northwest of the RSA boundary, to Kennady Lake. The Winter Access Road to Kennady Lake crosses Reid, Munn, Margaret, and Murdock lakes as well as several smaller lakes and streams. Northwest of the RSA boundary, habitat conditions along the Winter Access Road resemble the undulating terrain of the tundra. Within a 6 km right-of-way (corridor) along the Winter Access Road, water covers about 37% of the corridor area (approximate corridor area = 700 km^2). Within a 2 km corridor, about 48% of the Winter Access Road is comprised of water (approximate corridor area = 238 km^2). Rocky terrain is less common farther north along this route and a few small esker systems are present. The tundra landscape along the Winter Access Road is characterized by low-growing vegetation such as lichens, mosses, and stunted shrubs. Closer to Munn Lake and Margaret Lake, the habitat becomes more varied with extensive boulder fields, steep cliffs, and esker complexes.

Baseline studies on wildlife species and wildlife habitat were completed in the RSA, LSA, and along the proposed Winter Access Road from 1996 to 2007 (Annex F, Wildlife Baseline). Additional studies on caribou were completed in 2010 (Annex F, Addendum FF). Ground and aerial surveys were designed to provide estimates of the natural variation in wildlife presence, abundance, distribution, and movement within the RSA, LSA, and along the Winter Access Road. The section below summarizes the baseline data collected on barren-ground caribou.

7.3.2 Methods

7.3.2.1 Gahcho Kué Project Baseline Study

Barren-ground caribou have an important social, cultural, and economic value for the people and communities living in the Canadian Arctic. Aboriginal people have a strong connection with caribou, and rely on the animals for food, clothing, and cultural wellness. Caribou also influence the landscape through their movements and foraging, and provide food resources for predators and scavengers such as wolves, grizzly bears, wolverines, and foxes. As a result, the Bathurst, Ahiak, and Beverly herds are listed as *sensitive* (Working Group on General Status of NWT Species 2006). The Bathurst, Ahiak, and Beverly herds are not listed federally (COSEWIC 2009 internet site).

LEGEND

- Gahcho Kué Project
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Survey Transect
- Local Study Area
- Regional Study Area
- Winter Access Road Study Area (1Km)
- Winter Access Road Study Area (5Km)

NOTES
Base data source: National Topographic Base data (NTDB) 1:250,000

GAHCHO KUE PROJECT

Caribou Aerial Surveys in the Regional Study Area 2004 and 2005

PROJECTION: UTM Zone 11	DATUM: NAD83	De Beers Canada
FILE No: KLOI-07-025-GIS		DATE: November 11, 2010
JOB NO: 09-1365-1004	REVISION NO: 4	Figure 7.3-1
OFFICE: GOLD-SAS	DRAWN: MK / CHECK: JV	

Baseline field studies were initiated in 1996, and completed annually from 1999 through 2005 in the RSA, LSA, and along the Winter Access Road route. In addition, satellite collar data from the Bathurst, Ahiak, and Beverly herds were assessed from 1995 to 2010. The objectives of the studies were to estimate the natural range of variation in the following parameters:

- annual and seasonal occurrence, abundance, distribution, group size, and group composition of barren-ground caribou in the LSA, RSA, and along the Winter Access Road route;
- habitat associations, caribou movement patterns, and important movement corridors in the LSA, RSA, and along the Winter Access Road route; and
- annual and seasonal likelihood of the Bathurst, Ahiak, and Beverly herds interacting with the Project.

Satellite collar data (provided by ENR) suggests that the annual home range of three barren-ground caribou herds may overlap the Project:

- Bathurst herd;
- Queen Maud Gulf or Ahiak herd; and
- Beverly herd.

Annual and seasonal ranges were calculated for satellite-collared caribou in the Bathurst, Ahiak, and Beverly herds using data from 1995 to 2007. Annual and seasonal ranges for the Bathurst herd were calculated based on satellite collar data from January 1, 1996 through October 31, 2007. The temporal extent of satellite collar data for the Beverly herd is from January 1, 1995 through October 31, 2007, whereas the Ahiak is based on data from January 1, 2001 to October 31, 2007. Caribou distribution for each herd was classified into six periods based on inspection of annual movements of satellite-collared caribou (ENR 2010a, internet site):

- northern migration (May 1 to 31);
- calving (June 1 to 15);
- post-calving aggregation (June 16 to July 1);
- summer dispersal (July 2 to August 31);
- rut and fall migration (September 1 to October 31); and
- winter dispersal (November 1 to April 30).

Initial aerial reconnaissance surveys that documented barren-ground caribou and caribou sign in the RSA and along the Winter Access Road were completed in 1996 and 1998. Additional aerial reconnaissance surveys were completed from 1999 to 2003 within the RSA, LSA, and along the Winter Access Road (Table 7.3-1). In 2004 and 2005, systematic aerial surveys were completed within the RSA, LSA, and along the Winter Access Road route (Figure 7.3-1). The 2004 aerial surveys were unbounded (i.e., not fixed width transect; all animals seen were recorded), and survey coverage was estimated at 25% of the RSA. In contrast, a fixed width of 600 m on either side of the helicopter was used in 2005 such that results would correspond with aerial survey methods at existing diamond mines. Survey coverage for aerial surveys completed in 2005 was estimated at 15% of the RSA.

Table 7.3-1 Barren-Ground Caribou Aerial Survey Dates from 1999 to 2005 in the Regional Study Area

Year	Date
1999[a, b]	May 6 to 9; July 17 to 22; October 3 to 4
2000[a, b]	September 10; October 13
2001[a, b]	May 10; October 25
2002[a, b]	May 8; July 2 to August 31; September 25
2003[a, b]	May 13; August 4; October 4
2004[c]	May 4 to 7; May 26 to 28; July 27 to 30; October 8 to 9
2005[c]	March 28 to 31; April 30 to May 2; May 18 to 20; July 28 to 31; September 22 to 25

(a) Unbounded surveys.

(b) Reconnaissance-level survey only.

(c) Fixed width surveys.

Survey periods for the 2004 and 2005 surveys were selected to coincide with the peak movement of barren-ground caribou through the area during the northern migration, late summer, and rut/fall migration periods (Table 7.3-1). Information on movements of satellite-collared caribou, provided by ENR, was used to help determine the timing of surveys. As well, the timing of each aerial survey was determined from Project camp observations and incidental reports, historical information on caribou movements, and reports from personnel at the Snap Lake, Ekati, and Diavik diamond mines.

Estimates of caribou group size, direction of movement, behaviour (i.e., feeding, bedding, standing, walking, trotting, or running), and group composition (i.e., groups with calves, groups without calves) were collected during the 2004 and 2005 aerial surveys. When large groups were observed, ground observations were used to confirm herd composition and approximate size. Habitat information was collected for each caribou observation during snow-free periods, and determined using the regional ELC during snow cover conditions.

Friction modelling or least cost path analysis was completed to identify the location of potential caribou movement pathways within the RSA during the northern and fall migrations. Results were compared to caribou trails recorded in the LSA during the summer and fall aerial surveys. Data collection and analysis of caribou trail density in the RSA was completed in 2010 (Annex F, Addendum FF).

Habitat preferences during the northern migration, summer, and fall seasons within the RSA were determined using pooled caribou observations from 1996 through 2005. The proportion of caribou observed in each habitat was compared to the proportion of each habitat available. Although some aerial surveys were unbounded, habitat area calculations were based on a 1.2 km transect width (600 m on either side of the helicopter). Detailed information on the methods used for barren-ground caribou baseline studies for the Project can be found in Annex F.

Baseline survey data described above were supplemented with ecological information from regional wildlife studies, published and unpublished scientific literature, discussions with wildlife experts, and TK. Traditional knowledge information was obtained from the research, experience, and expertise of the Elders from each of the potentially affected Aboriginal communities (Annex M).

7.3.2.2 Review of Regional Effects Monitoring and Research Programs

A literature review of all available information on caribou from effects monitoring and research programs was completed. Monitoring reports from existing mining developments (e.g., Diavik Diamond Mine, Ekati Diamond Mine, and Snap Lake Mine), scientific publications, and government manuscripts and file reports were reviewed. Current knowledge and relevant information regarding caribou research and the results of related monitoring activities for potentially affected caribou herds were included in the summary.

7.3.2.3 Traditional Knowledge and Resource Use

The TK and traditional land use (TLU) study program was individually tailored for each of the potentially affected Aboriginal communities. The specific methods used to collect TK and TLU from the relevant Aboriginal communities is detailed in Annex M. Secondary source TK information was obtained using various, previously completed reports on experiences and expertise of the Elders from each of the potentially affected Aboriginal communities (Annex M).

7.3.2.4 Socio-Economics

Available literature was reviewed to develop an approach for understanding the cultural values and ways of life associated with the region of the Project. Traditional knowledge studies and reports from the Łutselk'e Dene First Nation (LKDFN), as well as from the GNWT and internet searches were available to enable a discussion of the cultural values, meanings, ways of life, and significance associated with the Aboriginal cultural landscape.

7.3.3 Results

7.3.3.1 Gahcho Kué Project Baseline Study

7.3.3.1.1 Barren-Ground Caribou in the Regional Study Area

Barren-ground caribou populations with ranges that potentially overlap with the RSA are the Bathurst, Ahiak, and the Beverly herds. For the purposes of the Project, the locations of satellite-collared cows from the Bathurst (1996 to 2010), Beverly (1995 to 2007), Ahiak herds (2001 to 2007), and combined Ahiak and Beverly herds (2008 to 2010) were used to describe the annual and seasonal movements for each herd (data courtesy of ENR).

The estimated annual home range for the Bathurst herd (1996 to 2007 based on 95% kernel density) is 309,000 km^2. Satellite collar data also indicates that the Bathurst population has the greatest likelihood of interacting with the Project. Of approximately 10,564 satellite locations for 135 collared cows collected from January 1996 through March 2010, 81 collared cows (and 182 point locations) were from the Bathurst herd, and located in the RSA during the winter dispersal, northern migration, summer dispersal, and rut/fall migration periods (Table 7.3-2). Caribou were also observed during aerial surveys in the RSA during these periods (Figures 7.3-2 to 7.3-4). In addition, the likelihood of the Bathurst herd occurring in the RSA was similar across the winter dispersal, northern migration, summer dispersal, and fall migration periods. No collared animals were located in the RSA during the calving and post-calving seasons.

Table 7.3-2 Number of Collared Caribou and Number of Locations within the Regional Study Area, by Herd and Season from 1995 to 2010

Herd	Season	Number of Collared Caribou in the RSA	Total Number of Collared Caribou		Number of Satellite Point Locations in the RSA	Total Number of Satellite Point Locations	
		Max	Min	Max	Max	Min	Max
Bathurst[a]	winter dispersal	24	6	31	41	29	4,792
	northern migration	18	6	22	24	39	457
	calving	0	6	20	0	19	189
	post-calving	0	6	20	0	37	728
	summer dispersal	11	5	20	39	56	3,828
	rut and fall migration	28	7	22	78	52	570
Ahiak[b]	winter dispersal	3	1	18	5	18	2,698
	northern migration	1	2	18	1	16	625
	calving	0	2	13	0	9	303
	post-calving	0	2	13	0	8	326
	summer dispersal	0	2	13	0	54	1,114
	rut and fall migration	0	2	13	0	21	1,174
Beverly[c]	winter dispersal	1	0	5	1	0	417
	northern migration	0	0	2	0	0	54
	calving	0	0	6	0	0	18
	post-calving	0	0	6	0	0	12
	summer dispersal	0	0	11	0	0	892
	rut and fall migration	0	0	11	0	0	963
Ahiak/ Beverly[d]	winter dispersal	9	35	42	323	5,995	6,645
	northern migration	0	29	40	0	1,341	1,752
	calving	0	28	37	0	641	831
	post-calving	0	26	37	0	663	924
	summer dispersal	0	26	37	0	2,102	2,184
	rut and fall migration	0	22	37	0	1,842	1,940

[a] The Bathurst collared caribou estimates are based from 1996 to 2010.

[b] The Beverly collared caribou estimates are based from 1995 to 2007.

[c] The Ahiak collared caribou estimates are based from 2001 to 2007.

[d] Collared individuals from the Ahiak/Beverly herds could not be separated during the years 2008 to 2010. Collared caribou estimates are based from November 2007 to March 2010.

Min = minimum observed per year; Max = maximum observed per year, RSA = Regional Study Area.

LEGEND

- Gahcho Kué Project
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Northern Migration, 2004
- Northern Migration, 2005
- Survey Transect
- Local Study Area
- Regional Study Area
- Winter Access Road Study Area (1 Km)
- Winter Access Road Study Area (3 Km)

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Observations of Caribou in the Regional and Winter Access Road Study Areas During the Northern Migration 2004 and 2005

PROJECTION: UTM Zone 11	DATUM: NAD83
Scale 1:500,000 (Kilometres)	DE BEERS
FILE No: KLOI-07-026-GIS	DATE: November 11, 2010
JOB NO.: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: MK / CHECK: JV

Figure 7.3-2

LEGEND

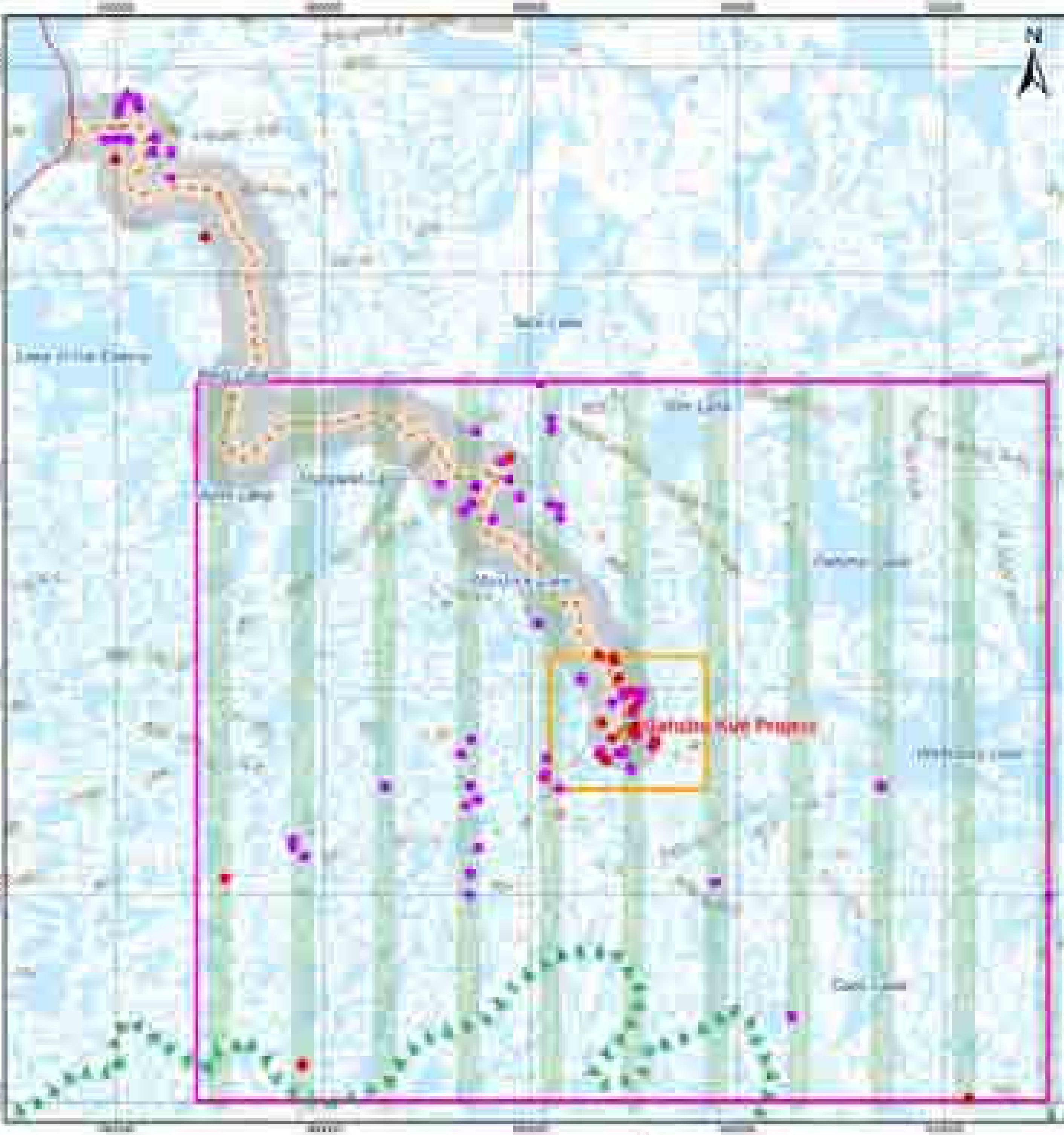
- Gahcho Kué Project
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Summer Dispersal 2004
- Summer Dispersal 2005
- Survey Transect
- Local Study Area
- Regional Study Area
- Winter Access Road Study Area (1 Km)
- Winter Access Road Study Area (3km)

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Observations of Caribou in the Regional and Winter Access Road Study Areas During the Summer Dispersal Period 2004 and 2005

PROJECTION: UTM Zone 11	DATUM: NAD83		
FILE No: KLOI-07-027-GIS		DATE: November 11, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 7.3-3**



LEGEND

- Gahcho Kué Project
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Fall Migration, 2004
- Fall Migration, 2005
- Survey Transect
- Local Study Area
- Regional Study Area
- Winter Access Road Study Area (1km)
- Winter Access Road Study Area (3km)

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Observations of Caribou in the Regional and Winter Access Road Study Areas During the Fall Migration 2004 and 2005

PROJECTION	DATUM
UTM Zone 11	NAD83

Scale 1:550,000

Kilometres

FILE No.	DATE
KLOI-07-028-GIS	November 11, 2010

JOB NO.	REVISION NO.	
09-1365-1004	4	
OFFICE	**DRAWN**	**CHECK**
GOLD-SAS	MK	JV

Figure 7.3-4

The estimated area of the annual home range of the Ahiak herd is 345,000 km^2 (data from 2001 to 2007). Based on approximately 6,240 point locations for 88 collared cows from January 2001 through October 2007, only three collared caribou from the Ahiak herd (and five point locations) were recorded in the RSA during the winter dispersal period, and one during the northern migration period (Table 7.3-2). The estimated seasonal distributions suggest that the Ahiak herd may occur in the RSA during the summer dispersion, rut/fall migration, winter dispersion, and northern migration periods. Similar to the Bathurst and Beverly herds, no collared animals were located in the RSA during the calving and post-calving periods.

The estimated annual home range for the Beverly herd (1995 to 2007) is 282,000 km^2. Based on approximately 2,950 point locations for 19 collared cows from January 1995 through October 2007, only one collared animal (and only one point location) from the Beverly herd was recorded in the RSA during the winter dispersal period (Table 7.3-2). No collar locations were observed in the RSA during the other seasons. The estimated seasonal home ranges also suggest that the Beverly herd has a low likelihood of occurring in the RSA during the northern migration, calving, post-calving, and summer dispersion periods, but may interact with the Project during the rut/fall migration and winter dispersion periods. However, these results are based on a maximum of one collared cow per year from January 1995 to May 2006, 5 to 6 collared animals from June 2006 to December 2006, and two cows during the late winter northern migration of 2007 (no collar data for calving and post-calving in 2007).

Based on approximately 14,276 point locations for 230 collared cows from November 2007 to March 2010, nine collared caribou from the combined Ahiak/Beverly herd (and 323 point locations) were recorded in the RSA during the winter dispersal period (Table 7.3-2). No collared animals were recorded within the RSA during other seasons.

7.3.3.1.2 Caribou Behaviour, Habitat Use, and Abundance in the Regional Study Area

Caribou Behaviour and Habitat Use

Habitat selection and behaviour of barren-ground caribou are frequently the result of their response to environmental conditions; therefore, caribou can be found in a variety of habitat types at any one time (Case et al. 1996). The selection of habitat appears to be related to food availability, ease of travel, relief from insects, and predation (Curatolo 1975). Analysis indicated that caribou were found more frequently than expected on frozen lakes during the northern migration, which were used for travel through the RSA ($\chi^2 = 22.84$, $P = 0.04$). During summer, caribou used peat bog, heath tundra, and tussock-hummock habitats in higher proportion than their availability (χ^2=62.58, P <0.01). In the fall, caribou selected heath tundra, sedge wetlands, and tussock-hummock habitats relative to their availability (χ^2=86.95, P <0.01).

Historic movements (or migrations) of barren-ground caribou have been identified based on trails that scar the landscape. The general paths of the observed trails in the LSA were similar to the predicted fall migratory routes generated from the least cost path analyses. For example, several of the caribou pathways predicted travel for the fall migration through the LSA, near Kennady Lake, and Lake N16. Landscape scarring that is indicative of historic caribou water crossing was documented near both of these lakes during aerial surveys. Although it was not possible to determine how frequently caribou preferred to use these crossings, their presence suggests that large numbers of caribou moved through this area in the past.

Surveys completed at the start of the northern migration (late April to early May) in 2004 and 2005, documented 42% and 29%, respectively, of the caribou groups foraging and resting, while the remaining groups were observed walking. The proportion of caribou groups observed foraging and resting near the end of the northern migration (mid-to-late May) was 13% and 38% in 2004 and 2005, respectively. The remaining 87% and 62% of the caribou groups were walking in 2004 and 2005, respectively.

The Project is not located near the calving grounds for the Bathurst, Beverly, and Ahiak caribou herds and no observations of caribou were reported in the RSA during this time. While caribou were observed in the RSA during the post-calving period, no satellite-collared caribou from the Bathurst, Beverly, and Ahiak herds were recorded during this period in the RSA from 1995 to 2010.

The proportion of nursery groups (groups with calves) within the RSA in 2004 and 2005 was similar to nursery groups observed near the Ekati Diamond Mine and Diavik Diamond Mine. Eleven percent of the caribou groups observed within the RSA in 2004 had calves, while the average proportion of groups with calves in the Lac de Gras region in 2004 was 15% (10% to 22% [95% confidence interval]) (Golder 2008a). In 2005, very few calves were observed within the RSA, and the proportion of caribou groups with calves was about 4%. The Ekati and Diavik diamond mines also reported relatively low proportions of nursery groups at 7% and 6%, respectively in 2005 (BHPB 2007; Golder 2008a). In contrast, the proportion of groups with calves in the Snap Lake Mine study area (3,000 km^2) in 2004 and 2005 was 37% and 34%, respectively (De Beers 2007). Overall, there is high annual variation in the occurrence of nursery groups at the mine sites and general correspondence in the years of high and low calf occurrence (Golder 2008a, b).

Fall movement towards the wintering grounds was not evident in 2004 and 2005, as most animals were observed foraging and resting in the RSA. In 2004, 37% of the caribou groups were observed walking, while 50% were foraging and resting. One group of caribou was running as they were being pursued by a single wolf. In 2005, 22% of the 86 caribou groups were walking, while 78% were foraging and resting. Track evidence suggested that animals had not reached the southwest corner of the RSA.

Although aerial surveys were not completed during the winter dispersal period, satellite collar data indicates that, over the years, caribou from the Beverly (2006), Bathurst (1996, 2003, 2005, and 2006), and Ahiak (2002, 2006, and 2007) herds were present in the RSA (data courtesy of ENR). In addition, observations from wildlife log books recorded caribou in the LSA during the winter. Snow track surveys completed in late winter 2004 also provided evidence of caribou feeding and foraging in the LSA.

Seasonal and Annual Trends in Abundance

Barren-ground caribou generally first appear near the Project in late April and early May. From 1999 to 2005, 100 to over 3,000 caribou (with the exception of 2002 when 9 caribou were observed) were observed in the RSA during the northern migration. Satellite collar data suggests that caribou observed in the RSA during the northern migration were likely from the Bathurst and Ahiak herds. Similar estimates were reported in the Ekati Diamond Mine and Diavik Diamond Mine study areas (combined area = 2,800 km^2), as over 2,500 individuals were observed each year from 1998 to 2002 (with the exception of 2001 when approximately 1,672 individuals were recorded) (Golder 2005). Similarly, over 14,000 caribou were estimated to be in the Snap Lake Mine study area (3,000 km^2) during the 2000 and 2002 northern migrations (De Beers 2007).

Barren-ground caribou were observed within the RSA during the summer dispersal period; however, the number of caribou present within the RSA during the summer of any given year varied greatly (ranged from 104 to 30,000). The largest of these groups was estimated at 30,000 caribou in 1999. Satellite collar data suggests that caribou observed in the RSA during the summer dispersal were likely from the Bathurst herd. Although surveys completed in the summer of 2003 found few caribou in the RSA (104 individuals), the results suggest that there is a high likelihood of caribou occurring in the RSA during the summer dispersal period. In late July 1999, almost 7,000 caribou were observed in the Snap Lake Mine study area (3,000 km^2) (De Beers 2007).

The timing of fall movements towards wintering grounds also varied among years; however, surveys completed from 1999 to 2005 indicated that caribou were usually present in the RSA in late September or early October. Large aggregations of caribou were observed in the RSA in 1999, 2000, and 2005, which corresponds to the satellite collared data recorded for the RSA. Satellite data indicated that no caribou from the Beverly or Ahiak herds were present within the RSA during the fall migration; however, collared individuals from the Bathurst herd were recorded in several years. Less than 1,000 caribou were estimated in the RSA during the fall migration from 2001 to 2004. Few caribou were counted along the Winter Access Road route in 2004 and 2005.

The estimated number of barren-ground caribou in the Snap Lake Mine study area (3,000 km^2) during the summer to fall migration periods has also varied among years. For example, less than 500 caribou were observed within the Snap Lake Mine study area during the post-calving migration (defined as July to October) in 2000 and 2006, while about 7,000 caribou were observed in 1999, and 10,000 in 2005 (De Beers 2007). Similar results for the post-calving migration were also reported for the Diavik Diamond Mine and the Ekati Diamond Mine study areas, where caribou estimates have ranged from over 14,000 in 1999 to less than 2,000 caribou in 2000 (Golder 2005). Estimates for these areas in 1998, 2004, and 2006 exceeded 5,000 caribou.

7.3.3.2 Review of Regional Effects Monitoring and Research Programs

7.3.3.2.1 Caribou Habitat Use

Caribou, like many wide-ranging species, likely select habitats at several spatial scales. At the scale of the seasonal range, resource selection models suggest that caribou select habitats dominated by lichen veneer, heath tundra and rock vegetation types (Johnson et al. 2004, 2005). Observational studies also found that Bathurst caribou preferentially selected lichen heath habitat, and their calving and post-calving diet is dominated by lichens (Griffith et al. 2002). Cows select calving grounds based on the potential for high levels of green plant biomass at peak lactation when energy demands are highest. The quality (energy content) of forage within the Bathurst calving range may be lower compared to other herds (e.g., Porcupine Herd) (Griffith et al. 2002).

Habitat associations of caribou are also recorded during aerial surveys for mine monitoring programs. At the regional scale, heath tundra, heath tundra/boulder-bedrock, and riparian shrub appear to be the most preferred habitat types during both the northern and post-calving migration periods (BHPB 2004; Golder 2008a, b). Feeding and resting behaviours (from aerial survey observations) were more common in riparian shrub and sedge wetland habitats (Golder 2008a, b). Frozen lakes and eskers may be important as movement corridors during the northern migration (Golder 2004, 2008a). Large lakes also appear to influence caribou distribution during the summer period as animals tend to move around large open bodies of water (Golder 2008a, b).

Caribou are also known to use artificial habitats created by mine structures (roads, Fine Processed Kimberlite Containment [PKC] Facility, Coarse Processed Kimberlite [PK] Pile, mine rock piles). These structures may provide a means of avoiding insect harassment, as caribou are often observed bedding or resting on these structures (Gunn et al. 1998; BHPB 2004, 2007). An analysis of fecal pellets from the Colomac gold mine and Ekati Diamond Mine areas found elevated levels of ash content, indicating uptake of inorganic minerals (MacDonald and Gunn 2004). Through foraging on lichens in dust deposition areas and re-vegetation on PKC areas, and possibly through direct consumption of soils, caribou may be increasing metal uptake. There is incomplete information on the effects of metal intake on caribou.

Vegetation type remained important in resource selection models that also incorporated the influence of major developments (Johnson et al. 2004, 2005). Caribou demonstrated a strong response to disturbance during the post-calving period, and avoidance of major developments; these developments reduced high quality habitats and increased the amount of low quality habitat. The population-level consequences of a reduction in availability of high quality habitat due to avoidance of major developments are currently not clear.

7.3.3.2.2 Caribou Behaviour and Distribution

Behaviour

Changes in caribou behaviour are one type of predicted indirect effect from mine-related disturbance. In particular, there is concern that caribou experiencing disturbance from a mine would reduce the amount of time feeding, which may lead to physiological effects, and influence survival and recruitment (Gunn et al. 2001). Therefore, behaviour monitoring is a component of most mine monitoring programs. Based on point observations of behaviour made during aerial surveys over the last decade, the majority of caribou groups have continued to exhibit feeding or resting behaviours throughout the study areas of the mine sites. Behavioural monitoring over a longer period (activity budget scan sampling of individuals) also indicated that resting or feeding behaviours were most common, even near airstrips or roads (Gunn et al. 1998; BHPB 2007).

Likewise, statistical models indicate that point observations of caribou behaviour are largely driven by habitat type or insect activity, rather than distance to the mine (BHPB 2004; Golder 2008a, b). In the cases where distance to the mine was related to behaviour, feeding or resting was more common closer to the mine. In some cases, feeding or resting behaviour declined during the construction phase of mine development, when noise and disturbance is predicted to be at a maximum (Golder 2005, 2008a). Nursery groups appear to be slightly more sensitive to behavioural changes than adults alone (BHPB 2004; Golder 2008a, b).

Ground-based studies of behavioural responses to stressors at the Ekati Diamond Mine found that nursery groups were also more likely to respond to stressors (BHPB 2007). Blasting was the most likely type of stressor to induce a response for all caribou groups (over vehicle or human stressors). The level of response, (low = looking up; high = running away) decreased as distance from the stressor increased (BHPB 2007).

Activity budgets of caribou are influenced by both environmental and anthropogenic (man-made) variables. Insect harassment is known to reduce foraging and influence body condition for caribou (Gunn et al. 2001; Weladji 2003). Recent analyses of point observations of behaviour confirmed that the likelihood of feeding or resting declined as insect abundance increased (Golder 2008a,b).

Behavioural monitoring of Bathurst caribou on the calving grounds indicated the active feeding cycle is about 98 minutes, while the resting cycle is 78 minutes (Griffith et al. 2002). Exposure to mining disturbance was predicted to reduce foraging (Gunn et al. 2001). Model based data from the Porcupine caribou herd in Alaska found that exposure to development may cause a 13% decline in fall body fat, and a 7% decline in herd growth rates (Gunn et al. 2001).

This model by Gunn et al. (2001) has not yet been confirmed with Bathurst or Ahiak herd activity budget data from diamond developments in the NWT. Only the Ekati Diamond Mine has substantial activity budget data. From 1998 through 2003, caribou with calves spent about 10 to 13% less time feeding within 5 km of the mine than groups greater than 5 km from the mine, but the results were not statistically significant (BHPB 2004). The largest amount of variation in behaviour was explained by year effects. Further data on activity budgets at mine sites is required to assess potential behavioural changes due to mine-related disturbance, and cumulative effects of insect harassment combined with mine disturbance.

Distribution

Overall, there is a high level of spatial and annual variation in the distribution of caribou (BHPB 2007; Golder 2008a, b). The Bathurst herd typically winters south of the treeline and may overlap with the Ahiak and Beverly herds.

Although the annual calving ground is the most predictable part of the annual home range, over decadal periods the annual calving grounds may shift across the landscape (Gunn et al. 2002).

Shifts in the calving range to north or west may likely result in reduced green forage and may be detrimental to the nutrition of the herd (Griffith et al. 2002). The calving ranges of the Bathurst and Ahiak herds are geographically separate but are adjacent to each other (Gunn and D'Hont 2002). The size of calving ranges varied from 7,440 to 16,460 km^2. Synchrony of herd and individual movements indicate that satellite-collar techniques are an appropriate way of tracking migration routes and estimating range size and location (Gunn and D'Hont 2002; Gunn et al. 2002).

Distribution Relative to Mines and Zones of Influence

There is considerable evidence to suggest that caribou herds respond to diamond mine developments by changing their distribution (Boulanger et al. 2004; Golder 2005; Johnson et al. 2005; BHPB 2007; Golder 2008a, b; Boulanger et al. 2009). These studies found a significant positive relationship between the occurrence of caribou and distance to the mine. In other words, caribou were more likely to occur further from the mine than closer to the mine. This reduction in caribou occurrence has been called the ZOI.

At the Diavik Diamond Mine, the ZOI ranged from 16 to 36 km, and was on average 29 and 23 km for the northern and post-calving migrations, respectively (Golder 2008a). Although there has been no temporal increase in the size of the ZOI, it exceeds the original prediction of 3 to 7 km (DDMI 1998).

For Snap Lake Mine, the ZOI ranged from 10 to 28 km and was on average 19 km and 17 km for the northern and post-calving migrations respectively. During the post-calving migration there was some indication that the ZOI has been increasing linearly with time from baseline through construction (Golder 2008b).

Resource selection models based on satellite-collared caribou, after controlling for vegetation, found that mines and other major developments might have a ZOI of up to 33 km (Johnson et al. 2005). A comparative study using satellite and aerial survey caribou locations around three mines in the NWT (Diavik, Ekati, and Snap Lake), estimated ZOIs ranging from about 16 to 50 km; aerial survey-based zones of influence were generally smaller than those generated from satellite data (Boulanger et al. 2004). More recent analyses have estimated the ZOI to be 11 to 14 km near the Ekati-Diavik mine complex during the operation phase (Boulanger et al. 2009). Habitat selection by caribou was about four times higher outside the ZOI in the Lac de Gras area. At the smaller Snap Lake Mine, a weaker ZOI of 6.5 km was detected (Boulanger et al. 2009).

The high level of variability in the estimates for the ZOI from projects is in part due to the highly variable annual distribution of caribou. In addition, variation in the predicted ZOI is likely associated with differences in the size of the mine footprint and level of activity for a project. Habitat and the presence of large lakes also influence the distribution of caribou near mine sites (Golder 2008a,b).

Overall the presence of caribou within the mine study areas has been variable among years, but has not declined as mine activity increased (BHPB 2007; Golder 2008a, b). However, it seems clear that spatial mine effects cause a behavioural response by caribou. Most studies show that caribou appear to change their distribution and reduce habitat use within approximately 10 to 30 km from a mine site.

7.3.3.2.3 Caribou Population Characteristics

The number of individuals in the Bathurst herd has declined almost 75% from a reported maximum population size in the late 1980s to 64,579 females in 2006 (Boulanger and Gunn 2007; Nishi et al. 2008). Gunn et al. (2005) reported an annual rate of decline of about 5% from 1996 to 2006. In 2009, the population of breeding females was estimated to 16,604, and the estimate for the number of animals greater than one years of age on the calving grounds was 23,273 (Adamczweski et al. 2009). Reduced fecundity and adult survival have been cited as contributing factors to the recent decline in herd size.

Using modelling techniques and data collected from 1996 to 2003, Boulanger and Gunn (2007) estimated annual survival rates of caribou: female adult = 0.842, female yearlings (age 1) = 0.842, and female calves (i.e., young-of-the year) = 0.259. Male adult survival was estimated to be 0.730. Estimates of survival rates for male yearlings and calves were not presented in Boulanger and Gunn (2007). Fecundity, defined as the average number of calves produced for each sex and a function of adult survival was 0.45. Modelling also showed that survival rates of adult females were relatively constant from 1986 to 2006, but that fecundity and calf survival declined during this period. For the population to exhibit a positive growth rate, it is predicted that calf and adult survival, as well as fecundity, must increase from current estimates (Boulanger and Gunn 2007).

The links between demographic variables (e.g., adult and calf survival), environmental factors (e.g., food quality and quantity, insects, hunting, and development), and population growth are not well understood. Although direct losses of habitat (e.g., total mining footprint) are relatively small, and likely have marginal influences on the carrying capacity of the landscape (Johnson et al. 2005), industrial development has the potential to disrupt movements and reduce availability of high quality habitat. For example, Johnson et al. (2005) showed that Bathurst caribou avoided areas of industrial development, particularly during post-calving movements, suggesting that caribou can adjust their behaviour to accommodate some disturbance (e.g., Colman et al. 2001).

However, if avoidance behaviour is a product of a disturbance response, then there may be implications of auditory or visual disturbance at the population level, such as reduced recruitment. If animals are exposed to multiple disturbance events, then there may be energy costs (e.g., Tyler 1991). A single encounter with disturbance (i.e., loud noise) is unlikely to cause adverse energy consumption by an animal, however, the effect from exposure to disturbance should be proportional to the number of times an animal encounters disturbance events (Bradshaw et al. 1998).

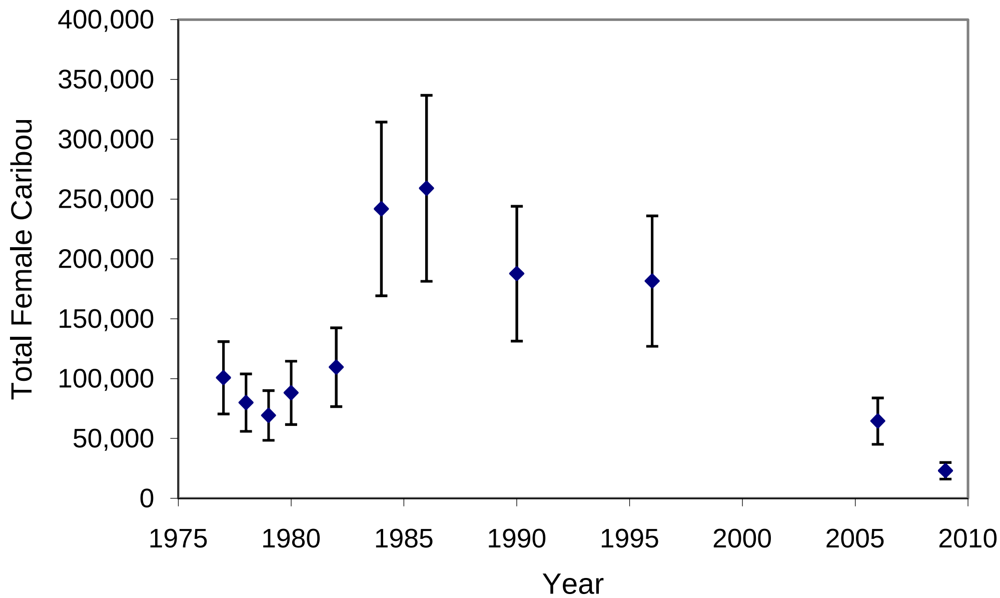
Natural stressors, such as insect pest outbreaks and climate, may also have an important role in population dynamics, and their interacting effects with habitat requirements may confound any perceived relationships with human activity (e.g., Tews et al. 2006). For example, Tłįchǫ caribou harvest data from 1916 to 1998, revealed that hunters reported harvesting at least some underweight caribou, approximately 33 out of the 1,026 cases (about 3% of the time) (Dogrib Treaty 11 Council 2001). Of these 33 cases, there were 7 instances where all caribou harvested were considered to be underweight (the winters of 1917, 1918, and 1937; the falls of 1921, 1931 and 1956; and the spring of 1957). Traditional knowledge suggests that poor body condition was due to shorter foraging times and harassment by predators and parasites (LKDFN 2005: 28, internet site).

Other possible causes of recent reductions in herd size include commercial and subsistence hunting (Boulanger and Gunn 2007). Case et al. (1996) estimated that between 14,500 and 18,500 Bathurst caribou were harvested annually from 1982 to 1995. Based on the Dogrib Harvest Study, Boulanger and Gunn (2007) estimated that, on average 6.7% of bulls (range = 3.0 to 9.2%) and 4.1% of cows (range = 1.4 to 7.0%) were harvested annually from 1988 to 1993 (based on estimated population size). However, demographic models suggest that reduced levels of hunting generated only a slight increase in adult survival (3%), which was not enough to produce positive population growth (Boulanger and Gunn 2007).

In addition to the above-mentioned environmental and human-related external factors, density dependence may be an important factor in the population dynamics of barren-ground caribou (Tews et al. 2007). Density dependence occurs when the growth rate of a population decreases as its density increases.

In some cases, growth rates decrease because of declining forage quality that cause decreases in survival and/or reproduction. This mechanism can lead to cyclical trends in abundance starting when foraging levels surpass a critical level for maintenance of population size, resulting in either gradual reductions in population growth or abrupt population declines. Temporal data on population size in Case et al. (1996) combined with more recent information from Boulanger and Gunn (2007), clearly show cyclical trends in abundance of Bathurst caribou from 1976 to 2006. Thus, density-dependence is one possible mechanism that may underlie recent declines (beginning in the 1990s) in population size (Figure 7.3-5).

Figure 7.3-5 Temporal Trend in Number of Female Caribou from the Bathurst Herd, 1976 to 2009



Note: Values from 1977-1984 are from Case et al. (1996), values from 1986-2006 are from Boulanger and Gunn (2007), and the value from 2009 is from Adamczewski et al. (2009); also, values from 1997 to 1980 were determined using a visual census, whereas values after 1980 were based on the photograph method.

Error bars = standard deviation calculated using 30% coefficient of variation.

7.3.3.2.4 Specific Mining-caribou Interactions

Food Waste

Food waste at mines represents a hazard to caribou primarily because improperly handled waste can become an attractant to predators such as bears and wolves, and increase the risk of predation on caribou. The risk of food waste attractants at mines is mitigated by sorting waste, burning all food refuse, regular monitoring of landfills for the evidence of attractants, educating staff about waste sorting and proper disposal, and enclosing waste transfer areas and incinerators (Section 11.9).

Although waste management and wildlife mitigation practices have been successful at reducing risks to wildlife, attractants are routinely found in landfills at most mines. Most animals and sign observed during these landfill surveys were associated with foxes. Grizzly bears, wolverine, and wolf tracks were occasionally observed (Section 11.9). At the Snap Lake Mine, there were no reported waste or attractant-related incidents or mortalities from 1999 to 2009 (Golder 2008b; De Beers 2009, 2010). There were no incidents involving black bears, grizzly bears, or wolves. The record at the De Beers Snap Lake Mine indicates that the implementation of waste management and wildlife mitigation plans can be effective at limiting the risks of injury and death to wildlife.

Pits and Processed Kimberlite Containment Facilities

Pits represent a potential hazard because if a caribou falls in, it may be injured or become trapped and vulnerable to predation. No caribou have been observed falling into pits (BHPB 2007; BHPB 2010; DDMI 2010). Although caribou mortalities have occurred near pits and facilities, there have been no confirmed mortalities as a result of interaction with pits or containment facilities. Mortalities associated with containment facilities are presumed to be the result of predation by wolves or bears (BHPB 2006, 2007).

Surveys of the PKC area at the Ekati Diamond Mine have recorded observations of caribou and caribou tracks (BHPB 2006, 2007). In addition, caribou have been observed to bed on and travel over processed kimberlite. To date, no injuries or death of animals have been attributed to the PKC area at either the Ekati Diamond Mine or the Diavik Diamond Mine (BHPB 2010; DDMI 2010).

Roads and Airstrips

Caribou mortality due to collisions with vehicles and aircraft represent direct effects from mines and mine-related developments (i.e., winter roads and airstrips). Numerous mitigation policies and practices are in place at active mines and winter roads to prevent vehicle collisions with caribou (EBA 2001; BHPB 2010; De Beers 2010; DDMI 2010).

Mitigation includes:

- speed limits;
- caribou advisory notification;
- giving wildlife the right-of-way;

- electric fencing, flagging or inukshuks around airstrips or other hazardous mine structures;
- road closures during periods of high caribou presence;
- employee education;
- careful herding of caribou away from hazards; and
- ploughing snowbanks on winter roads to allow for wildlife crossing.

Caribou have been observed bedding or travelling on roads and airstrips. Road and airstrip traffic mitigation appear effective, as no caribou have been killed in vehicle or aircraft collisions at mine sites. The exception is the Tibbitt-to-Contwoyto Winter Road, where five caribou were killed by a grocery truck (EBA 2001).

Electric fencing, flagging, and inukshuks have been moderately successful at deterring caribou from airstrips and other mine facilities. However, caribou have become entangled in electric fences. At the Ekati Diamond Mine, six caribou have been entangled in the electric fence surrounding the airstrip from 2001 through 2009 and four of these animals died (BHPB 2005, 2010). At the Diavik Diamond Mine, a caribou became entangled in an electric fence and was killed by a grizzly bear (DDMI 2006). Since 1995, one caribou died while becoming entangled in an electric fence at the Project.

7.3.3.3 Traditional Knowledge and Resource Use

Aboriginal groups have had a historically important and respectful relationship with caribou, and continue to do so today. The Tłı̨chǫ (Dogrib) people state that respect is shown by only taking what is needed, using all parts of the harvested animals, and discarding any unused parts in respectful ways. Respect is also shown by having and sharing knowledge of the caribou. A lack of knowledge, and therefore respect, will result in the caribou migrating elsewhere and a population decline. Traditional knowledge is collected through harvesting activities, verified through discussions with other harvesters and elders, and shared through oral narratives (Dogrib Treaty 11 Council 2001).

Caribou is the most important resource harvested by Aboriginal groups with traditional lands near the Project, and as a result, the people have developed a wealth of information about these animals (LKDFN 2003, internet site, 2005, internet site; Dogrib Treaty 11 Council 2001, 2002). Caribou consume a range of vegetation including lichen (white, black, yellow, gray reindeer lichen, northern reindeer lichen, Iceland moss, hair lichen, leaf lichen-green kidney), grass, sedge, cranberry leaf, willow leaf, cloudberry leaf, blueberry leaf, birch leaf, crowberry, and mushrooms (LKDFN 1999; Dogrib Treaty 11 Council 2001).

According to TK, caribou migrate through the barrenland region twice a year: once in the fall and once in the spring, and that during these migrations the caribou pass through the area surrounding the Project (LKDFN 1999). The Tłįchǫ report that in March and from November to December caribou can be found around Snare Lake (northwest of the Project) in large numbers as they migrate to their summer calving grounds or winter feeding grounds (Helm 1981).

In 2002 and 2003, caribou migrated through Artillery Lake (southeast of Kennady Lake) in what the LKDFN refer to as the "normal" way although some hunters noted that the caribou were more spread out than usual (LKDFN 2005:55, internet site). In 2004 and 2005, the herd was considered

to be further away from Łutselk'e. Information suggests that some LKDFN hunters were concerned that there were "less animals than there used to be in that area" (eastern side of Artillery Lake) and that the caribou were late and were "crossing at different locations than they used to, migrating more towards the north shore of Artillery Lake and not through the traditional crossings." Two explanations were proposed for why the caribou were migrating further away from Łutselk'e. One explanation suggests that forest fires have burned caribou habitat. Another explanation is that mining and other development activities are stressing the caribou. Several people in the Deninu Kué First Nation (DKFN) community are concerned that they have to travel farther than they did in the past to harvest caribou and believe the species population is decreasing (DKFN 2007, internet site).

7.3.3.3.1 Human Use of Caribou

Caribou have and continue to be the most important resource harvested by Aboriginal groups with traditional lands near the Project (Annex M). Case et al. (1996) estimated that between 14,500 and 18,500 Bathurst caribou were harvested annually from 1982 to 1995. However, there is some belief that these numbers are substantially overestimated, and that the harvest in more recent years is well below these values (Adamczewski et al. 2009).

Non-Aboriginal harvest of caribou is regulated by GNWT ENR. Resident hunters were allowed to harvest up to two barren-ground caribou, males only, each year. The resident harvest occurred in two peaks: one in the fall when the caribou are near the treeline (August 15 to November 15) and another in winter when the herd is accessible by ice road for part of the section (November 15 to April 30). Non-resident hunters could harvest a maximum of two caribou per year (August

15 to November 30 in the North Slave region), and must obtain the services of a licensed outfitter. These outfitted hunts provide business and employment opportunities to local residents and bring about $3 million a year into the territorial economy (ENR 2010b, internet site).

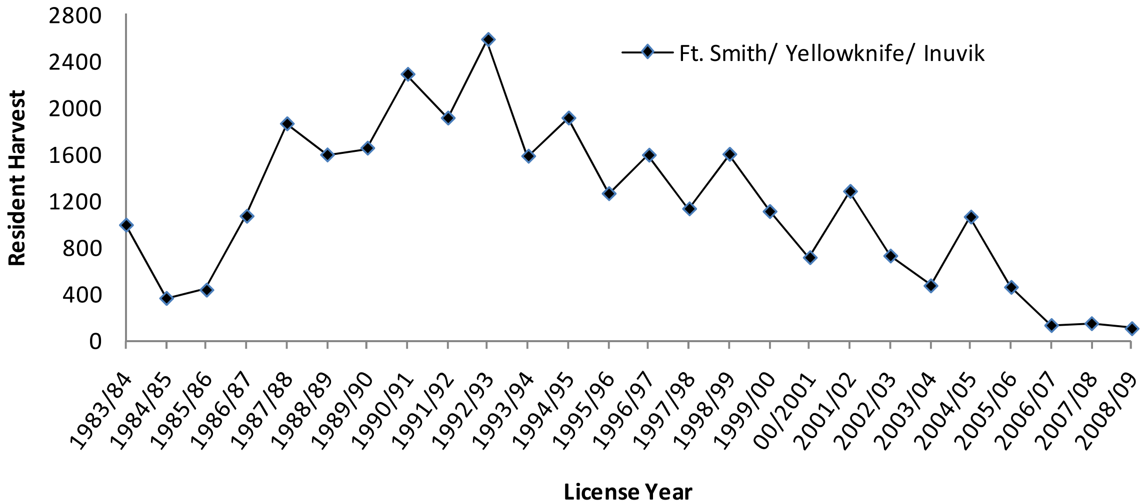
In December 2009, interim emergency actions were put in place to help conserve the Bathurst herd (ENR 2009, internet site). Beginning January 1, 2010, barren-ground caribou commercial/meat tag, resident and non-resident harvesting was closed in the North Slave and South Slave regions and all hunting was closed in a new no-hunting conservation zone established north of Yellowknife where the Bathurst herd winters (ENR 2010b, internet site). The new zone includes the Tibbitt-to-Contwoyto Winter Road, the Winter Access Road, as well as all diamond mines in the NWT, including the Project. A current proposal under review suggests revising the annual allowable hunt to 300 animals for Aboriginal hunters within the current no hunting zone, but no resident or non-resident hunting in the North Slave and South Slave regions as well as the new conservation zone (Tlicho Government and ENR 2010).

The numbers of barren-ground caribou harvested by resident hunters fluctuated annually from 1983 to 2008, peaking at 2,576 bulls during the 1991-92 license season, and averaging 1,194 bulls across all years (plus or minus (±) 660 standard deviation [SD]) (Figure 7.3-6). These harvest numbers represent those collected for Ft. Smith region, Inuvik region, and Yellowknife, the majority of which are from Yellowknife (78% of harvest). If considering harvests from Kitikmeot, Keewater and Baffin regions, the total harvest of barren-ground caribou was, on average, 28% higher or 1,563 bulls in total. Data from these regions are not plotted in Figure 7.3-6 because no recent data on harvests were available. Compared to the resident harvest, the outfitter harvest (i.e., non-resident harvest) was generally lower (mean of 733 ± 270 SD), but increased from 1990 to 2002, and has since been decreasing. The number of bulls harvested by non-residents in 2009 was only 223 animals. The outfitter harvest is thought to be of Bathurst caribou (Adamczewski et al. 2009). During the past three years, the estimated annual harvest of Bathurst caribou from outfitters, residents, and Aboriginal hunters is 4,000 to 5,000 cows and 2,000 bulls (Adamczewski et al. 2009).

Residents of the NWT may also harvest caribou from the Beverly and Quamanirjuaq herds. Hunters from NWT, Nunavut, Manitoba, and Saskatchewan harvest about 18,500 caribou annually from these two herds for subsistence use. In the NWT, the non-Aboriginal resident and non-resident harvest of these herds is extremely small as the Beverly herd seldom travels close to NWT communities (ENR 2010b, internet site).

The Ahiak herd is seasonally hunted by people from Gjoa Haven, Umingmaktok, Cambridge Bay, and Łutselk'e in some winters (ENR 2010b, internet site). No estimates on the number of animals harvested were available.

Figure 7.3-6 Numbers of Barren-ground Caribou Harvested Annually by Resident Hunters in Yellowknife, Fort Smith, and Inuvik Regions



Data received from ENR.

7.3.3.4 Socio-economics Related to Caribou

Barren-ground caribou have an important social, cultural, and economic value to residents of the NWT. The herds are hunted by Aboriginal and non-Aboriginal people from almost all communities. The minimum annual harvest is 11,000 caribou with a minimum economic value of $17 million dollars (includes meat replacement and outfitting) (ENR 2006). A recent socio-economic study found that the annual net value of the Beverly and Qamanirjuaq caribou harvest is more than $20 million (Soublière 2007). The NWT share of the Beverly and Qamanirjuaq caribou harvest accounts for less than $1 million of the annual revenue from harvested caribou. However, the economic value of harvested caribou is more than just food replacement value. Wild meat can be nutritionally superior to store-bought meat, and hunting provides exercise and contributes to a healthy lifestyle, and has other cultural benefits as well (Soublière 2007).

Aboriginal peoples are dependent upon the land for their survival and prosperity. For generations, they have harvested resources for their own use, and continue to do so today. In the 21st century the economy of many communities is made up of a mixture of the wage economy, the traditional/resource harvesting economy, and government transfer payments. Typically in many of these smaller communities, traditional harvesting continues to play an important role in the economy as well as in the social and physical well-being of the community (Parlee 1998; Fast and Berkes 1999).

Caribou, ducks, moose, muskrat, goose, and fish are some of the species consumed on a regular basis, and all community residents in Łutselk'e consume some traditional food from the land (Parlee and Marlowe 2001, internet site). Participation in these harvesting activities not only provides food and resources, but also directly reduces economic stress on many Aboriginal households. On average, value attained from wild meat and fish harvested from the land has been related to $10,000 per household (Usher 1989). Involvement in harvesting activities also provides the intangible benefit in contributing to their identity and reaffirming their connection with the land.

A large percentage of Łutselk'e adults (55% to 68%) and youth (26% to 27%) consume caribou meat on a regular basis. Over half of the adults and one-third of the youth surveyed ate six or more meals of caribou in a week. It was noted that caribou have been harvested less in the past few years because the herds are further from the community and it takes longer to reach them. Families and harvesters without access to snowmobiles and sufficient gas have difficulty reaching and harvesting from the herds (LKDFN 2005, internet site). Recently a high percentage of the adult and youth population have not harvested caribou. Reasons for the lack of participation in harvesting caribou include the prohibitive costs and lack of proper equipment, the need to travel further distances from the community to reach the caribou herds, the lack of monetary resources, limited profits, and the lack of people possessing necessary traditional skills to share with others in the community.

The health and survival of many aspects of the Aboriginal cultural landscape components are dependent upon the continued pursuit of traditional activities across the land and within the communities. Through years of continual use of the land and its resources, and the accumulated wealth of TK, a strong cultural link between the people and the land has been established. As a result, there is a high level of respect for the land and the multitude of resources that it supplies (Annex M).

Caribou hunts often occur at specific locations during certain times of the year, and the success of these events is dependent upon the strong social customs associated with them (Annex M). Families, band members, and friends gather communally to participate in these activities. Hunts rely on strong social customs and cooperation, and these gatherings foster social customs, strengthen family ties, TK, and an awareness of the land and its health and condition. Often there is the sharing and retelling of stories, as well as games, ceremonies, and rituals that reaffirm the existence, history, and identity of the group.

7.4 PATHWAY ANALYSIS

7.4.1 Methods

Pathway analysis identifies and assesses the issues and linkages between the Project components or activities, and the corresponding potential residual effects on caribou. Barren-ground caribou populations with ranges that overlap or may overlap the RSA of the Project are the Bathurst, Ahiak, and Beverly herds (Section 7.3.3.1). Satellite collar data from 1996 to 2010 indicates that the Bathurst herd has the greatest likelihood of interacting with the Project during the winter, northern migration, summer, and autumn periods. Estimated seasonal distributions for the Ahiak herd (2001 to 2007) also suggest that individuals may occur in the RSA during the winter, northern migration, summer, and autumn periods. However, collared animals from the Ahiak herd were only located in the RSA during winter and northern migration periods.

In contrast, the estimated seasonal ranges and movements for the Beverly herd (1995 to 2007) suggest that the population has the lowest likelihood of interacting with the Project relative to the Bathurst and Ahiak herds (Section 7.3.3.1). Although individuals from the Beverly herd can be expected to travel through the RSA during the autumn or winter periods in some years, the direct and indirect effects from the Project on the population are predicted to be negligible. The Project will likely alter the behaviour and movement of individuals that travel through the RSA. However, the frequency and number of animals affected is not expected to result in a measurable change in the population size and distribution of the Beverly herd relative to baseline conditions. Subsequently, the Project was determined to have no linkage to effects on the Beverly herd.

Because the Bathurst herd has the greatest likelihood of interacting with the Project, emphasis in the effects analysis is on the Bathurst population. In addition, current knowledge and relevant information regarding caribou research in the SGP is focused on the Bathurst herd (Section 7.3.3.1.1). Therefore, potential Project-related effects predicted for the Bathurst herd are anticipated to be representative and provide conservative estimates of effects for the Ahiak herd (i.e., the effects for the Bathurst herd will likely overestimate effects for the Ahiak herd).

Pathway analysis is a three-step process for determining linkages between Project activities and environmental effects that are assessed in Sections 7.5

to 7.8. Potential pathways through which the Project could influence caribou were identified from a number of sources including:

- the *Terms of Reference for the Gahcho Kué Environmental Impact Statement* (Gahcho Kué Panel 2007) and the Report of Environmental Assessment (MVEIRB 2006);
- a review of the Project Description and scoping of potential effects by the environmental assessment and Project engineering teams for the Project; and
- consideration of potential effects identified for the other diamond mines in the NWT and Nunavut.

The first part of the analysis is to produce a list of all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on caribou. This step is followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove the pathway or limit (mitigate) the effects to caribou. Environmental design features include Project designs and environmental best practices, and management policies and procedures. Environmental design features were developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the ecological system and environmental design features and mitigation is then applied to each of the pathways to determine the expected amount of Project-related changes to the environment and the associated residual effects (i.e., after mitigation) on caribou. For an effect to occur there has to be a source (Project component or activity), a change in the environment, and a correspondent effect on caribou.

Project activity → change in environment → effect on VC

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on caribou. Pathways are determined to be primary, secondary (minor), or as having no linkage using scientific and TK, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and, therefore, no residual effects to a VC relative to baseline or guideline values;

- secondary - pathway could result in a measurable and minor environmental change, but would have a negligible residual effect on a VC relative to baseline or guideline values; or
- primary - pathway is likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values.

Primary pathways require further effects analysis and impact classification to determine the environmental significance from the Project on the persistence of caribou populations, and continued opportunity for traditional and non-traditional use of caribou. Pathways with no linkage to caribou populations or that are considered minor are not analyzed further because environmental design features and mitigation will remove the pathway (no linkage) or residual effects can be determined to be negligible through a simple qualitative evaluation of the pathway (secondary). Pathways determined to have no linkage to caribou or those that are considered secondary are not predicted to result in environmentally significant effects on the persistence of caribou populations and continued opportunity for traditional and non-traditional use of caribou. Primary pathways are assessed in more detail in Sections 7.5 to 7.8.

7.4.2 Results

Pathways potentially leading to effects on caribou include direct and indirect changes to habitat, and survival and reproduction (Table 7.4-1). These changes may ultimately affect the persistence of caribou populations, and the continued opportunity for traditional and non-traditional use of caribou. Evaluation of effects on caribou also considers changes to hydrology, water quality, air quality, soil quality, and vegetation during the construction, operation, and closure of the Project, as well as effects remaining after closure.

Because potential pathways are based primarily on public concerns identified during the Mackenzie Valley Environmental Impact Review Board (MVEIRB) scoping process (MVEIRB 2006). Many environmental design features were incorporated during the development of the Project to address these issues by reducing or eliminating potential effects. Also, preliminary analysis may have shown that potential effects considered during issue scoping are so small that they are not relevant. Other potential pathways are considered to be primary and are included in the effects analysis. The following sections discuss the potential pathways relevant to caribou.

Table 7.4-1 Potential Pathways for Effects to Caribou

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Project Footprint (e.g., pits, Fine PKC Facility, Coarse PK Pile, mine rock piles, Winter Access Road and Tibbitt-to-Contwoyto Winter Road)	• direct loss and fragmentation of wildlife habitat from the physical footprint of the Project may alter caribou movement and behaviour	• backfilling the mined-out pits with PK and mine rock will decrease the on-land Project footprint • compact layout of the surface facilities will limit the area disturbed at construction and increase site operations efficiency • mine rock will be used as the source of aggregate production, thereby, reducing the need for separate quarries • blasting in pits will be carefully planned and controlled to maintain a safe workplace and reduce the throw of ore bearing materials • where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms • to the extent practical, the total amount of area disturbed by Project activities at any one time will be reduced through the use of progressive reclamation • ramps to facilitate the access and egress of caribou from the mine rock piles will be constructed during closure • culverts or stream-crossing structures will be removed and natural drainage re-established • at closure, transportation corridors and the airstrip will be scarified and loosened to encourage natural revegetation, and re-contoured where required • at closure, the entire site area will be stabilized and contoured to blend with the surrounding landscape • conditions will be monitored over time to evaluate the success of the Closure and Reclamation Plan and, using adaptive management and newer proven methods as available, adjust the Plan, if necessary • De Beers will actively liaise with other mine operators in the Canadian Arctic to understand the challenges and successes they have encountered with respect to reclamation	Primary
	• physical hazards from the Project may increase the risk of injury/mortality to individual animals, which can affect caribou population size		Secondary

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and operations (e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities) Winter Access Road and Tibbitt-to-Contwoyto Winter Road	• dust deposition may cover vegetation and decrease abundance of forage for caribou (i.e., habitat quantity)	• a program of carbon and energy management will be implemented once the generators are commissioned. • generator efficiencies and equipment will be tuned for optimum fuel-energy efficiency • load management will allow for the optimization of the load factors on the generators • pumping circuits will be operated so that no unnecessary pumping takes place and pump efficiencies are optimized • power and heat use to reduce energy use, and therefore air emissions, will be reviewed on a regular basis • piping will be insulated for heat conservation • personnel arriving at or leaving the site will be transported by bus, therefore, reducing the amount of traffic between the airstrip and the accommodation complex • compact layout of the surface facilities will reduce traffic, and therefore dust and air emissions, around the site • watering of roads, airstrip, and laydown areas will facilitate dust suppression • enforcing speed limits will assist in reducing production of dust	Secondary
	• dust deposition may cover vegetation and change the amount of different quality habitats, and alter caribou movement and behaviour		Primary
	• dust deposition and air emissions may change the amount of different quality habitats (through chemical changes in soil and vegetation), and alter caribou movement and behaviour		Secondary
	• ingestion of soil, vegetation, and water, or inhalation of air that has been chemically altered by air emissions (including NOx and PAI deposition) or dust deposition, may affect caribou survival and reproduction		No Linkage
	• sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats, and alters caribou movement and behaviour, which can influence survival and reproduction	• compact layout of the surface facilities will limit the area disturbed at construction and reduce traffic around the site • a minimum flying altitude of 300 m above ground level (except during takeoff and landing and field work) will be maintained for cargo, passenger aircraft, and helicopter outside of the Project site • limit the amount of noise from the Project site to the extent practical • equipment noise sources will be limited by locating them inside buildings, to the extent possible	Primary

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and operations (continued) Winter Access Road and Tibbitt-to-Contwoyto Winter Road (continued)	• sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats, and alters caribou movement and behaviour, which can influence survival and reproduction (continued)	• downward directional and low impact lighting will be used to reduce light pollution • a minimum 200 m distance from wildlife will be maintained, when possible • environmental sensitivity training for personnel • at closure, the entire site area will be stabilized and contoured to blend with the surrounding landscape	Primary
	• aircraft/vehicle collisions may cause injury/mortality to individual animals	• personnel arriving at or leaving the site will be transported by bus, which will decrease the amount of traffic between the airstrip and the accommodations complex • speed limits will be established and enforced • wildlife will be provided with the "right-of-way" • levels of private traffic using the Winter Access Road will be monitored • the site will be designed to limit blind spots, where possible, to reduce the risk of accidental wildlife-human encounters • drivers will be warned when wildlife are moving through an area using signage and radio • safe, effective methods will be used to remove caribou from the airstrip before aircraft land or takeoff	Secondary
	• chemical spills (including de-icing fluid run off) may cause negative changes to health or mortality of individual animals	• processing of the kimberlite ore will be mechanical, with limited use of chemicals • hazardous, non-combustible waste and contaminated materials will be temporarily stored in the waste storage transfer area in sealed steel or plastic, wildlife-resistant drums, and shipped off-site for disposal or recycling • chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums, and stored in suitable sealed containers in the waste transfer area • the waste transfer storage area will include a lined and enclosed pad for the collection and subsequent return of hazardous waste to suppliers or to a hazardous waste disposal facility • emulsion materials will be stored at the emulsion plant where spills would be 100% contained within the building	No Linkage

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and operations (continued) Winter Access Road and Tibbitt-to-Contwoyto Winter Road (continued)	• chemical spills (including de-icing fluid run off) may cause negative changes to health or mortality of individual animals (continued)	• all fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard and placed in a lined and dyked containment area to contain any potential fuel spills • aviation fuel will be stored in self-contained, Underwriters Laboratories Canada-rated envirotanks mounted on an elevated pad at the air terminal shelter • aviation fuel for helicopters will be stored in sealed drums inside a lined berm area near the airstrip • to prevent accumulation and/or runoff of de-icing fluid sat the airstrip from aircraft de-icing operations, aircraft will be sprayed in a specific area that will be equipped with swales to collect excess fluids is necessary • puddles of de-icing fluid in the swales will be removed by vacuum truck and deposited into waste de-icing fluid drums for shipment to recycling facilities • an Emergency Response and Contingency Plan has been developed • spill containment supplies will be in designated areas • any spills will be isolated and immediately cleaned up by a trained spill response team consisting of on-site personnel who will be available at all times	No Linkage
Construction and operations (e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities) (continued)	• attractants to site (e.g., food waste, oil products) may increase predator numbers and increase predation risk	• separate bins will be located throughout the accommodations complex, processing plant, shops, and other facilities on-site for immediate sorting of domestic wastes • food wastes will be collected from the food waste bins in the accommodations complex, service complex, and other facilities and immediately placed and sealed in plastic bags; the plastic bags will be stored in sealed containers at each facility before transport directly to the incinerator storage area for incineration • chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums and stored in suitable sealed containers in the waste transfer area; chemicals that cannot be incinerated will be shipped off-site for disposal or recycling • incinerator ash from combustion of kitchen and office waste will go to the landfill • Inert solid waste will be deposited into a small area of the PK and mine rock piles or Fine PKC Facility • care will be taken to prevent the inclusion of wastes that could attract wildlife	Secondary

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and operations (continued)	• attractants to site (e.g., food waste, oil products) may increase predator numbers and increase predation risk (continued).	• two dual-chambered, diesel-fired incinerators will be provided for the incineration of combustible waste, including kitchen waste. The incinerators will also be used to burn waste oil. Incinerator ash will be collected in sealed, wildlife-resistant containers and transported to the landfill • a fenced area will be established for the handling and temporary storage of wastes. Fencing will be 2 m high, slatted-type, and partially buried to prevent animals from burrowing underneath • education and reinforcement of proper waste management practices will be required for all workers and visitors to the site • the efficiency of the waste management program and improvement through adaptive management will be reviewed as needed	Secondary
Mine Rock Management	• leaching of PAG mine rock may change the amount of different quality habitats, and alter caribou movement and behaviour.	• mine rock used to construct the dykes will be NAG. • any mine rock containing kimberlite will be separated from the tundra by at least 2 m of inert and kimberlite-free rock to prevent drainage with low pH • any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles in areas that will allow permafrost to develop or will be underwater when Kennady Lake is refilled. • till from ongoing pit stripping will be used to cover PAG rock placed within the interior of the structure to keep water from penetrating into the portion of the repository. • the PAG rock will be enclosed within enough non-acid generating (NAG) rock that the active frost zone (typically 2 m) will not extend into the enclosed material and water runoff will occur on the NAG rock cover areas • to confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed • minimal water is expected to penetrate to the PAG rock areas. • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock piles; the thickness of the cover layer is predicted to be sufficient so that the active freeze-thaw layer remains within the non-reactive mine rock • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development. The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen • mine rock piles will not be covered or vegetated to limit attraction of wildlife to them after Project closure	No Linkage
	• ingestion of soil, vegetation, or water that has been chemically altered by leaching of PAG mine rock may affect caribou survival and reproduction.		No Linkage

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Site Water Management	• release of seepage and surface water runoff (including erosion) from the Coarse PK Pile, Fine PKC Facility and mine rock piles may change the amount of different quality habitats, and alter caribou movement and behaviour	• the performance of the dykes will be monitored throughout their construction and operating life. Instrumentation monitoring together with systematic visual inspection will provide early warning of many conditions that can contribute to dyke failures and incidents. Additional mitigation will be applied, if required. • a system of ditches and sumps will be constructed, maintained, and upgraded throughout the operation phase of the Project to manage groundwater from the open pits • site runoff will flow naturally to the dewatered areas of Kennady Lake that will act as a control basin for storage of water. Within this basin, water flows can be managed. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms. • no substantial runoff and seepage from the mine rock piles is expected • a soil-bentonite slurry cutoff wall through a till fill zone placed over the overburden and the overburden to the bedrock surface has been adopted as the main seepage control for the diversion dyke separating Areas 7 and 8 • the cut-off wall for the dyke separating Areas 7 and 8 will be protected by a downstream filter zone and mine rock shell zone • for the retention dyke that separates Areas 3 and 4, Areas 5 and 6, and Areas 4 and 6, a wide till core has been selected as the main seepage control • the water retention dyke separating Area 2 and Lake N7, as well as diversion dykes dealing with Lakes A3, A4, B1, N13, D2, E1, and E3 will have a liner keyed into the competent frozen ground or bedrock to control seepage • the curved filter dyke to retain the particles in the fine PK placed in Areas 1 and 2 will be construction material and will be free of roots, organics, and other materials not suitable for construction • the PAG rock will be enclosed within enough NAG rock to prevent the active zone (typically 2 m) from extending into the enclosed material and water runoff will occur on the NAG rock cover areas • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development. The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen	No Linkage
	• ingestion of seepage and surface water runoff from the Coarse PK Pile, Fine PKC Facility and mine rock piles, or ingestion of soil, vegetation, or water that has been chemically altered by seepage and runoff, may affect caribou survival and reproduction		No Linkage

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Winter Access Road and Tibbitt-to-Contwoyto Winter Road	• road footprint decreases habitat quantity and may cause fragmentation, which can alter caribou movement and behaviour	• low profile roads will be used so that they do not act as a barrier to movement for wildlife • winter road snow berms will be removed so that they do not act as a barrier to movement for wildlife	Primary
	• road footprint may cause changes to the amount of different quality habitats (e.g., degradation to vegetation), and alter caribou movement and behaviour	• use of proven best practices for winter road construction	Secondary
	• increased access for traditional and non-traditional harvesting may alter caribou movement and behaviour, which can affect survival and reproduction	• seasonal use of Winter Access Road • prohibit firearms of any type, bows, and crossbows at the Project • prohibit hunting, trapping, harvesting, and fishing by employees and contractors and enforce this prohibition	Secondary
Dewatering of Kennady Lake	• ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect caribou survival and reproduction	• none	No Linkage
	• injury or mortality to individual animals getting trapped in sediments		Secondary
	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may affect the quantity of riparian habitat, which could alter caribou movement and behaviour	• Lake N11 is capable of accepting water at the proposed discharge rate without erosion damage to downstream watercourses	Secondary
	• dewatering may result in newly established vegetation on the exposed lakebed sediments and increase habitat quantity, which may alter caribou movement and behaviour	• dykes will be constructed to divert fresh water from entering areas of Kennady Lake • the height of the diversion structures will be designed such that the excess water from the surrounding sub-watershed will remain in the original N watershed • dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline two-year flood levels in downstream lakes and channels	Secondary
	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering Kennady Lake may cause injury/mortality to individual animals		No Linkage
	• changes in the timing of freeze and break-up downstream may alter caribou movement and behaviour, and could cause injury/mortality to individual animals		No Linkage

Table 7.4-1 Potential Pathways for Effects to Caribou (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Closure and Reclamation	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from the refilling of Kennady Lake may affect the quantity of riparian habitat, which could alter caribou movement and behaviour	• mined-out pits will be backfilled with PK and mine rock to reduce the time required for filling these portions of Kennady Lake because less water is required to refill the partially backfilled pits • Kennady Lake will be refilled using natural runoff and supplemental water drawn from Lake N11 • while fine PK is being discharged in the mined-out pits (primarily Hearne, but potentially 5034) process water will not be reclaimed from the pits. Instead the slurry discharge water will be used to accelerate the infill of the mined-out pits. The process will facilitate a more rapid re-filling and progressive reclamation of Area 6 within Kennady Lake • the 5034 Pit will be backfilled to the extent possible with mine rock and the remaining space will be eventually filled with water once mining in the Tuzo Pit is complete • the Tuzo Pit will be allowed to flood following the completion of the operations phase. Natural watershed inflows will be supplemented by pumping water from Lake N11 • the pumping rates are anticipated to be managed such that the total outflow from Lake N11 does not drop below the 1 in 5-year dry conditions	Secondary
	• long-term seepage from the Coarse PK Pile and mine rock piles may cause local changes to habitat quality, and alter caribou movement and behaviour	• the PAG rock will be enclosed within enough NAG rock to prevent the active zone (typically 2 m) from extending into the enclosed material and water runoff will occur on the NAG rock cover areas. • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development. The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen • the Coarse PK Pile will be shaped and covered with a layer of mine rock of a minimum 1 m to limit surface erosion • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock piles. The thickness of the cover layer is predicted to be sufficient so that the active freeze-thaw layer remains within the non-reactive mine rock • no substantial runoff and seepage from the mine rock piles is expected	No Linkage

CCME = Canadian Council of Ministers of the Environment; m = metre; NAG = non-acid generating; NO_X = nitrogen oxide; PK = processed kimberlite; PKC = processed kimberlite containment; PAG = potentially acid generating; PAI = potential acid input.

7.4.2.1 Pathways with No Linkage

A pathway may have no linkage if the activity does not occur (e.g., effluent is not released), or if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) environmental change and residual effects to caribou. The following pathways are anticipated to have no linkage to caribou, and will not be carried through the effects assessment.

7.4.2.1.1 Changes to Habitat Quality, Movement, and Behaviour

The pathways described in the following bullets have no linkage to habitat quality, movement, and behaviour of caribou. To be conservative, it is assumed that all habitats within the Project footprint that have not been used for construction or storage of material are available to wildlife but of no value.

- Leaching of potentially-acid generating (PAG) mine rock may change the amount of different quality habitats, and alter caribou movement and behaviour.

Any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles in areas that will allow permafrost to develop or will be underwater when Kennady Lake is re-filled (Table 7.4-1). Overburden, including lakebed sediments, will be used to cover any areas in the core of the mine rock piles where PAG mine rock is sequestered. The overburden (including sediments), which consist mainly of till, will provide a low permeability barrier that will limit infiltration and encourage water to flow over the surface of the mine rock pile, rather than through it. Water quality will be monitored on site, and additional mitigation will be applied if required to limit changes to the environment.

Further, the PAG rock will be enclosed with enough non-acid generating (NAG) rock that the active zone (typically 2 m) will not extend into the enclosed material, and water runoff will occur on the NAG rock cover areas (Table 7.4-1). While all water will not be stopped completely from penetrating the till and NAG rock envelop, the amounts that may penetrate deeper into the pile are expected to be trapped in void spaces and likely freeze. Minimal water is expected to penetrate to the PAG rock areas. To confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed (Table 7.4-1).

Experience at the Ekati Diamond Mine suggests that coarse kimberlite in direct contact with the naturally acidic tundra soils can lead to drainage with low pH. Therefore, barren kimberlite or mine rock mixed with kimberlite will not be placed directly on the tundra soils, and will be separated from the tundra by at least 2 m of inert and kimberlite-free clean rock (Table 7.4-1).

Progressive closure and reclamation of the mine rock piles will involve contouring and re-grading. The piles will not be covered or vegetated, consistent with the approaches in place at the Ekati Diamond Mine and Diavik Diamond Mine. Thermistors will be installed within the mine rock piles to monitor the progression of permafrost development (Table 7.4-1). The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are predicted to remain permanently frozen.

Overall, leaching of PAG mine rock is not expected to result in a detectable change to habitat quality relative to baseline conditions. Consequently, this pathway was determined to have no linkage to effects on the persistence of caribou populations, and continued opportunity for traditional and non-traditional use of caribou.

- Release of seepage and surface water runoff from the PK and mine rock piles may change the amount of different quality habitats, and alter movement and behaviour.
- Long-term seepage from the Coarse PK Pile and mine rock piles may cause local changes to habitat quality, and alter movement and behaviour.

Water-borne chemicals can adversely affect habitat quality through surface water runoff and seepage. Environmental design features and mitigation have been incorporated into the Project to eliminate or reduce potential effects from surface water runoff and seepage (Table 7.4-1). Runoff and seepage from the Fine PKC Facility, coarse PK and mine rock piles will not be released to the environment outside of the Project footprint during construction and operations, with the exception of a monitored discharge to Lake N11. Runoff from the coarse PK and mine rock plies will be contained in the affected basins and drain to either Area 3 or to one of the mined-out pits using natural drainage channels (Table 7.4-1). Natural drainage channels will provide opportunities for monitoring runoff quality, and additional mitigation will be applied if required to limit changes to the existing environment outside of the footprint.

The Coarse PK Pile will not be designed to have a single point of release for seepage and runoff. Any runoff will flow through natural channels within the watershed and be retained in the controlled basin associated with Area 4, which in later years represents the Tuzo Pit area. Groundwater entering the open pits during mining will be routed by ditches to a series of sumps (Table 7.4-1). Groundwater inflows collected in the pit dewatering systems will be discharged to either Area 5 or the process plant, where groundwater will be incorporated in the fine PK and pumped to the Fine PKC Facility.

As part of reclamation, the Fine PKC Facility will be covered with a 1 to 2 m layer of NAG mine rock (Table 7.4-1). The facility will be graded so that surface runoff will flow towards Area 3. The final geometry of the cover layer will be graded to limit ponding of water over the mine rock covered fine PK in Areas 1 and 2 of the Fine PKC Facility. Permafrost development in the Fine PKC Facility and underlying talik is expected to occur over time. Thermistors will be installed in the Fine PKC Facility to monitor the formation of permafrost in the solids. The Coarse PK Pile will also be shaped and covered with a layer of mine rock of approximately 1 m thick to limit surface erosion. Runoff will be directed to Area 4.

Overall, release of seepage and surface water runoff from the PK and mine rock piles, and long-term seepage from the Coarse PK Pile and mine rock piles is not expected to result in a detectable change to habitat quality relative to baseline conditions. Consequently, this pathway was determined to have no linkage to effects on the persistence of caribou populations, and continued opportunity for traditional and non-traditional use of caribou.

7.4.2.1.2 Changes to Survival and Reproduction

The pathways described in the following bullets have no linkage to the survival and reproduction of caribou.

- Ingestion of soil, vegetation, and water, or inhalation of air that has been chemically altered by air emissions (including nitrogen oxide [NO_X] and potential acid input [PAI] deposition) or dust deposition, may affect caribou survival and reproduction.
- Ingestion of soil, vegetation, or water that has been chemically altered by leaching of PAG mine rock may affect caribou survival and reproduction.
- Ingestion of seepage and runoff from the PK and mine rock piles, or ingestion of soil, vegetation, or water that has been chemically altered by seepage and runoff, may affect caribou survival and reproduction.
- Ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect caribou survival and reproduction.

Caribou within the RSA may be directly and indirectly exposed to airborne chemicals through fugitive dust and air emissions from the Project. Direct exposure to chemicals includes inhalation of fugitive dust and air emissions, drinking of water, inadvertent ingestion of soil while foraging or grooming, and ingestion of vegetation. Airborne chemicals may deposit directly onto the surface of plants or may deposit onto soils and be subsequently taken up through plant roots (vascular plants) or tissues (lichen). Therefore, caribou may be indirectly exposed to chemicals from fugitive dust and air emissions by intentionally or inadvertently consuming vegetation that has accumulated chemicals through the soil or air.

There is a general concern that caribou may drink from the collection ponds or associated containment ditches, which may result in negative changes to caribou health. As such, environmental design features have been incorporated into the Project to eliminate or reduce potential effects from surface water runoff and seepage (Table 7.4-1). Runoff and seepage from the Fine PKC Facility, Coarse PK and mine rock piles will not be released beyond the active mined area during construction and operations, with the exception of a monitored discharge to Lake N11. Runoff from the mine rock facilities will be contained and flow to either Area 3 or to one of the mined-out pits using natural drainage channels (Table 7.4-1). Natural drainage channels will provide opportunities for monitoring runoff quality, and additional mitigation will be applied if required to limit changes to the existing environment outside of the footprint. Any runoff from the Coarse PK Pile will flow through natural channels within the watershed and be retained in the controlled basin associated with Area 4, which in later years represents the Tuzo Pit area (Table 7.4-1).

Any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles. Overburden, including lakebed sediments, will be used to cover any areas in the core of the mine rock piles where potentially reactive mine rock is sequestered (Table 7.4-1). Limited water is expected to penetrate to the PAG rock areas. To confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed (Table 7.4-1). Experience at the Ekati Diamond Mine suggests that coarse kimberlite in direct contact with the naturally acidic tundra soils can lead to drainage with low pH. Therefore, barren kimberlite or mine rock mixed with kimberlite will not be placed directly on the tundra soils, and will be separated from the tundra by at least 2 m of inert and kimberlite-free clean rock.

As part of reclamation, the Fine PKC Facility will be covered with a 1 to 2 m layer of NAG mine rock. The facility will be graded to encourage surface runoff and limit infiltration. Progressive closure and reclamation of the mine rock piles will involve contouring and re-grading. The piles will not be covered or vegetated, consistent with the approaches in place at the Ekati Diamond Mine and Diavik Diamond Mine. Thermistors will be installed within the Coarse PK and mine rock piles and the Fine PKC Facility to monitor the progression of permafrost development (Table 7.4-1). The Coarse PK Pile will also be shaped and covered with a layer of mine rock of approximately 1 m thick to limit surface erosion and infiltration into the pile (Table 7.4-1). The 5034 Pit will be backfilled to the extent possible with mine rock and fine PK, respectively. All pits, including the 5034, Hearne, and Tuzo pits, will be allowed to flood following the completion of the operation phase.

While lake-bed sediments will be exposed following the dewatering of Kennady Lake, it is predicted they will form a hardpan crust and will not be a substantial source of dust (Section 11.7). However, dust from Project activities may settle on the exposed portion of the lake-bed sediments, and be inadvertently ingested by caribou foraging in this area. Caribou may be indirectly exposed to chemicals by consuming vegetation that has accumulated chemicals through the sediment.

An ecological risk assessment was completed to evaluate the potential for adverse effects to individual animal health associated with exposure to chemicals from the Project. Emission sources considered in the assessment included those outlined above (i.e., fugitive dust, air emissions, surface water runoff and seepage, leaching of PAG rock, and exposed sediments), and potential exposure pathways included changes in air, water, soil, and vegetation quality. The result of the assessment was that no impacts were predicted for caribou. Consequently, the pathways described above were determined to have no linkage to effects on the persistence of caribou populations, and continued opportunity for traditional and non-traditional use of caribou.

- Chemical spills (including de-icing fluid runoff) within the Project footprint, the airstrip, or along the Winter Access Road or Tibbitt-to-Contwoyto Winter Road may cause negative changes to health or mortality of individual animals.

Chemical spills have not been reported as the cause of wildlife mortality at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, or Snap Lake Mine (BHPB 2010; Tahera 2007; DDMI 2010; De Beers 2010). Chemical spills are usually localized, and are quickly reported and managed. Mitigation practices identified in the Emergency Response and Contingency Plan (Section 3, Appendix 3.I, Attachment 3.I.1), and environmental design features will be in place to limit the frequency and extent of chemical spills at the Project, and along the winter roads (Table 7.4-1). The following are examples of environmental design features and mitigation practices that will be used to reduce the risk to wildlife from chemical spills.

- Hazardous, non-combustible waste, and contaminated materials will be temporarily stored in the waste storage transfer area in sealed steel or plastic, wildlife-resistent drums, and shipped off-site for disposal or recycling.
- Chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums and stored in suitable sealed containers in the waste transfer area.
- All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard.
- The design of the containment area for tanks will be based on the requirements of the Canadian Council of Ministers of the Environment (CCME) *Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products* (CCME 2003 internet site), the National Fire Code of Canada, and any other standards that are required.
- Aviation fuel for helicopters will be stored in sealed drums inside a lined berm area at the helipad.
- Aircraft will be sprayed with de-icing fluid in a specific area at the airstrip that will be equipped with swales to collect excess fulids if necessary.
- Puddles of de-icing fluids in the swales will be removed by a vacuum truck and deposited into de-icing fluid drums for shipment off-site and recycling if necessary.
- Soils will be sampled during closure and analyzed for contaminants. Any contaminated soil will be excavated and either permanently encapsulated in a secure area, treated on-site to an acceptable standard, or stored in appropriate sealed containers for off-site shippment and disposal.
- Any spills will be isolated and immediately cleaned up by a trained spill response team consisting of on-site personnel who will be available at all times.

The implementation of the Emergency Response and Contingency Plan, environmental design features, mitigation, and monitoring programs is expected to result in no detectable change to health or mortality of caribou. Consequently, this pathway was determined to have no linkage to effects on the persistence of caribou populations, and continued opportunity for traditional and non-traditional use of caribou.

- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may cause injury/mortality to individual animals.

Caribou mortality from stream flooding is not anticipated to increase beyond the number of animals drowning that occur naturally. Dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels (Table 7.4-1). Consequently, caribou mortality from dewatering of Kennady Lake is determined to have no linkage to effects on the persistence of caribou populations.

- Changes in the timing of freeze and break-up downstream may alter caribou movement and behaviour, and could cause injury/mortality to individual animals.

Dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels (Table 7.4-1). It is anticipated that pumping will begin in June immediately after ice-out and will continue until ice begins to form on the shorelines. Dewatering and pumped discharge over the life of the Project may result in a thaw period extending into November for Lake N11 and the interlake system. However, the extended thaw period is not anticipated to affect the movement and behaviour of caribou. For example, caribou generally disperse throughout their winter range beginning in November. It is expected that the dewatering of Kennady Lake will have no measurable influence on the freeze and break-up cycle downstream. Consequently, this pathway was determined to have no linkage to effects on the persistence of caribou populations and continued opportunity for traditional and non-traditional use of caribou.

7.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on caribou relative to baseline or guideline values (e.g., a slight increase in a soil quality parameter above CCME guidelines that would not affect wildlife health). The following pathways are anticipated to be secondary, and will not be carried through the effects assessment.

7.4.2.2.1 Changes to Habitat Quantity and Fragmentation

The pathways described in the following bullets are expected to result in minor changes to habitat quantity and fragmentation.

- Dust deposition may cover vegetation and decrease abundance of forage for caribou (i.e., habitat quantity).

Accumulation of dust (i.e., total suspended particulate [TSP] deposition) produced from the Project may result in a local direct changes to the quantity of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition from the Project. Air quality modeling was completed for the baseline case, construction case, and application case. The baseline case also includes emissions from the Snap Lake Mine (Section 11.4).

As per the Terms of Reference, a construction case was modeled for the Project. Typically, the construction phase will have lower emissions than the operations phase of a project. As expected, the construction case emissions are much lower than the application case emissions, and therefore, result in lower predictions than those for the application case (Section 11.4). The assessment of the application case (i.e., operations) is anticipated to capture the maximum effects resulting from the Project.

Sources of dust deposition modelled in the application case include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile, and Fine PKC Facility), and vehicle traffic along the Winter Access Road (Section 11.4). Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 7.4-1). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression (Table 7.4-1). Although these environmental design features and mitigation will be implemented to reduce dust deposition, assumptions incorporated into the model are expected to contribute to conservative estimates of deposition rates (Section 11.4).

The results of the air quality modelling predicted that the maximum annual dust deposition resulting from the Project is 6,292 kilograms per hectares per year (kg/ha/y) within the Project development area boundary and 5,520 kg/ha/y outside of the Project development area boundary (Table 7.4-2). The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum deposition rate for dust is predicted to occur within 100 m of the Project footprint. The strongest effects from dust are generally confined to the immediate area adjacent to the dust source, such as roads (Walker and Everett 1987).

Table 7.4-2 Summary of Key Predicted Annual Deposition Rates from the Project

Substance	Criteria	Maximum Predicted Deposition Rate		
		Local Study Area Baseline	Application	
			Outside Project development area boundary	Distance to Maximum from the Project development area boundary
TSP Annual	none	0.00 kg/ha/y	5,520 kg/ha/y	0 m
PAI Annual	0.25 keq/ha/y [a]	0.06 keq/ha/y	0.96 keq/ha/y	0.2 m

[a] Criteria is based on the Clean Air Strategic Alliance (CASA 1999).
m = metre; kg/ha/y = kilograms per hectare per year; keq/ha/y = kiloequivalent per hectare per year; TSP = total suspended particulate PAI = potential acid input.

Increased dust deposition has been documented to have varying effects on plants (Forbes 1995; Walker and Werbe 1980; Spatt and Miller 1981; Walker and Everett 1987). However, Auerbach et al. (1997) states that, although the species composition may change and the aboveground biomass is lowered due to dust deposition, the ground cover is still maintained. Some species such as cloudberry, willow, and cottongrass were observed to be more abundant as a result of dust deposition (Forbes 1995).

Overall, direct effects from dust deposition are predicted to be largely confined to the Project footprint and are anticipated to result in a minor change to habitat quantity relative to baseline conditions (secondary pathway; Table 7.4-1). Subsequently, residual effects to the persistence of caribou populations, and the continued opportunity for traditional and non-traditional use of caribou are predicted to be negligible.

- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may affect the quantity of riparian habitat, which could alter caribou movement and behaviour.

- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from refilling of Kennady Lake may affect the quantity of riparian habitat, which could alter caribou movement and behaviour.

Changes to downstream habitat quantity (i.e., riparian vegetation) from the discharge of water to Lake N11 (i.e., throughout construction and operations) are anticipated to be minor. Environmental design features and mitigation have been included to limit erosion, and subsequently, reduce the potential for loss of riparian habitat (Table 7.4-1). For example, discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels. These levels were selected to reduce potential bank erosion and limit the changes to habitat quantity (Section 9).

Construction of dykes will cause changes to drainage flow patterns and surface water elevations in some lakes. For example, the construction of Dykes E and D will divert drainage flows from Lake B1 to N6 (Section 3). Construction of Dykes F and G will divert water from Lakes D3, D2, E1, and N14 through Lake N17. The construction of Dyke C will divert water from Lake A3 through Lake N9. In addition to diversion of drainage flows, the construction of these dykes will also raise baseline surface water elevations in Lakes D2, D3, E1, and A3. For example, it is anticipated that surface water elevations in Lakes D2 and D3 will increase from approximately 424.2 m and 425.4 m at baseline, respectively, to 427.0 m throughout the construction and operational phases (Section 3). Surface water elevation in Lake E1 is anticipated to increase from 425.2 m to 426.0 m. The greatest increase in lake levels is predicted to be in Lake A3 where surface water elevations will increase from 423.0 m to 426.5 m after the construction of Dyke C. Because of the anticipated changes in lake levels, riparian vegetation surrounding Lakes D2, D3, E1, and A3 will be removed during the construction of the diversion dykes, prior to flooding (Section 3).

Vegetation ecosystems and plants downstream of Kennady Lake that could be affected by the dewatering process include sedge-dominated wetlands and riparian areas, and upland tundra comprised primarily of dwarf woody vegetation (Section 11.7). Wetlands and riparian plant species are better adapted to fluctuating water levels and should be able to withstand and recover from high water level conditions more successfully than their upland counterparts. Upland ecosystem types with more freely drained soils and dwarf vegetation will likely be less resilient to prolonged flooding, and are expected to display a more adverse response to these conditions (Section 11.7). In addition, the margins of Kennady Lake are composed primarily of boulder and cobble substrates (Section 8). Portions of the lake margin that are vegetated may die back if they are sensitive to water table declines resulting from dewatering. However, as the margins become drier, the species composition may shift to plants more commonly found in upland areas.

The progressive reclamation strategy will be extended to the water management of Kennady Lake, where portions of the lake will be isolated and brought back to original water levels and compliant water quality as quickly as possible. The closure water management plan requires annually pumping water from Lake N11 to Area 3 to reduce the overall time for the closure phase. The pumping rates are anticipated to be managed such that the total outflow from Lake N11 does not drop below the 1 in 5-year dry conditions (Table 7.4-1). At closure, dykes will be breached to return drainage flows and water levels to baseline conditions. While most changes are predicted to revert back to natural conditions, it is anticipated that the drainage flow from Lake A3 to Lake N9 will be permanent and the surface water elevation in Lake A3 will remain above baseline conditions (Section 3).

Overall, the increase in drainage flows and surface water elevations associated with the dewatering and refilling of Kennady Lake is localized and is expected to have a minor influence on habitat quantity for caribou relative to baseline conditions. Therefore, the residual effects to the persistence of caribou populations, and continued traditional and non-TLU of caribou from the dewatering and refilling of Kennady Lake are predicted to be negligible.

- Dewatering may result in newly established vegetation on the exposed lakebed sediments.

The development of the Project will require the dewatering of Kennady Lake, resulting in the exposure of a portion of the lake-bed. Although it is anticipated that the sediment would solidify and form a hardpan crust, there is potential for vegetation to establish on the exposed lake-bed sediments. The exposure of bare, nutrient-rich lakebed sediments can provide a substrate that may favour the establishment of rapid colonizing plants, some of which could be weedy, invasive species (Shafroth et al. 2002). If the substrate remains moist during the initial stages of plant colonization, then riparian plant species may become established on the exposed lakebed. Over time as the substrate becomes drier, the species composition may shift to plants more commonly found in upland areas (Section 11.7).

The lack of fine sediment around the periphery of Kennady Lake, and the consistent presence of boulder and cobble through the shallow areas of the lake should effectively limit colonization of the lakebed by terrestrial vegetation through vegetative propagation (i.e., root growth). Vegetation is more likely to be established through seed dispersal and subsequent germination, with the seeds being dispersed across the nearshore rocky habitat to colonize the fine sediments that are currently located in the deeper sections of the lake (Section 8). Vegetation is expected to establish slowly and coverage would be patchy. Initial colonizers are thought to be graminoids (grasses and sedges).

The anticipated effects on riparian vegetation will be localized, and it is expected that dewatering will result in a minor change to the quantity of forage available for caribou relative to baseline conditions (secondary pathway; Table 7.4-1). Therefore, the residual effects to the persistence of caribou populations and the continued opportunity for traditional and non-traditional use of caribou resulting from the dewatering of Kennady Lake are predicted to be negligible.

7.4.2.2.2 Changes to Habitat Quality, Movement, and Behaviour

The pathways described in the following bullets are expected to result in minor changes to habitat quality, movement, and behaviour of caribou.

- Dust deposition and air emissions may change the amount of different quality habitats (through chemical changes in soil and vegetation), and alter caribou movement and behaviour.

Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (Section 11.4). Air quality modeling was completed for the baseline case, the construction case, and the application case (Section 11.4). The baseline case includes background concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM), as well as background PAI depositions from the regional modelling network. The baseline case also includes air emissions from the Snap Lake Mine (Section 11.4).

Sources of dust deposition and air emissions modelled in the application case (maximum effect case) include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile and Fine PKC Facility), and vehicle traffic along the Winter Access Road (Section 11.4). Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 7.4-1). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression. In addition, programs will be instituted to review power and heat use to reduce energy use. Although these environmental design features and mitigation will be implemented to reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates (Section 11.4).

Haul trucks travelling on the Winter Access Road have the potential to transfer dust from vehicles and loads during the winter months (e.g., dust deposited on wheels and undercarriage while at mine sites and in Yellowknife). However, the relative contribution of these loads to the overall dust accumulation in the area along the roads is considered to be negligible (Section 11.4). During the winter, dust that accumulates on snow may settle on vegetation during the spring melt. Although snow melting does not result in “washing away” of dust, the dust that has accumulated on snow during the winter may be diluted during snow melt and spring freshet, and eventually removed by rain (Section 11.7). The air emissions from the Winter Access Road were included in the application case and assumed that the road was in operation for 63 days (Section 11.4). In general, emissions from the Winter Access Road are small, and if extended over whole the year, a negligible effect on annual depositions was predicted (Section 11.4). Annual emissions from the Winter Access Road are anticipated to result in no detectable changes to vegetation (Section 11.7).

The results of the air quality modelling predicted that the maximum annual dust deposition resulting from the Project is 6,292 kg/ha/y within the Project footprint and 5,520 kg/ha/y outside of the Project footprint (Table 7.4-2). The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum predicted dust deposition rate outside the Project development area boundary is predicted to occur within 100 m of the Project footprint (Table 7.4-2). The strongest effects from dust are generally confined to the immediate area adjacent to the dust source, such as roads (Walker and Everett 1987). Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50-m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that most of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road.

The PAI modelling results indicate maximum deposition rates of 0.06 kiloequivalent per hectare per year (keq/ha/y) and 0.96 keq/ha/y beyond the Project development area boundary for the baseline and application case, respectively (Table 7.4 2). The maximum deposition occurs near the three mine pits and around of the plant site, where haul road emissions are coupled with those from the power generation plant. Interpretation of PAI predictions is based on the Clean Air Strategic Alliance (CASA 1999) deposition loading benchmarks, including the critical threshold of 0.25 keq/ha/y for the most sensitive ecosystems. The area outside the Project development area boundary (i.e., Project footprint) that is predicted to have above the critical load of 0.25 keq/ha/y is estimated at 169 hectares (ha), extending up to 500 m from the Project development area boundary.

The air emissions modelling results show that predicted peak concentrations for SO_2 are below the Ambient Air Quality Standards for NWT for the application case (Table 7.4-3). Annual peak concentrations for NO_2 are predicted to slightly exceed guidelines at 64.3 micrograms per cubic metre (µg/m^3). The area of exceedances is predicted to occur near the South Mine Rock Pile and the haul roads along the south side of the development area (Table 7.4-3). The Annual maximum TSP concentration outside the Project development area boundary is predicted to be 604.8 µg/m^3, compared to the NWT standard of 60 µg/m^3. The area that is predicted to exceed the NWT standard extends no further than approximately 1 km from the Project development area boundary.

Table 7.4-3 Summary of Key Predicted Peak Annual Air Quality Concentrations in the Regional Study Area

Substance	Criteria ($\mu g/m^3$)	Maximum Predicted Concentration			
		Baseline		Application	
		Concentrations in the Regional Study Area ($\mu g/m^3$)	Distance to Peak Predictions (km)	Concentrations Outside Project Development Area Boundary ($\mu g/m^3$)	Distance to Peak Predictions (km)
NO_2 Annual	60	11.9	86.1	**64.3**	1.6
SO_2 Annual	30	3.0	86.1	4.8	2.9
TSP Annual	60	7.1	8.5	**604.8**	1.6
$PM_{2.5}$ Annual	none	2.2	86.1	24.1	1.6

Note: A predicted value that exceeds a criterion is accentuated in bold.
$\mu g/m^3$ = micrograms per cubic metre; NOx = nitrogen oxides; NO_2 = nitrogen dioxide. SO_2 = sulphur dioxide.
$PM_{2.5}$ = fine particles in the (ambient) air 2.5 micrometres or less in size. TSP = total suspended particulate.

Although concentrations are predicted to be above baseline conditions, the anticipated changes to habitat quality are localized and considered minor. The maximum predicted annual TSP deposition rate is expected to occur within 100 m of the Project footprint. When comparing changes to the elemental concentrations in soil from TSP deposition, predictions are below CCME (2007) soil quality guidelines. Therefore, changes to the chemical content of soil should not affect the soils ability to support vegetation (habitat quality). In addition, the deposition predictions are considered to be conservative, and therefore the presented deposition rates are likely overestimated. Overall, changes in habitat quality (and associated changes to caribou movement and behaviour) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions (secondary pathway; Table 7.4-1). Consequently, residual effects to the persistence of caribou populations and the continued opportunity for traditional and non-traditional use of caribou from dust deposition and air emissions are predicted to be negligible.

- Road footprint may cause changes to the amount of different quality habitats (e.g., degradation to vegetation), and alter caribou movement and behaviour.

Construction and operation of the Winter Access Road connecting the Project with the Tibbitt-to-Contwoyto Winter Road will follow best practices (e.g., use of snow or ice pads of sufficient thickness to limit damage to overland portages between lakes, and discontinued use of the road when the ground surface becomes too soft). These practices are implemented in the design, construction, and operation of the Tibbitt-to-Contwoyto Winter Road and have proven to be successful in limiting the effects to vegetation (EBA 2001) (Section 11.7). Only minor compression of vegetation comprising the portages is anticipated. Some degradation to vegetation along the boundary between lakes and shorelines may also occur.

Overall, the Winter Access Road is anticipated to have a minor influence on habitat quality relative to baseline conditions (secondary pathway; Table 7.4-1). Therefore, the residual effects to the persistence of caribou populations are predicted to be negligible.

7.4.2.2.3 Changes to Survival and Reproduction

The pathways described in the following bullets are expected to result in a minor change to the survival and reproduction of caribou.

- Physical hazards from the Project may increase the risk of injury/mortality to individual animals, which can affect caribou population size.
- Injury or mortality to animals getting trapped in exposed sediments.

The presence of physical hazards (e.g., open pits, ditches, blasting, and exposed sediments) on-site may result in the injury or mortality of individual caribou. However, the implementation of environmental design features (Table 7.4-1) and the Wildlife Effects Mitigation and Management Plan (Appendix 7.I) are expected to decrease the risk to animals from physical hazards on-site.

  – Blasting in pits will be carefully planned and controlled to reduce the throw of ore bearing materials.
  – At closure, the entire site area will be re-contoured to reduce hazards to wildlife.
  – Non-salvageable and non-hazardous components from demolition of the site buildings, structures, and equipment will be dismanteled and deposited in the inert materials landfill within the mine rock pile, and will then be covered with a layer on NAG mine rock.
  – Ramps to facilitate the access and egress of caribou form the mine rock piles will be constructed during closure.

Wildlife deterrent actions will be also implemented by knowledgeable and trained personnel. The goal of these deterrents is to respond to wildlife situations using humane management methods in ways that will keep both humans and animals safe. Although caribou mortalities have occurred near pits and facilities, there have been no confirmed mortalities as a result of direct interaction with pits or containment facilities at other mines in the NWT. Mortalities associated with containment facilities are presumed to be the result of predation by wolves or bears (BHPB 2006, 2007).

The frequency of mine-related mortality on caribou is extremely low. For example, at the Lupin Mine, three mine-related caribou deaths were recorded from 1980 through 1996. At the Diavik Diamond Mine, a caribou became entangled in an electric fence and was then killed by a grizzly bear, but no other mine-related mortalities have been recorded from 1998 through 2009 (DDMI 2010). At the Ekati Diamond Mine, six caribou have been entangled in the electric fence surrounding the airstrip from 2001 through 2009 and four of these animals died (BHPB 2005, 2010). The Snap Lake Mine has had no incidents with caribou (injury or mortality) during the ten-year period from advanced exploration through construction (De Beers 2010). Since 1995, one caribou died while becoming entangled in an electric fence at the Gahcho Kué Project. There is no record of injury or mortality to caribou from becoming trapped in PK fines in the PK containment areas at existing mine sites.

Although there is a potential for mortality or injury to occur, the implementation of the Wildlife Effects Mitigation and Management Plan is anticipated to reduce the risk of caribou mortality from physical hazards on-site. Changes in mortality are predicted to be minor relative to baseline conditions (secondary pathway; Table 7.4-1). As such, mortality from physical hazards on-site is expected to have a negligible residual effect on the persistence of caribou populations and the continued opportunity for traditional and non-traditional use of caribou.

- Aircraft/vehicle collisions may cause injury or mortality to individual animals.

There is potential for an increase in the risk of injury or death to caribou through collisions with aircraft and on-site vehicles. Caribou have been observed bedding or travelling on roads and airstrips. Road and airstrip traffic mitigation appear effective, as no caribou have been killed in vehicle or aircraft collisions at mine sites (Tahera 2007; BHPB 2010; DDMI 2010; De Beers 2010).

Similar to other mining operations in the region, access to the Project will be via a 120 km winter spur road, connecting with the Tibbitt-to-Contwoyto Winter Road at kilometre 271, just north of Lake of the Enemy. The Winter Access Road will typically be in operation for about eight to 12 weeks per year. From 1998 to 2007, traffic volume on the Tibbitt-to-Contwoyto Winter Road increased from 2,543 loaded trucks in 2000 to 10,922 in 2007 (GNWT 2006, internet site; Tibbitt-to-Contwoyto Winter Road Joint Venture 2007, internet site). Traffic volume on the Tibbitt-to-Contwoyto Winter Road decreased during 2008 through 2010 (3,506 northbound loads in 2010; Section 11.8.2.5).

The predominant factors that contribute to road-related wildlife deaths are traffic volume and vehicle speed (EBA 2001). These factors directly affect the success of an animal reaching the opposite side of the road. An increase in either factor reduces the probability of an animal crossing safely (Underhill and Angold 2000). However, implementation of the Winter Road Policy, Rules and Procedures for the Tibbitt-to-Contwoyto Winter Road is anticipated to reduce the potential for injury/mortality of wildlife from vehicle collisions (Tibbitt to Contwoyto Winter Road Joint Venture 2000). For example, from 1996 to 2009, there have been three reported road-related wildlife mortalities along the Tibbitt-to-Contwoyto Winter Road. In 1996, a wolverine was killed by a pick-up truck (Banci, pers. comm. in EBA 2001). In March 1999, five caribou were killed by a grocery (meat) truck on a portage near Gordon Lake (EBA 2001). In 2009, a red fox was killed on the Tibbitt-to-Contwoyto Winter Road (Madsen 2010, pers. comm.)]

Numerous mitigation policies and practices are implemented at mines to prevent vehicle collisions with caribou (Tahera 2007; BHPB 2010; De Beers 2010; DDMI 2010). These strategies are outlined in the Wildlife Effects Mitigation and Management Plan (Appendix 7.I), and are similar to management practices and policies implemented at other diamond mines in the NWT and Nunavut. The following environmental design features and mitigation are expected to limit the risk from vehicle and aircraft collisions with caribou.

- Personnel arriving at or leaving the site will be transported by bus, which will reduce the amount of traffic between the airstrip and the accommodation complex.
- Levels of private traffic using the Winter Access Road will be monitored.
- All wildlife have the “right-of-way”.
- The site will be designed to limit blind spots where possible to reduce the risk of accidental wildlife-human encounters.
- Speed limits will be established and enforced.
- Drivers will be warned when wildlife are moving through an area using signage and radio.
- Safe, effective methods will be used to remove caribou from the airstrip before aircraft land or takeoff.

The implementation of the Winter Road Policy, Rules and Procedures, and the Wildlife Effects Mitigation and Management Plan is anticipated to limit caribou mortality from vehicle collisions along the Winter Access Road. Based on the success of mitigation and management practices used at operating mines in the NWT, the environmental design features and mitigation implemented for the

Project are anticipated to reduce caribou mortality from vehicle and aircraft collisions. As such, caribou mortality from vehicle and aircraft collisions is expected to have a negligible residual effect on the persistence of caribou populations, and the continued opportunity for traditional and non-traditional use of caribou.

- Attractants to site (e.g., food waste, oil products) may increase predator numbers and increase predation risk.

Carnivores have a keen sense of smell and can be attracted from long distances to the Project if food items are frequently present. Carnivores are also attracted to aromatic waste material such as oil and aerosols, and to infrastructure that can serve as a temporary refuge to escape extreme heat or cold.

Environmental design features and mitigation have been established to reduce the attraction of wildlife to the Project. Based on the results from monitoring programs for other mining projects in the NWT and Nunavut, it is anticipated that not all wildlife will be deterred from the site. For example, wildlife effects monitoring programs completed at the Ekati Diamond Mine (2000 through 2009), the Diavik Diamond Mine (2002 through 2009), the Jericho Diamond Mine (2000, 2005 through 2007), and the Snap Lake Mine (2001 through 2009) have reported attractants (e.g., non-burned food items, oil products, and food packaging) in the landfill. Most of the animals and sign observed during these landfill surveys were associated with foxes. Grizzly bears, wolverine, and wolf tracks were occasionally observed (Section 11.9).

Human presence and activities can alter interspecific interactions, such as rates of predation (Bergerud et al. 1984; Rich et al. 1994; James and Stuart-Smith 2000; Marchand and Litvaitis 2004). The increased presence of carnivores can result in an increased frequency of predation on caribou, and change survival and reproduction. However, environmental design features and mitigation strategies have been established to reduce the numbers of carnivores attracted to the Project (Table 7.4-1). These strategies are outlined in the Wildlife Effects Mitigation and Management Plan, and are similar to management practices and policies implemented at other diamond mines in the NWT and Nunavut. The following wildlife-specific environmental design features are included in the Waste Management Plan (Section 11.9) and the Wildlife Effects Mitigation and Management Plan and should reduce the numbers of carnivores attracted to the Project.

  - Education and reinforcement of proper waste management practices to all workers and visitors to the site will be provided.

- Separate bins will be located throughout the accommodations complex, processing plant, shops, and other facilities on-site for immediate sorting of domestic waste.
- Food waste will immediately be placed and sealed in plastic bags. The plastic bags will be stored in sealed, wildlife-resistant containers before transport directly to the incinerator storage area for incineration.
- Incinerator ash from combustion of kitchen and office waste will be stored in wildlife-resistant containers and transported to the landfill.
- The landfill will be covered regularly with crushed mine rock.
- A fenced area will be established for the handling and temporary storage of wastes. Fencing will be 2 m high, slatted-type, and partially buried to prevent animals from burrowing underneath.
- People will be educated on the risks associated with feeding wildlife and careless disposal of food garbage.
- Ongoing review of the efficiency of the waste management program and improvement through adaptive management.

At the Snap Lake Mine, there were no reported waste or attractant-related incidents or mortalities to carnivores from 1999 to 2009 (Golder 2008b; De Beers 2009, 2010), which indicates a low frequency of attractants at site. The implementation of the Waste Management Plan and the Wildlife Effects Mitigation and Management Plan are expected to limit the numbers of carnivores attracted to the site. Based on the effectiveness of mitigation at the Snap Lake Mine, predation of caribou by grizzly bears and wolves is not anticipated to increase above baseline conditions as a result of attractants to the site. Therefore, caribou mortality from increased predation is expected to have a negligible residual effect on the persistence of caribou populations.

- Increased access for traditional and non-traditional harvesting may alter caribou movement and behaviour, which can affect survival and reproduction.

Because the Winter Access Road leading to the Project connects with the Tibbitt-to-Contwoyto Winter Road, the improved access may lead to an increase in harvest rates on caribou. Caribou is the most important resource harvested by Aboriginal groups with traditional lands near the Project (Section 7.3.3.3.1). Case et al. (1996) estimated that between 14,500 and 18,500 caribou were harvested annually from 1982 to 1995. However, there is some belief that these numbers are substantially overestimated, and that the harvest in more recent years is well below these values (Adamczewski et al. 2009).

Non-Aboriginal harvest of caribou is regulated by the GNWT ENR. Non-resident hunters can only harvest caribou during August 15 to November 30 (ENR 2010b, internet site), which is not within the winter road season. The resident harvest occurred in two peaks: one in the fall when the caribou are near the treeline (August 15 to November 15) and another in winter when the herd is accessible by ice road for part of the section (November 15 to April 30).

Resident hunters were allowed to harvest up to two barren-ground caribou, males only, each year. The numbers of barren-ground caribou harvested by resident hunters fluctuated annually from 1983 to 2008, peaking at 2,576 bulls during the 1990-91 license season, and averaging 1,194 bulls across all years (± 660 SD) (Figure 7.3-6). Compared to the resident harvest, the outfitter harvest (i.e., non-resident harvest) was generally lower (mean of 733 ± 270 SD), but increased from 1990 to 2002, and has since been decreasing. The number of bulls harvested by non-residents in 2009 was only 223 animals.

In December 2009 interim emergency actions were put in place to help conserve the Bathurst herd (ENR 2009, internet site). Beginning January 1, 2010, barren-ground caribou commercial/meat tag, resident and non-resident harvesting was closed in the North Slave and South Slave regions and all hunting was closed in a new no-hunting conservation zone established north of Yellowknife where the Bathurst herd winters (Tlicho Government and ENR 2010). The new zone includes the Tibbitt-to-Contwoyto Winter Road, the Winter Access Road, and all diamond mines in the NWT, including the Project. A current proposal under review suggests revising the annual allowable hunt to 300 animals for Aboriginal hunters within the current no hunting zone, but no resident or non-resident hunting in the North Slave and South Slave regions as well as the new conservation zone (Tlicho Government and ENR 2010).

Although no harvest data exists for the Tibbitt-to-Contwoyto Winter Road, Ziemann (2007, internet site) tracked the level of hunting activity for 2004 through 2006. The number of vehicles travelling for hunting on the Tibbitt-to-Contwoyto Winter Road showed a decline from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann 2007). Decreases in hunting traffic may be due to high volumes of mine-related vehicles on the road (e.g., 2,543 loaded trucks in 1998 versus 11,740 in 2007 [Section 11.8.2.5]).

Increased access from the Winter Access Road may increase the number of individuals harvested from the RSA by residents and Aboriginals. However, the increase in access to the region associated with the winter roads is limited to eight to 12 weeks each year, and should result in minor changes to the annual harvest rate of caribou relative to baseline conditions. The number of animals harvested by residents and non-residents is regulated, and the Winter Access

Road will not influence accessibility to caribou for non-residents. Policies implemented by De Beers will prevent people at the Project site from using the Winter Access Road for hunting caribou (while they are on-site). Therefore, increased access for harvesting along the winter roads is expected to have a negligible residual effect on the persistence of caribou populations, and the continued opportunity for traditional and non-traditional use of caribou.

7.4.2.3 Primary Pathways

The following primary pathways are analyzed and classified in the effects assessment.

7.4.2.3.1 Changes to Habitat Quantity and Fragmentation

- Direct loss and fragmentation of habitat from the physical footprint of the Project may alter caribou movement and behaviour.
- Winter road footprint decreases habitat quantity and may cause fragmentation, which can alter caribou movement and behaviour.

7.4.2.3.2 Changes to Habitat Quality, Movement, and Behaviour

- Dust deposition may cover vegetation and change the amount of different quality habitat, and alter caribou movement and behaviour.
- Sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats around developments and winter roads, and alters movement and behaviour, which can influence survival and reproduction.

7.5 EFFECTS ON POPULATION SIZE AND DISTRIBUTION OF CARIBOU

7.5.1 General Approach

As discussed in Section 7.4, most of the effects from the Project will influence the Bathurst herd, followed by the Ahiak and Beverly herds. The Project will likely alter the behaviour and movement of individuals from the Beverly herd that periodically travel through the RSA during autumn and winter. However, the frequency and number of animals affected is not expected to result in a measurable change in the population size and distribution of the Beverly herd relative to current (baseline) conditions. Subsequently, the pathway for effects from the Project on the Beverly herd was determined to have no linkage.

Because the Bathurst herd has the greatest likelihood of interacting with the Project, emphasis in the effects analysis is on the Bathurst population. In addition, current knowledge and relevant information regarding caribou research in the SGP is focused on the Bathurst herd (Section 7.3.3.1). Therefore, potential Project-related effects predicted for the Bathurst herd are anticipated to be representative and provide conservative estimates of effects for the Ahiak herd (i.e., the effects for the Bathurst herd should overestimate effects for the Ahiak herd).

The effects analysis considers all primary pathways that result in expected changes to the population size and distribution of caribou from the Project, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects to caribou are analyzed using measurement endpoints (e.g., habitat quantity and quality, survival, and reproduction) and are expressed as effects statements, including:

- direct effects from changes in habitat quantity and fragmentation from the physical footprint of the Project and winter roads; and
- indirect effects from the Project on habitat quality, movement, and behaviour, which can influence energy balance, and survival and reproduction.

The magnitude, spatial extent, and duration of changes in measurement endpoints (e.g., habitat quantity and quality) from the Project and other developments are expected to be similar to or greater than the actual effects to the abundance and distribution of populations. Effects statements may have more than one primary pathway that link a Project activity with a change in caribou population size and distribution. For example, the pathways for effects from changes in habitat quality, movement, and behaviour include influences from noise, dust deposition, and the presence of vehicles and Project infrastructure. The combination of direct (physical footprint) and indirect (noise, dust, and other sensory disturbances) effects can create a ZOI around the Project that can change the behaviour and occurrence of caribou (Section 7.3.3.2).

Changes in the quantity and quality of habitat within the ZOI can influence the number of animals that the landscape is able to support (i.e., carrying capacity). If animals strongly avoid human development, then the use of less disturbed areas may become higher and more concentrated. Changes to behaviour (such as decreased time spent feeding or increased time spent moving away from disturbance) within the ZOI can influence the energy balance of caribou and alter survival and reproduction. All of these changes can ultimately affect caribou population size and distribution.

The spatial scale of the analysis considers natural and human-related effects that occur within the seasonal ranges of caribou. Analyses were completed within the seasonal ranges of the annual ranges of the Bathurst and Ahiak caribou herds (i.e., Caribou Study Area [Section 7.1.3.3; Figures 7.1-2 and 7.1-3]). The seasonal ranges represent the effects study area for each caribou population (Section 6.4). Analysis was not completed in the calving range because the calving ranges of the Bathurst and Ahiak herds do not overlap the Project (Section 7.3.3.1).

The temporal scale looks at natural and development-related changes from reference conditions through application of the Project and reasonably foreseeable developments (most effects from potential future projects are qualitatively discussed in Section 7.9). Baseline conditions represent a range of temporal values on the landscape from reference (little to no development) to existing (2010) conditions. Environmental conditions on the landscape before industrial development (i.e., reference conditions) are considered part of the baseline. This is because the baseline represents a range of conditions over time, and not just a single point in time (Section 6.6). Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increases in development on caribou populations.

The effects analyses determine both the incremental and cumulative changes from the Project on the landscape, caribou, and the use of caribou by people. Incremental effects represent the Project-specific changes relative to baseline values in 2010 (current or existing conditions). Project-specific effects typically occur at the local scale (e.g., habitat loss due to the Project footprint) and regional scale (e.g., combined habitat loss, dust, noise, and sensory disturbance from Project activities [i.e., ZOI]).

Cumulative effects are the sum of all changes from reference values through application of the Project (and future developments). In contrast to Project-specific (incremental) effects, cumulative effects occur across the range of the population (i.e., beyond local and regional scales). This is because caribou travel large distances during their seasonal and annual movements and can be affected by the Project and several other developments (Section 6.4 and 6.6). In other words, the combined local and regional effects from the Project and other developments overlap with the distribution of the population.

Cumulative effects do not just include the combined effects from human development on caribou populations. Cumulative effects represent the sum of all natural and human-induced influences on the landscape and caribou populations through time and across space. Some changes may be human-related, such as increasing development or hunting pressure. Other changes may be associated with natural phenomenon such as extreme insect harassment years, and periodic harsh and mild winters. The objective of the cumulative effects analysis is to estimate the relative contribution of natural and human-related influences on the observed and expected changes to caribou population size and distribution.

Detailed descriptions of the spatial and temporal boundaries, and methods used to analyze residual effects from the Project on caribou are provided in the following sections. The analyses were quantitative, where possible, and included data from field studies, scientific literature, government publications, effects monitoring reports, and personal communications. Traditional knowledge and community information were incorporated where available. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

7.5.2 Habitat Quantity and Fragmentation

7.5.2.1 Methods

The incremental and cumulative direct habitat effects from the Project footprint and other previous, existing, and future developments on the Bathurst and Ahiak caribou herds were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). Landscape metrics for each habitat included total area, number of patches, and mean distance to the nearest similar patch in the seasonal ranges (i.e., effects study area). Decreases in habitat area and number of similar quality habitat patches can directly influence population size by reducing the carrying capacity of the caribou range. Changes in the number of patches and distance between similar habitat patches can influence the distribution (and abundance) of caribou by affecting the ability of animals to travel across the land.

The incremental and cumulative changes in landscape metrics from the Project and other developments were determined for the northern migration (May 1 to May 31), summer (July 2 to August 31), autumn or rut (September 1 to October 31), and winter ranges (November 1 to April 30) (Figure 7.1-2). Analyses for the Ahiak herd were completed for the winter range only because that was the only seasonal range that overlapped with the Project (Figure 7.1-3). Although few individuals of the Ahiak herd may be present in the RSA during other seasons (i.e., northern migration, summer, and autumn periods [Section 7.3.3.1]), the likelihood of large aggregations interacting with the Project is low.

The quantity of caribou habitat was classified using the remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a GIS platform (Johnson et al. 2004, 2005). The land cover dataset was modified from 1,000-m cell sizes to a 25-m resolution, and then joined with esker habitat in 1:50,000 scale national topographic database (NTDB) layers. The merged database was similar to the SGP dataset used in Johnson et al. (2004, 2005).

However, upon joining layers, the dataset was re-sampled to 200-m cell sizes using a nearest neighbour algorithm (versus 100 m in Johnson et al. [2004, 2005]) because of computational constraints with generating habitat rasters over each seasonal home range. Tests for accuracy suggested that there were marginal differences in the overall areas per cover type between a 100-m resampled dataset, versus a 200-m resampled dataset (i.e., less than 0.1%). Finally, the Land Cover of Canada dataset was reclassified into 12 classes similar to Johnson et al. (2004, 2005). Visual inspections of the distribution of cover data in the areas that overlapped the SGP and Land Cover of Canada guided the reclassification process.

Landscape metrics were determined using the program FRAGSTATS (Version 3.0; McGarigal et al. 2002, internet site) within a GIS platform. The analysis determined the extent of landscape fragmentation by calculating statistical outputs based on the values of each raster cell. Raster cells for habitats with extensive coverage (including disturbed areas) were increased to 200 m by 200 m in size. For example, road widths are about 20 m. However, to include roads in the 200 m ecological land cover layer, roads must have a width of 200 m. Therefore, results determined from the fragmentation analysis are conservative and result in an overestimation of disturbed area within the seasonal ranges.

The number and type of previous, existing, and reasonably foreseeable developments in the effects study areas for the Bathurst and Ahiak caribou herds are listed in Table 7.5-1 and illustrated in Figures 7.5-1 and 7.5-2. Data on the location and type of developments were obtained from the following sources:

- Mackenzie Valley Land and Water Board (MVLWB): permitted and licensed activities within the NWT;
- Indian and Northern Affairs Canada (INAC): permitted and licensed activities within the NWT and Nunavut;
- INAC: contaminated sites database;
- Natural Resources Canada (NRCAN): obtained a GIS file of community locations from NRCAN's GeoGratis website;
- Government of the Northwest Territories: Location of parks within the NWT;

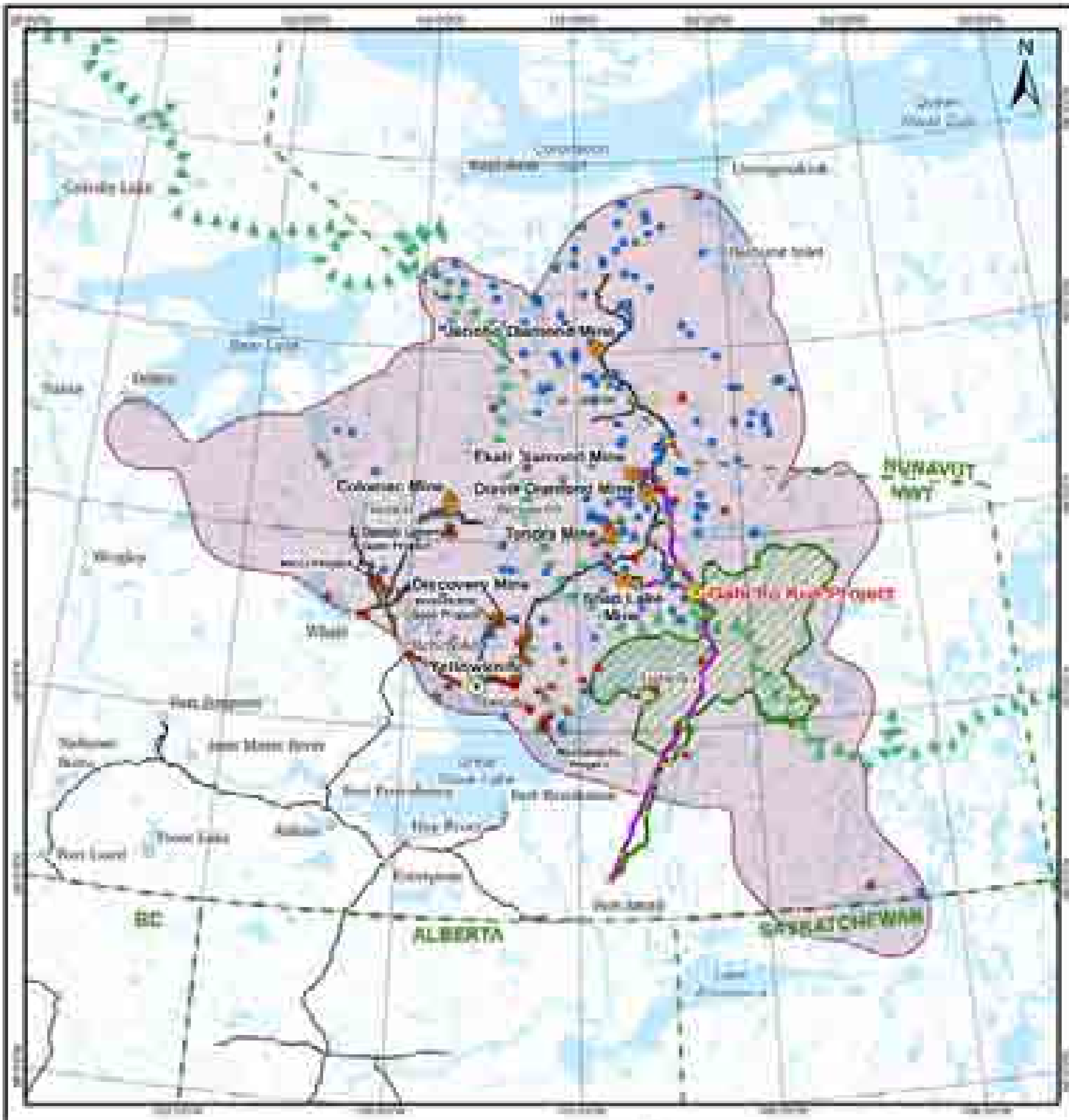
- provincial governments (Saskatchewan, Manitoba, Alberta): information related to location of mines and other developments that may occur within the spatial boundaries for caribou herds;
- company websites; and
- knowledge of the area and project status.

Table 7.5-1 Previous and Existing Developments in the Effects Study Area that Have the Potential to Affect the Bathurst and Ahiak Herds

Type of Development	Footprint Area (ha)	Number of Developments	Linear Feature Length (km)
Bathurst Herd			
Campground	138.1	11	n/a
Community	5,721.6	8	n/a
Communications (e.g., microwave towers)	62.8	5	n/a
Fuel storage	12.6	1	n/a
Historic remediated and non-remediated site[a]	602.8	52	n/a
Lodge (outfitters, tourism)	401.9	32	n/a
Mine	5,570.9	7	n/a
Mineral exploration	14,968.9	176	n/a
Miscellaneous (e.g., bridge / culvert installation)	62.8	5	n/a
Power	157.0	2	n/a
Quarrying	75.3	6	n/a
Staging area (equipment or material storage)	25.1	2	n/a
Transmission line	6,537.1	1	326.8
Winter road segments	37,073.7	140	1,926.8
All-season road segments	1,516.0	17	75.7
Highway segments	3,230.5	86	161.6
Total disturbance	**76,157.1**	**551**	**2,490.8**
Ahiak Herd			
Fuel storage	12.6	1	n/a
Lodge (outfitters, tourism)	113.0	9	n/a
Mine	1,151.8	2	n/a
Mineral exploration	3,194.4	42	n/a
Miscellaneous (e.g., bridge / culvert installation)	25.1	2	n/a
Staging area (equipment or material storage)	12.6	1	n/a
Winter road segments	9,144.1	20	459.6
Total disturbance	**13,653.5**	**77**	**459.6**

[a] includes moderate and high risk contaminated sites

n/a = not applicable; ha = hectares; km = kilometres



LEGEND

- Gahcho Kué Project
- Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Bathurst Caribou Herd Study Area

Previous and Existing Development

- Campground
- Communications
- Fuel Storage
- Historic Remediated and Non-Remediated Site
- Lodge
- Mineral Exploration Camp
- Miscellaneous
- Power
- Quarrying
- Staging Area
- All-Season Road/Highway
- Transmission Line
- Winter Road

Future Development

- Proposed Mine
- Taltson Staging Area
- Taltson Transmission Line
- Taltson Winter Road
- Proposed East Arm National Park

Base data source: The Atlas of Canada 1M...

GAHCHO KUÉ PROJECT

Previous, Existing, and Reasonably Foreseeable Future Developments in the Effects Study Area for the Bathurst Caribou Herd

PROJECTION: Canadian Lambert Conf. Conic		DATUM: NAD83	De Beers Canada
Scale 1:6,000,000			
FILE No: KLOI-07-023-GIS			DATE: December 7, 2010
JOB NO: 09-1365-1004	REVISION NO: 4		**Figure 7.5-1**
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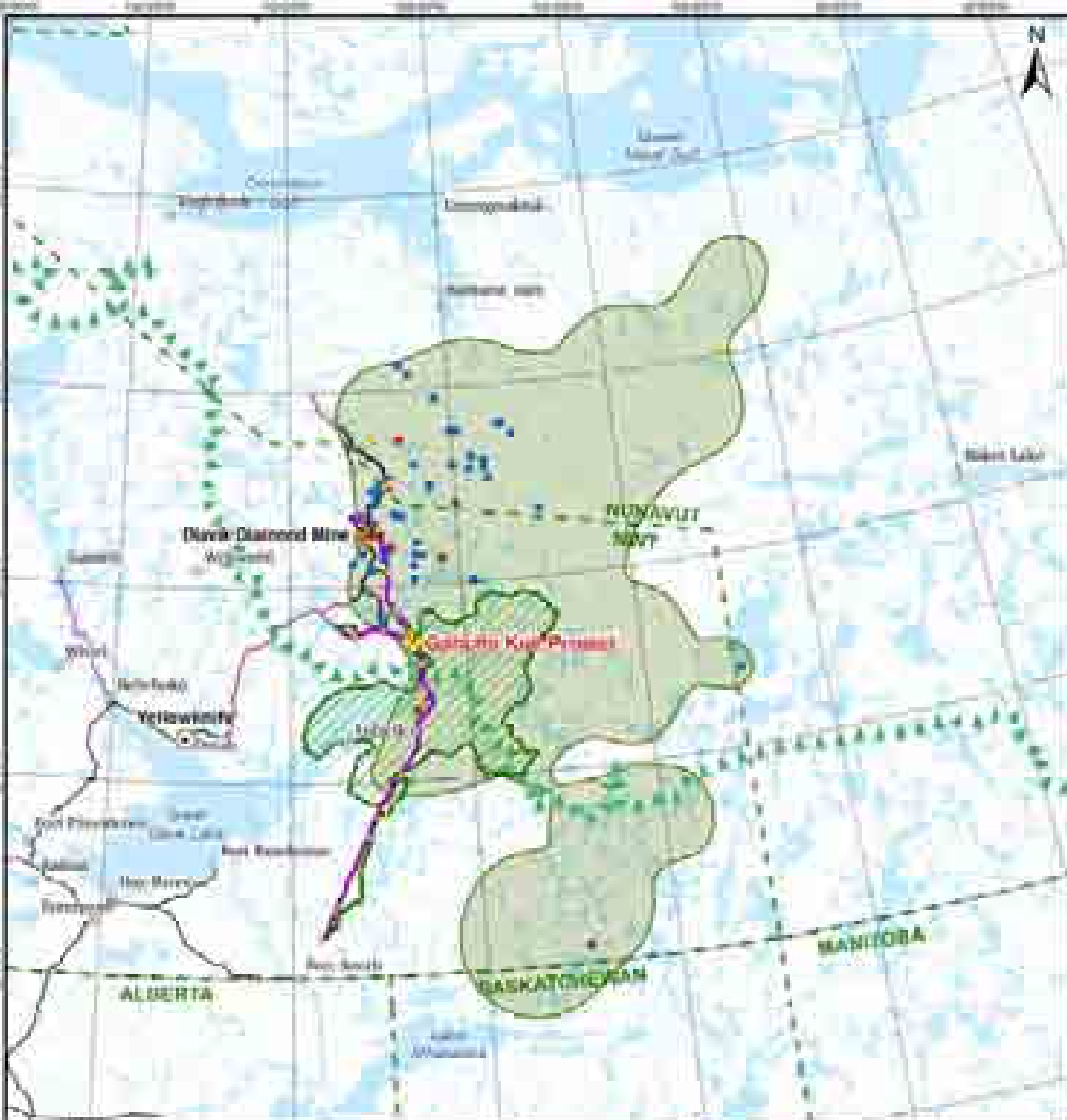


LEGEND

- Gahcho Kué Project
- Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Ahiak Caribou Herd Winter Range

Previous and Existing Development

- Fuel Storage
- Historic Remediated and Non-Remediated Site
- Lodge
- Mineral Exploration/Camp
- Miscellaneous
- Staging Area
- Winter Road

Future Development

- Taltson Staging Area
- Taltson Transmission Line
- Taltson Winter Road
- Proposed East Arm National Park

GAHCHO KUÉ PROJECT

Previous, Existing, and Reasonably Foreseeable Future Developments in the Effects Study Area for the Ahiak Caribou Herd

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale 1:5,000,000	
FILE No: KLOI-07-024-GIS	DATE: December 7, 2010
JOB No: 09-1365-1004	REVISION No: 4
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

De Beers Canada

Figure 7.5-2

Initially, data indicating permitted and licensed activities were obtained in spreadsheet format. Some temporal data were available prior to 1996, but most of the known start and end dates of land use permits for developments were available from 1996 through 2010. The file was examined for duplication of information (e.g., a water license and a land use permit for the same development). In cases where two or more pieces of location information for the same activity were present, the extra information was deleted from the file so that it contained only one point per development. Data associated with the location attributes (e.g., permit status, feature name) also were edited in some instances to update the information for running modelling scenarios efficiently. The information was used to generate a spatially and temporally-explicit development layer within a GIS platform.

The database contains no information on the size of the physical footprint of a development. For communities, and closed and operating mines, the footprint was digitized from Landsat 7 Imagery from the Government of Canada (CanImage 2007). For all other developments, the physical area of the footprint was estimated using a number of assumptions. For example, footprints for linear developments (all roads, transmission lines) were based on a 200 m corridor, which was related to the raster cell size of 200 x 200 m for the land cover data.

The area of the footprint for most other developments (except exploration sites and power plants) was assumed to be a 200-m radius (12.6 ha) (Table 7.5-2). A 500 m radius was used to estimate the area of the footprint for exploration sites and power plants (78.5 ha), which likely overestimates the amount of habitat directly disturbed by such activities. For example, exploration programs typically contain temporary shelters for accommodations and storage of equipment, and are elevated to limit the amount of disturbance to the soil and vegetation. Drilling is usually carried out with portable drill rigs (5 m x 5 m area) at one location at a time. For all closed mines and inactive land use permits, the physical footprint was carried through the entire effects analysis as it was assumed that direct disturbance to the landscape had not yet been reversed. Footprints with overlapping areas on the landscape were not counted twice.

The Project footprint was derived from the Project Description, and includes both the terrestrial and aquatic areas of disturbance. The development layer was then applied to the landscape classification of the seasonal ranges for the baseline, application, and future cases (Table 7.5-3).

Table 7.5-2 Hypothetical Footprints for Previous, Existing, and Future Developments in the Seasonal Ranges for the Bathurst and Ahiak Caribou Herds

Type	Feature Type[a]	Footprint Extent (m)
Campground	point	200
Community	polygon	Actual
Communications (e.g., microwave towers)	point	200
Fuel storage	point	200
Historic remediated and non-remediated site	point	200
Lodge (outfitters, tourism)	point	200
Mine	polygon	Actual
Mineral exploration	point	500
Miscellaneous (e.g., bridge / culvert installation)	point	200
Power	point	500
Quarrying	point	200
Staging area (equipment or material storage)	point	200
Transmission line	line	200
Winter road segments	line	200
All-season road segments	line	200
Highway segments	line	200

[a] Footprint estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.

m = metre.

Table 7.5-3 Contents of an Assessment Case

Baseline Case	Application Case	Future Case
Range of conditions from little or no development to all previous and existing projects[a] prior to the Gahcho Kué Project	Baseline Case plus the Gahcho Kué Project	Application case plus reasonably foreseeable projects

[a] Includes approved projects.

The baseline case includes the temporal changes in the number of previous and existing projects known to occur within the, seasonal ranges, which can include little or no previous development (Section 6.6.2). Environmental conditions on the landscape before human development (i.e., reference conditions) were also included in the analysis. Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increasing development on caribou populations. The application case occurs during the anticipated year of construction of the Project, through the duration of predicted effects (i.e., until the effects are reversed or are deemed irreversible).

The future case includes the baseline case, application case, and reasonably foreseeable developments (Section 6.6.2). Currently, there are two reasonably foreseeable developments that may generate incremental changes on vegetation ecosystems (habitat) in the effects study areas (seasonal ranges) for the Bathurst and Ahiak caribou herds:

- Taltson Hydroelectric Expansion Project; and
- East Arm National Park.

For the Bathurst herd, there are four additional reasonably foreseeable developments that could affect population size and distribution:

- Yellowknife Gold Project;
- Nechalacho Project;
- Damoti Lake Gold Project; and
- NICO Project.

The temporal boundary for cumulative effects from future developments is a function of the duration of effects from the Project on caribou populations. At a minimum, the time period for effects from the Project, and reasonably foreseeable developments would occur over 22 years (construction through closure). Except for the Taltson Hydroelectric Expansion Project (for which the anticipated footprint is known), effects analyses for the future case are mostly qualitative due to the large degree and number of uncertainties. There are uncertainties associated with the rate, type, and location of developments in the seasonal ranges. There are also uncertainties in the direction, magnitude, and spatial extent of future fluctuations in vegetation (i.e., habitat), independent of Project effects. Consequently, potential cumulative effects from reasonably foreseeable developments (future case) other than the Taltson Hydroelectric Expansion Project are discussed in the section on uncertainty (Section 7.9).

Landscape metrics were determined for the reference, 2010 baseline, application, and future case. Fragmentation analysis included the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads for the winter season only. As mentioned above, reference conditions represent the initial period of baseline conditions (as far back as data are available). Here, the 2010 baseline case includes all previous, existing, and approved developments up to 2010, and includes the Winter Access Road for the Project (which was constructed in 2001, 2002, and 2006).

The incremental and cumulative changes from the Project and other developments on the loss and fragmentation of habitat were estimated by calculating the relative difference between the 2010 baseline case and reference case, between the application and 2010 baseline case, and between the future and application case. The following equations were used:

- (2010 baseline value – reference value) / reference value

- (application value – 2010 baseline value) / 2010 baseline value
- (future case – application value) / application value

The resulting value was then multiplied by 100 to give the percent change in a landscape metric for each comparison. The result provides both the direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type (and potential reduction in carrying capacity). Alternately, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity (and possible increase in travel efficiency for caribou and other wildlife). Absolute values for landscape metrics for each habitat and assessment case (i.e., reference, baseline, application, and future) are provided in Appendix 7.III.

7.5.2.2 Results

The total area of the Project footprint is estimated to be 1,235 ha. This includes 853.3 ha of mine and infrastructure that will directly affect terrestrial and aquatic resources (Section 11.7). An additional 382.1 ha of water (shallow and deep water) is not expected to be directly altered by the Project during construction and operation. Approximately 68% of the Project footprint is aquatic habitat and 32% is terrestrial habitat.

At the local scale, the Project footprint will alter 4.4% of the baseline LSA. Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA (and RSA). Other terrestrial habitats altered by the Project footprint include heath tundra, heath tundra with bedrock or boulders, birch seep, and riparian tall shrub (all decreased by less than 0.4% relative abundance in the LSA). No esker is expected to be altered. During construction and operation, the Project footprint will decrease the lake surface area within the LSA by 2.2%.

Although progressive reclamation will be integrated into mine planning as part of De Beers' design for closure policy, arctic ecosystems are slow to recover from disturbance. In addition, not all of the areas will be reclaimed. For example, as a result of locally expressed concerns, the Fine PKC Facility will not be vegetated to prevent the facilities from becoming attractive to wildlife (Section 11.7). The mine rock piles, Coarse PK Pile and Fine PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha.

At the scale of the seasonal ranges, the analysis classified 12 habitat types for the Bathurst and Ahiak herds (Table 7.5-4 and Table 7.5-5). Under reference conditions (i.e., no development), heath tundra typically dominates the landscape (about 27% to 42%) for northern migration, summer, and autumn ranges of the Bathurst and Ahiak herds. Forest is the dominant cover type in the winter range of Bathurst caribou (45%), as well as in the autumn range (29%). In contrast, forest comprises about 15% of the winter range for the Ahiak herd, while heath tundra and rock association each comprise about 27% of the range. Sedge wetland, riparian, lichen veneer, and low shrub habitats each represent less than 7% of the seasonal ranges for the Bathurst and Ahiak herds. Eskers represent less than 1% of any seasonal range for both herds. Non-vegetated habitat, which includes waterbodies, ranged from 11% to 18% of the seasonal ranges.

When considering the cumulative change of development from reference conditions to 2010 baseline conditions, there was a less than 0.4% decrease in area per habitat type (excluding burns) per seasonal range for the Bathurst and Ahiak caribou herds (Tables 7.5-4 and 7.5-5). Habitat-specific decreases from reference to 2010 baseline conditions among seasonal ranges varied from less than 0.01% to 0.4%. Total loss of habitat (excluding burns) up to 2010 baseline conditions was less than 1.1% per seasonal range for the Bathurst and Ahiak caribou. Decreases in the amount of forage habitats (i.e., heath tundra, sedge wetland, riparian shrub, and lichen veneer) in the summer and autumn ranges were no greater than 0.2%. During winter, forest habitat has decreased by less than 0.2% due to increases in development from reference to 2010 conditions.

Comparison of 2010 baseline and application landscapes indicated that habitat-specific incremental changes from the Project footprint were less than 0.1% per seasonal range for the Bathurst and Ahiak herds (Tables 7.5-4 to 7.5-5). For many habitats, the local change from the Project relative to the seasonal range of the herd was so small that it was not measurable (i.e., <0.01%). For other habitats, the decrease in availability ranged from 0.01% to 0.1%. The cumulative decrease in the area of habitats within caribou seasonal ranges from reference conditions to future landscapes was estimated to be less than 0.4% for any given habitat (excluding burns).

For the Bathurst and Ahiak herds, the cumulative direct disturbance to each seasonal range from the Project and other previous, existing and future developments is predicted to be less than or equal to 1.7% relative to reference conditions for seasonal ranges of Ahiak and Bathurst caribou. This change is well below the 40% threshold value identified for habitat loss associated with declines in bird and mammal species (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002; Swift and Hannon 2010).

Table 7.5-4 Change (%) in Area and Configuration of Habitat Types from Development within Seasonal Ranges of the Bathurst Herd during Baseline, Application, and Future Conditions

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Northern Migration												
Esker	22,000	-0.20	0.00	-0.05	4,329	-0.23	0.00	-0.05	1,701	0.14	-0.11	0.02
Forest	5,903,556	-0.03	-0.01	-0.05	1,069	0.19	0.75	1.20	1,442	-0.13	-0.48	-0.98
Heath rock	1,428,552	-0.10	0.00	0.00	1,066	0.75	-0.19	0.00	1,381	-0.60	0.17	0.00
Heath tundra	6,682,876	-0.09	0.00	-0.05	834	0.48	0.48	0.71	1,610	-0.23	-0.32	-0.53
Lichen veneer	452,268	-0.08	0.00	0.00	142	0.00	0.00	0.00	3,396	0.00	0.00	0.00
Riparian shrub	688,316	-0.04	0.00	-0.06	794	0.38	-0.13	0.25	2,844	-0.57	0.14	-0.25
Sedge assoc.	131,496	-0.07	0.00	-0.04	176	0.00	0.00	0.57	5,334	0.00	0.00	-0.74
Low shrub	34,268	0.00	0.00	0.00	21	0.00	0.00	0.00	21,748	0.00	0.00	0.00
Rock assoc.	4,839,828	-0.10	-0.01	-0.02	1,497	0.60	0.13	0.66	1,591	-1.40	-0.14	-0.55
Non-vegetated	3,858,744	-0.08	0.00	-0.01	789	0.63	-0.25	0.25	2,852	-0.97	0.55	-0.30
Old burn	273,568	-0.12	-0.01	-0.16	209	0.48	0.00	0.48	5,947	-0.58	0.00	-0.50
Young burn	611,392	-0.04	0.00	-0.03	210	0.95	0.00	0.94	3,741	-5.75	0.00	-1.01
Spring / Summer												
Esker	12,640	-0.35	0.00	-0.10	2,496	-0.40	0.00	-0.08	1,723	0.25	-0.19	0.04
Forest	1,513,160	-0.06	-0.04	-0.10	707	0.42	0.99	1.53	1,549	-0.30	-0.65	-1.29
Heath rock	887,108	-0.14	0.00	0.00	658	1.37	-0.15	0.00	1,533	-1.06	0.22	0.00
Heath tundra	5,241,388	-0.10	-0.01	-0.06	496	1.01	0.60	1.19	1,187	-0.41	-0.27	-0.89
Lichen veneer	96,632	-0.09	0.00	0.00	60	0.00	0.00	0.00	3,487	0.00	0.00	0.00
Riparian shrub	378,960	-0.04	0.00	-0.10	444	0.45	-0.22	0.45	2,420	-0.40	0.22	-0.45
Sedge assoc.	167,596	-0.06	0.00	-0.03	196	0.00	0.00	0.51	3,969	0.00	0.00	-0.71
Low shrub	13,660	0.00	0.00	0.00	12	0.00	0.00	0.00	31,373	0.00	0.00	0.00
Rock assoc.	2,418,576	-0.15	-0.02	-0.04	763	0.92	0.26	0.65	1,634	-1.12	-0.26	-0.53
Non-vegetated	1,662,588	-0.14	0.00	-0.03	272	1.10	-0.36	0.73	3,544	-1.00	0.36	-0.86
Old burn	7,300	-0.71	-0.06	0.00	6	0.00	0.00	0.00	75,269	0.00	0.00	0.00
Young burn	18,928	-0.95	-0.09	0.00	13	15.38	0.00	0.00	8,882	-41.92	0.03	0.00
Rut / Autumn												
Esker	17,160	-0.26	0.00	-0.07	3,408	-0.29	0.00	-0.06	1,768	0.19	-0.14	0.03
Forest	5,649,708	-0.07	-0.01	-0.05	952	0.53	0.84	1.35	1,308	-0.53	-0.48	-1.07
Heath rock	735,036	-0.16	0.00	-0.01	594	1.18	-0.17	0.00	1,589	-1.00	0.20	0.00

Table 7.5-4 Change (%) in Area and Configuration of Habitat Types from Development within Seasonal Ranges of the Bathurst Herd during Baseline, Application, and Future Conditions (continued)

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Heath tundra	5,474,612	-0.10	0.00	-0.06	744	0.54	0.53	0.80	1,527	-0.24	-0.34	-0.58
Lichen veneer	228,576	-0.11	0.01	0.00	62	0.00	0.00	0.00	2,910	0.00	0.00	0.00
Riparian shrub	932,628	-0.05	0.00	-0.04	873	0.34	-0.11	0.23	2,267	-0.56	0.13	-0.23
Sedge assoc.	218,944	-0.04	0.00	-0.02	255	0.00	0.00	0.39	3,986	0.00	0.00	-0.55
Low shrub	3,976	0.00	0.00	0.00	9	0.00	0.00	0.00	35,337	0.00	0.00	0.00
Rock assoc.	2,926,068	-0.21	-0.01	-0.04	1,123	1.25	0.44	0.88	1,723	-2.09	-0.44	-0.73
Non-vegetated	3,038,316	-0.11	0.00	-0.02	673	1.04	-0.44	0.30	2,812	-1.31	0.68	-0.36
Old burn	196,432	-0.15	-0.01	-0.14	130	0.77	0.00	0.76	8,775	-0.87	0.00	-0.78
Young burn	354,328	-0.11	0.00	-0.05	174	1.72	0.00	1.13	3,681	-9.18	0.00	-1.21
Winter												
Esker	19,848	-0.08	0.00	-0.02	3,850	-0.05	0.00	-0.03	1,682	0.09	0.00	0.02
Forest	11,514,780	-0.16	-0.01	-0.03	1,009	1.68	0.49	1.07	1,148	-1.25	-0.20	-0.93
Heath rock	109,504	-0.07	0.00	0.00	134	0.00	0.00	0.00	3,401	0.00	0.00	0.00
Heath tundra	2,672,968	-0.07	-0.01	-0.06	566	0.35	0.18	0.70	2,269	-2.51	-0.09	-0.57
Lichen veneer	1,424	0.00	0.00	0.00	3	0.00	0.00	0.00	198,215	0.00	0.00	0.00
Riparian shrub	1,869,408	-0.05	0.00	-0.06	1,342	0.37	0.00	0.22	2,067	-0.72	0.00	-0.20
Sedge assoc.	92,288	-0.09	0.00	0.00	119	0.00	0.00	0.00	6,685	0.00	0.00	0.00
Low shrub	1,308	0.00	0.00	0.00	4	0.00	0.00	0.00	112,775	0.00	0.00	0.00
Rock assoc.	2,155,668	-0.23	-0.02	-0.04	1,034	1.55	0.38	0.85	2,127	-3.07	-0.36	-0.71
Non-vegetated	4,515,576	-0.27	0.00	-0.07	1,087	2.21	0.00	0.90	2,604	-2.11	0.00	-1.36
Old burn	788,732	-0.07	0.00	-0.10	570	0.35	0.00	0.17	3,437	-0.52	0.00	-0.19
Young burn	1,643,596	-0.08	0.00	-0.08	453	0.44	0.00	0.66	3,699	-1.08	0.00	-0.63

Note: % Change was measured as the relative incremental change from one time period to the next (e.g., reference [no to little development] to 2010 baseline, 2010 baseline to application, and application to future).

Values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha= hectares; m = metres

Table 7.5-5 Change (%) in Area and Configuration of Habitat Types from Development within the Winter Range of the Ahiak Herd during Baseline, Application, and Future Conditions

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Esker	22,272	-0.09	0.00	-0.04	4,333	-0.12	0.00	-0.05	1,669	0.22	0.00	0.02
Forest	3,510,368	-0.03	-0.02	-0.09	862	0.70	0.58	1.49	1,757	-0.62	-0.36	-1.33
Heath rock	2,113,536	-0.02	0.00	0.00	1,543	0.13	0.00	0.00	1,210	-0.02	0.00	0.00
Heath tundra	6,372,196	-0.04	0.00	-0.05	768	0.26	0.13	0.91	1,673	-0.13	-0.05	-0.68
Lichen veneer	766,024	0.00	0.00	0.00	243	0.00	0.00	0.00	2,875	0.00	0.00	0.00
Riparian shrub	617,276	-0.08	0.00	0.00	41	0.00	0.00	0.00	10,980	0.00	0.00	0.00
Sedge assoc.	73,824	-0.12	0.00	-0.07	102	0.00	0.00	0.98	5,060	0.00	0.00	-1.28
Low shrub	38,428	-0.05	0.00	-0.09	540	0.19	0.00	0.37	2,559	-0.15	0.00	-0.34
Rock assoc.	6,368,832	-0.03	-0.01	-0.01	1,358	0.44	0.29	0.66	1,344	-0.34	-0.27	-0.49
Non-vegetated	2,648,080	-0.26	0.00	-0.07	604	0.50	0.00	0.49	3,563	-0.59	0.00	-1.08
Old burn	295,016	-0.04	0.00	-0.23	234	0.00	0.00	0.43	4,600	0.00	0.00	-0.45
Young burn	970,700	-0.02	0.00	-0.10	182	1.10	0.00	1.09	3,662	-6.74	0.00	-1.06

Note; % Change was measured as the relative incremental change from one time period to the next (e.g., reference to 2010 baseline, 2010 baseline to application, and application to future)

values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha= hectares; m = metres

Increasing development from reference to existing (2010) conditions has also resulted in habitat fragmentation, specifically changes to the number and location of habitat patches in the seasonal ranges of caribou. For example, habitat-specific changes in patch numbers ranged from -0.2 to 1% for typical forage habitats (i.e., heath tundra, sedge association, riparian shrub, and lichen veneer) in the summer and autumn ranges of the Bathurst herd (Table 7.5-4). Decreases in the mean distance to nearest neighbour for these habitats ranged from less than 0.01% to 0.6%.

The addition of the Project to the 2010 baseline landscape resulted in incremental changes to the configuration of Bathurst and Ahiak caribou habitats. For example, habitat-specific changes to the number of patches across seasonal ranges varied from -0.4% to 1% for the Bathurst herd, and from 0% to 0.6% for the Ahiak herd (excluding burns; Tables 7.5-4 and 7.5-5). Changes in mean distance to nearest neighbour ranged from -0.7% to 0.7% for the Bathurst herd, and from -0.4% to 0% for the Ahiak herd. The Project and previous, existing and future developments resulted in habitat-specific cumulative changes to the number and distance between similar habitat patches ranging from 0% to 5% (excluding burns).

In the winter range, development (which includes the Tibbitt-to-Contwoyto Winter Road) has also changed the configuration of habitats on the landscape for the Bathurst and Ahiak caribou herds. For the Bathurst herd, the number of forest patches has increased by 1.7% from reference to existing baseline conditions, and the distance between neighbouring forest patches has decreased by 1.3% during this season (Table 7.5-4). A similar trend was observed for the Ahiak herd (Table 7.5-5). The number of forest patches has increased by 0.7% from reference to existing baseline conditions, and the distance between neighbouring forest patches has decreased 0.6% during this season. Although the presence of the Tibbitt-to-Contwoyto Winter Road may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range (Trombulak and Frissell 1999), the road is in operation for about eight to 12 weeks each year. The Winter Road may in fact be a “leaky barrier” (where some animals manage to cross successfully) but it may nevertheless restrict the landscape-scale movements of caribou for short periods of time (Treweek 1999).

7.5.3 Habitat Quality, Behaviour, and Movement

Cumulative and incremental direct disturbance and fragmentation of habitat from the Project and other developments are factors that can influence caribou movement and the number of animals that the seasonal ranges can support (Section 7.5.2). Indirect effects from development can also influence caribou habitat, movement, and behaviour within their seasonal ranges. Accumulation of fugitive dust and sensory disturbances produced from the Project may result in indirect changes to the quality of habitat available at the local and regional scales.

For example, at the local scale, effect monitoring studies have suggested that caribou groups with calves spend less time feeding within 5 km of the Project footprint (BHPB 2004). Blasting was the most likely type of stressor to induce a response, such as running away, for all caribou groups (versus vehicle or human stressors) (BHPB 2007). In addition, some Elders are fearful that the caribou will be determined to travel in a particular direction that will lead them to migrate through mine sites. They are worried that in doing so the caribou will be adversely affected by noise and ash (Dogrib Treaty 11 Council 2001).

At the regional scale, there is good evidence to suggest that caribou herds respond to diamond mine developments by changing their distribution. The combination of direct (physical footprint) and indirect (noise, dust, and other sensory disturbances) effects can create a ZOI around the Project that can change the behaviour and occurrence of caribou (Section 7.3.3.2). This ZOI appears to be greater than the estimated spatial extent of the independent effects from infrastructure, activities, dust, air emissions, or noise. Most studies show that the estimated ZOI of diamond mines on caribou distribution ranges from 10 to 30 km (Johnson et al. 2005; Golder 2008a, b). Recent analyses by Boulanger et al. (2009) found that caribou were four times more likely to occur at distances greater than 11 to 14 km from the Ekati-Diavik diamond mine complex. A weaker ZOI of 6.5 km was detected for the smaller Snap Lake Mine (Boulanger et al. 2009).

Changes in the quantity and quality of habitat within the ZOI can influence the number of animals that the landscape is able to support (i.e., carrying capacity). If animals strongly avoid human development, then less disturbed areas may experience greater use and higher densities of caribou. Changes to behaviour (such as decreased time spent feeding or increased time spent moving away from disturbance) within the ZOI can influence the energy balance of caribou and alter survival and reproduction. All of these changes can ultimately affect caribou population size and distribution.

Caribou travel large distances during their seasonal movements and can be affected by the zones of influence from the Project and several other developments. In other words, the incremental local and regional effects from the Project and other developments in the seasonal ranges accumulate together to influence the population size and distribution of caribou. Natural factors, such as insects, periodic hard winters, and long-term weather patterns, also influence caribou population size and distribution.

The following sections provide an analysis of the predicted residual direct and indirect effects from the Project and other developments on caribou population size and distribution. Section 7.5.3.1 determines the local and regional-scale changes from the Project on caribou habitat quality, behaviour, and movement that are related to the primary pathways (Section 7.4.2.1).

Further analyses are conducted to estimate the incremental and cumulative effects from the zones of influence associated with the Project and other developments on caribou (i.e., beyond regional-scale effects from the Project [Section 7.5.3.2]). Development-related changes to the amount of different quality habitats within seasonal ranges are estimated (Section 7.5.3.2). In Section 7.5.3.2, changes in behaviour from development and insect harassment were used to estimate effects on female energy balance and associated calf production (i.e., fecundity). A population model was used to determine the relative contribution of the incremental and cumulative effects from the Project and other developments, and other factors (insects, extreme weather events, and harvesting) on changes in caribou population size (Section 7.5.3.2). The results from these analyses were then used to predict effects from the Project and other developments on the accessibility and availability of caribou for use by people (Section 7.5.4).

7.5.3.1 Local and Regional-scale Effects from the Project

7.5.3.1.1 Dust Deposition and Sensory Disturbances

Methods

Although the indirect effects from dust deposition and sensory disturbance are included in the habitat modelling, the potential effects on caribou from each stressor are also assessed separately. Accumulation of dust (i.e., TSP deposition) produced from the Project may result in a local indirect change on the quality of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition from the Project (Section 11.4). Air quality modeling was completed for the baseline case, the construction case, and the application case (i.e., operations). The assessment of the application case is anticipated to capture the maximum effects resulting from the Project.

Sources of dust deposition modelled in the application case include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile, and Fine PKC Facility), and vehicle traffic along the Winter Access Road. A CALPUFF plume dispersion model was used to provide a spatial understanding of ambient ground-level concentration and deposition distribution patterns (i.e., air quality predictions). Assumptions incorporated into the model (e.g., deposition velocity, and particle size) are expected to contribute to conservative estimates of deposition near the Project emission sources (Section 11.4).

Mining activities and associated infrastructure generate noise that may influence the local and regional movement and behaviour of caribou. Sensory disturbance can result in increased levels of stress and energy expenditure, and disruption of feeding behaviour. For example, disturbance may cause caribou to spend less time feeding or resting, and more time staying alert or moving away from the sources of disturbance (BHPB 2004). Therefore, a noise assessment was completed to identify the sound emissions associated with the Project activities and the potential effects on caribou.

The focus of the noise assessment was on determining changes to the existing ambient noise levels due to Project operation, and comparing the results with noise regulations and guidelines from North American jurisdictions. Because there are no noise level guidelines for wildlife, human noise level guidelines were applied to predict effects on caribou. The evaluation of the noise effects focused on evaluating the noise levels associated with the fully developed operations. Model scenarios were established to calculate normal Project operations that could potentially change noise levels (e.g., blasting, crusher, mill, workshop, power plant, auxiliary equipment, and “building hum”), and provide predictions for continuous noise, and airstrip noise events.

The Project will be accessed annually for delivery of goods and materials along the Winter Access Road, which will typically be in operation from late January or early February through March, and under favourable conditions, into early April (typically about 8 to 12 weeks). This may result in noticeable noise at key receivers near the Project during the winter season. As such, an assessment of noise caused by trucks was completed for the Winter Access Road so that all major sources of sound emissions from the Project were assessed. Effects from traffic activity associated with the Project along the Tibbitt-to-Contwoyto Winter Road and Winter Access Road are also predicted.

7.5.3.1.2 Results

The results from the air quality modelling predicted that the maximum annual dust deposition from the Project is 6,292 kg/ha/y within the Project development area boundary (i.e., Project footprint) and 5,520 kg/ha/y outside of the Project development area boundary. The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum predicted dust deposition rate is expected within 100 m of the Project footprint. The most detrimental effects from dust are generally confined to the immediate area adjacent to the dust source (e.g., a haul road) (Everett 1980; Walker and Everett

1987). Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50-m buffer on either side of a road. Meininger and Spatt (1988) found that the majority of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 and 500 m from the road.

Woo (1984) also observed that increased dust levels accelerated melting of snow. Dust-related acceleration of snowmelt also accelerated plant phenology (e.g., plant growth) in tundra communities (Forbes 1995). Early snowmelt could decrease the dormancy of plant species and result in early plant growth before seasonal growth conditions, (temperature and sunlight), are optimal. As such, early plant growth may not be sustainable, which may cause stress to plants, and influence their nutritional value for caribou.

Noise will be generated from mobile and stationary mining equipment, blasting, and aircraft at the Project. The recommended maximum value for the nighttime noise level for undeveloped areas is 40 A-weighted decibels (dBA). This is the average nighttime (23:00 to 07:00) sound level L_{eq} (equivalent continuous sound and noise level) in dBA that includes both project-related noises and the ambient sound level (existing sound levels without project-related noises). The typical nighttime ambient sound level in rural Alberta is 35 dBA L_{eq} (ERCB 2007) with higher winds, precipitation, and thunder being the principal sources of increase above this value (Appendix 7.II). The projected noise levels from the various Project activities are compared with benchmarks in Table 7.5-6. The results show that while noise will be generated by the Project, the projected levels at identified noise receptors are below the benchmarks (with the exception of the 40 dBA limit at 1.5 km from the Project due to mine operations).

Table 7.5-6 Summary of Noise Effects from the Project

Receptor	Mine Operations[c] L_{eq} (dBA)		Winter Road L_{eq} (dBA)		Airstrip L_{max} (dBA)	
	Prediction	Benchmarks	Prediction	Benchmarks	Prediction	Noise Event Benchmarks
Employee Camp West Location	69	55[a]	35	55[a]	68	70[c]
Employee Camp East Location	58	55[a]	35	55[a]	69	70[c]
East Arm National Park Boundary Location[d]	38	40[b]	35	40[b]	90	-
1.5 km Boundary Location[d]	44	40[b]	35	40[b]	92	-

[a] WHO 1999.
[b] ERCB 2007.
[c] Highest cumulative noise levels calculated at each receptor.
[d] Location with highest projected noise level along the length of the boundary.
L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibel; L_{max} = maximum sound and noise level;
km = kilometre; ≥ = greater than or equal to; - = not applicable.

The analysis of blasting activity indicates that the maximum distances at which the criteria for peak ground (12.5 millimetres per second [mm/s]) and airborne vibration levels (120 linear decibels [dBL]) would be met are 596 and 730 m, respectively. Monitoring studies at the Ekati Diamond Mine found that although caribou responded to blasting 60% of the time within 1 km of the blast, the response was low; animals were alert but typically did not move (BHPB 1999).

A summary of the maximum distances for Project noise to attenuate to background levels are shown in Table 7.5-7. The distances indicate the area that Project-related noises may be found to be distinguishable from the natural environment by people. When Project noise predictions diminish to levels below background, they are not expected to be distinguishable from natural noises. The distance for noise attenuation to background levels for mining operations is predicted to be 3.5 km (Table 7.5-7).

Table 7.5-7 Distance for Noise Attenuation to Background Sound Levels for the Project

Background Noise Level	Mine Operations (km)	Winter Access Road (km)	Airstrip (km)
Continuous (35 dBA)	3.5 [(a)]	–	–
Noise Event	–	3.0 [(b)]	5.5

[(a)] Based on the distance to the nearest noise sources

[(b)] Based on maximum pass-by level.

n/a = not applicable; dBA = A-weighted decibel; km = kilometres.

Aircraft will be used for the movement of personnel and supplies to the Project site year-round. Aircraft noise will be limited to a few minutes during take off and landing and a maximum of two round-trip flights per day are anticipated during Project construction and operation. The distance for noise to reach background sound levels from the airstrip is 5.5 km (Table 7.5-7). However, disturbance from large aircraft is expected to be infrequent and short-term (less than five minutes) in duration.

The conclusion of most studies is that the effects of acute (short-term, high-level) and chronic (long-term, low-level) noise on caribou results in variable types of disturbance responses occurring over variable time frames (Webster 1997). For example, after acute exposure to low-level (less than 150 m) helicopter or fixed-wing aircraft, unhabituated caribou demonstrated panic responses (Calef et al. 1976; Valkenburg and Davis 1983). After chronic noise exposure, caribou were found to significantly alter their daily activity cycles and movements as a result of overhead flights (Maier et al. 1998).

Effects from Winter Roads

During the two-year construction period, up to 25 trucks are anticipated to be on the Winter Access Road in a 24 hour period (1,500 to 2,000 trucks per year per 12 week period). Traffic is anticipated to decrease to 14 trucks and three trucks per 24 hour period on the Winter Access Road during operations and initial closure (two year period), respectively. The predicted noise levels from the winter road are compared with relevant criteria in Table 7.5-6. The results show that while noise will be generated by the Winter Access Road, the expected levels are within relevant criteria established for remote areas. This change in habitat suitability is periodic as winter roads are in operation for an average of eight to 12 weeks each year.

Noise from the Winter Access Road is predicted to diminish to background levels within 3 km (Table 7.5-7), based on traffic volume during the construction period, and within 500 m during the operation phase. Although there is potential for trucks passing by a location along the Winter Access Road to alter caribou movement and behaviour, the potential effects will be limited to the seasonal use of the Winter Access Road, and should be within the range of baseline conditions.

Because studies have documented that some ungulate species, such as muskoxen, are alerted by the noise at distances over 1 km (McLaren 1981; McLaren and Green 1985), there is potential for trucks passing by a location along the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads to alter caribou movement and behaviour. Some studies have found caribou were displaced within 2 to 4 km of roads (Dau and Cameron 1986; Cameron et al. 1992, 2005). Other studies have observed that resting and feeding behaviour was common for caribou near airstrips or roads (Gunn et al. 1998; BHPB 2007).

Traffic associated with the Project along the winter roads is predicted to affect the behaviour and movement of caribou (Treweek 1999; Trombulak and Frissell 1999). However, the frequency and duration of effects from winter roads occurs once per year for an eight to 12 week period. Part of the effect from winter roads was estimated in the analysis of habitat fragmentation (Section 7.5.2), which considered changes in habitat patch number and connectivity from development. These changes can influence the winter range movements of caribou. Based on the current literature and noise modeling results, the spatial extent of changes to the behaviour and movement of caribou from activity along winter roads is predicted to be within 5 km of a road. The magnitude of the cumulative change to caribou movement and behaviour is anticipated to approach the limits of current baseline conditions.

7.5.3.2 Effects Beyond the Regional Scale of the Project

7.5.3.2.1 Effects on Habitat Quality

Methods

At the scale of the population range, the quality of caribou habitat was classified using a combination of a resource selection functions (RSFs), a human development database (described in Section 7.5.2), and a remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a GIS platform (Johnson et al. 2004, 2005). The latter land cover dataset was modified from 1,000-m cell sizes to a 25-m resolution, and then joined with esker habitat in 1:50,000 scale NTDB layers. The merged database was similar to the SGP dataset used in Johnson et al. (2004, 2005). However, upon joining layers, the dataset was re-sampled to 200 m cell sizes using a nearest neighbour algorithm (versus 100 m in Johnson et al. [2004, 2005]) because of computational constraints with generating habitat rasters over each seasonal home range. Tests for accuracy suggested there were marginal differences in the overall areas per cover type between a 100-m resampled dataset, versus a 200-m resampled dataset (i.e., less than 0.1%). Finally, the Land Cover of Canada dataset was reclassified into 12 classes similar to Johnson et al. (2004, 2005). Visual inspections of the distribution of cover data in the areas that overlapped the SGP and Land Cover of Canada guided the reclassification process.

Using the output from the reclassified dataset, patches of habitat per land cover type were identified such that each patch was a contiguous group of cells. Next, the proportional area of each patch relative to that available for the related land cover type in a seasonal range was determined. Based on the resulting raster layers and the application of RSF coefficients and formulas in Johnson et al. (2004, 2005; Table 7.5-8), resource selection values were generated per cell. Waterbodies were calculated as nil (zero) during the habitat mapping process.

Table 7.5-8 Coefficients and 95% Confidence Intervals from Resource Selection Models for Caribou in the Canadian Central Arctic for Seasonal Ranges

Covariate	Spring/Calving			Post-calving			Autumn Migration		
	Coef.	Lower 95% CI	Upper 95% CI	Coef.	Lower 95% CI	Upper 95% CI	Coef.	Lower 95% CI	Upper 95% CI
Sedge patch	1.091	0.299	1.882	0.870	0.309	1.431	0.139	-1.022	1.300
Riparian shrub patch	-3.171	-6.663	0.322	0.166	-2.100	2.432	2.273	0.556	3.991
Peat bog patch	n/a	n/a	n/a	n/a	n/a	n/a	0.081	-3.124	3.285
Low shrub patch	-0.071	-2.078	1.935	-2.732	-6.453	0.990	n/a	n/a	n/a
Heath tundra patch	1.263	0.760	1.765	1.070	0.651	1.489	0.462	-0.216	1.140
Heath rock patch	0.990	0.398	1.582	0.982	0.503	1.460	0.982	0.269	1.695
Rock patch	1.429	0.832	2.026	0.334	-0.191	0.860	-0.620	-2.128	0.888
Forest patch	-0.936	-2.765	0.893	n/a	n/a	n/a	1.483	0.681	2.285
Lichen patch	1.856	1.059	2.654	-0.450	-1.612	0.712	2.173	0.777	3.568
Esker patch	-1.303	-4.414	1.808	0.138	-1.829	2.105	-1.021	-5.705	3.663
Old burn patch	n/a	n/a	n/a	n/a	n/a	n/a	2.442	0.057	4.826
Unvegetated patch	1.776	0.922	2.629	-0.331	-1.501	0.839	2.266	0.731	3.800

Source: Johnson et al. 2004, 2005.

n/a = not applicable; % CI = percent confidence interval; coef. = coefficient.

Analysis was completed for the following seasonal ranges: spring (April 15 to June 14), post-calving (June 15 to August 31) and autumn or rut (September 1 to October 31) (Table 7.5-8). Changes to habitat quality from development could not be estimated on the winter range because the current vegetation classification is not detailed enough to correspond with caribou resource selection models in the forest. As a result, the influence of winter roads on habitat quality was not estimated (current coefficients for the spring/calving range are outside the operational period of the winter roads).

Effects of assumed disturbance, which were based on hypothetical (not modelled) disturbance coefficients (DCs) and ZOI, were applied to the RSF outputs generated from land cover datasets. Hypothetical disturbance coefficients provide a surrogate to modelled coefficients and are consistent with previous efforts to estimate effects from development on habitat quality (Johnson et al. 2005). Disturbance coefficients reduce habitat quality within each defined ZOI. For example, a DC of 0.05 implies that habitat quality was reduced by 95% of the original value.

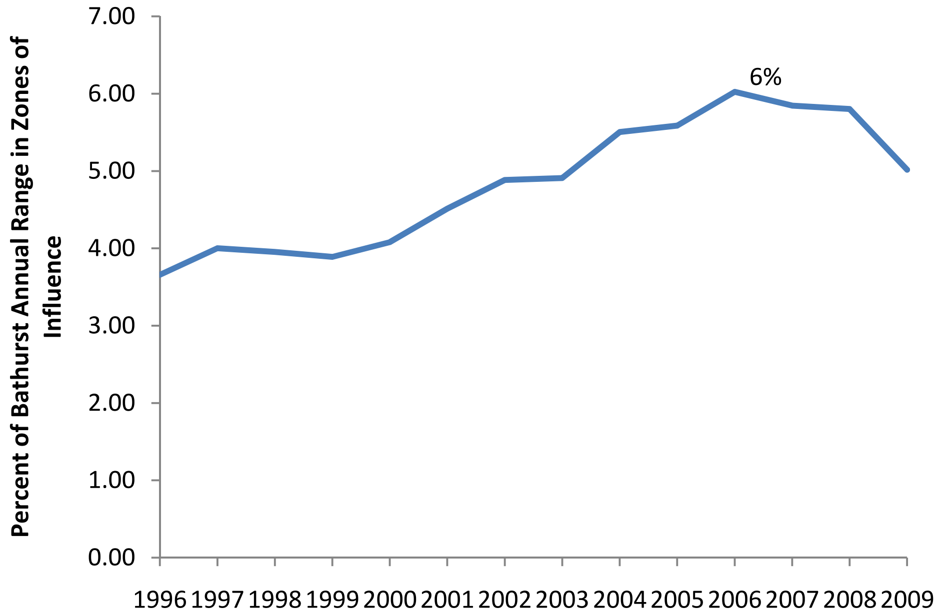
Several assumptions were made concerning the temporal and spatial extent of effects from the different types of development, particularly with respect to estimating the cumulative effects on caribou. The development layer database does not contain information on the duration of activities associated with land use permits. For example, although the land use permit for mineral exploration may be active for five years, there are no data on the actual frequency and length of time that exploration activities occurred during that period. Subsequently, to estimate the temporal extent of the ZOI from exploration sites, the analysis assumed that approved land use permits were active for five years. The assumption likely overestimates the effect from exploration activities, as exploration typically does not occur throughout the year.

Effects of assumed disturbance were used to quantify changes in the relative availability of different quality habitats during different periods of increasing and decreasing development during baseline conditions (i.e., reference, 2000, 2006, and 2010), application of the Project, and future conditions. The number of developments in the seasonal ranges (effects study area) has changed over time and a key driver of this change has been the number of mineral exploration camps (Table 7.5-1; Figure 7.5-3).

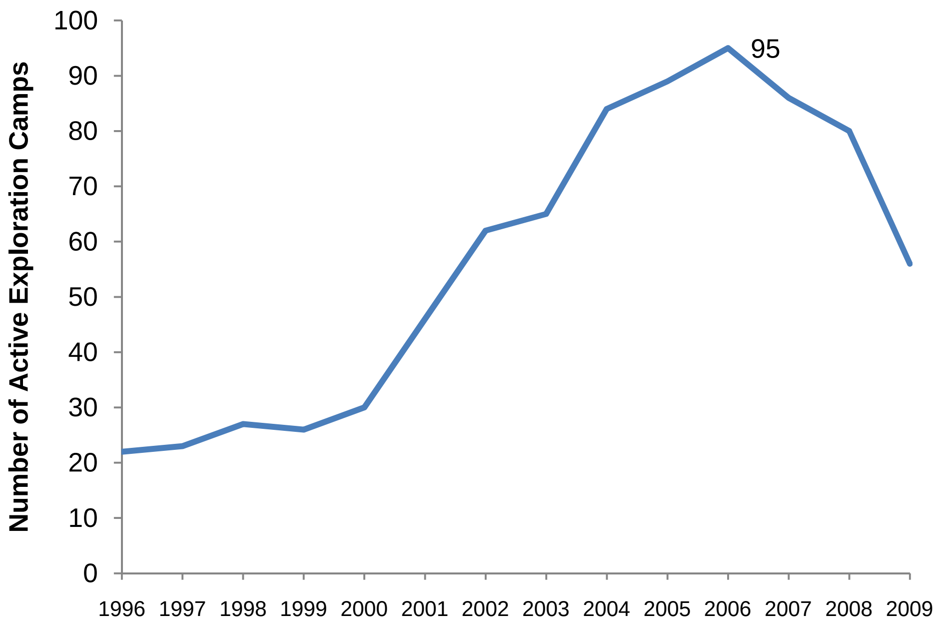
Values of DCs and ZOIs were taken from published literature (Johnson et al. 2004, 2005; Table 7.5-9). Correlation among disturbance locations could not be statistically controlled, and therefore, the effects of multiple coefficients at the same location were not multiplied. The coefficient with the strongest effect was applied where zones of influence overlapped, which increased certainty that the predicted effect would not be under estimated.

For all closed mines and inactive land use permits, the physical footprint was carried through the entire effects analysis as it was assumed that direct disturbance to the landscape had not yet been reversed. The size of the ZOI was similar for all permitted mines (i.e., 15 km) regardless of the level of activity or size of the Project footprint, which would overestimate the effect from the Snap Lake Mine relative to the Ekati-Diavik diamond mine complex (Golder 2008a, b; Boulanger et al. 2009).

Figure 7.5-3 Temporal changes in the proportion of habitat within zones of influence (a), and the number of active mineral exploration camps in the Bathurst caribou effects study area (b)



a)



b)

Table 7.5-9 Disturbance Coefficients and Associated Zones of Influence for Development Activities in the Effects Study Areas for Bathurst and Ahiak Herds

Disturbance Type	Feature Type	Footprint		ZOI Range 1		ZOI Range 2		ZOI Range 3	
		Extent (m)	DC	Range[d] (km)	DC	Range (km)	DC	Range (km)	DC
Campgrounds	point	200	0.00	NA	NA	NA	NA	NA	NA
Communications (e.g. microwave towers)	point	200	0.00	0 to 1	0.90	NA	NA	NA	NA
Community	polygon	actual[c]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 15	0.75
Fuel storage	point	200	0.00	NA	NA	NA	NA	NA	NA
Historic remediated and non-remediated sites[a]	point	200	0.00	NA	NA	NA	NA	NA	NA
Lodge (outfitters, tourism)	point	200	0.00	0 to 5	0.10	NA	NA	NA	NA
Mine	polygon	actual[c]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 15	0.75
Mineral exploration	point	500	0.00	0 to 1	0.50	1 to 5	0.75	NA	NA
Miscellaneous (e.g., bridges and culverts)	point	200	0.00	0 to 1	0.90	NA	NA	NA	NA
Power (plant)	point	500	0.00	0 to 1	0.50	NA	NA	NA	NA
Quarry	point	200	0.00	0 to 5	0.75	NA	NA	NA	NA
Staging area / barge landings	point	200	0.00	0 to 5	0.75	NA	NA	NA	NA
Transmission line[b]	line	200	0.25	0 to 1	0.50	1 to 5	0.75	NA	NA
All-season road	line	200	0.00	0 to 1	0.05	1 to 5	0.75	NA	NA

Note: Values were guided by published literature (Johnson et al. 2005).

(a) From Indian and Northern Affairs Canada contaminated sites database (classified as medium and high risk sites).

(b) DC and ZOI for transmission lines based on results reported in Mahoney and Schaefer (2002), Vistnes and Nelleman (2001) and Nelleman et al. (2003).

(c) Footprints estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.

(d) From edge of measured or hypothetical footprint.

n/a = not applicable; DC = disturbance coefficients; ZOI = zone of influence; m = metres; km = kilometre.

After habitat maps and modelling for each seasonal range were completed, raster cells were divided into four categories (high, good, low, and poor) of approximate equal area (delineated by quartiles). However, the ArcGIS algorithm for this task was constrained by the large seasonal ranges, and distribution of cell values. Thus, category thresholds were manually determined by plotting a histogram of raster cell values and running the equal area function on a lower range of data without outliers. Larger outlying values were grouped into the top category identified from the analysis on the lower (smaller) range of values. The RSF outputs based only on vegetation datasets were used as a reference condition (i.e., no development) within the baseline case.

Relative changes in the area of high, good, low, and poor quality habitat were then calculated for the spring (April 15 to June 14), post-calving (June 15 to August 31), and autumn/rut (September 1 to October 31) seasonal ranges. The following equations were used to calculate the relative change in the amount of different quality habitats for each seasonal range for different conditions on the landscape:

- (2000 baseline area – reference area) / reference area x 100
- (2006 baseline area – 2000 baseline area) / 2000 baseline area x 100
- (2010 baseline area – 2006 baseline area) / 2006 baseline area x 100
- (application case area – 2010 baseline area) / 2010 baseline area x 100
- (future case area – application case area) / application case area x 100

Results

The amount of preferred habitat (i.e., high and good quality habitats) for caribou in the seasonal ranges decreased from reference to 2010 baseline conditions (Tables 7.5-10 and 7.5-11). Most of the decline in habitat quality occurred from 2000 to 2006 and was associated with the increasing number of exploration sites on the landscape (Figure 7.5-3b). Relative to 2006, the availability of quality habitats in the seasonal ranges was higher in 2010 (Tables 7.5-10 and 7.5-11), which was due to the decrease in the number of active developments. Figures illustrating this change in area in habitat suitability per seasonal range are presented in Appendix 7.IV (Figures 7.IV-1 to 7.IV-36).

From reference to 2000 landscape conditions, high and good quality habitats declined about 3.1% on the spring range, 2.8% on the post-calving range, and 2.4% on the autumn range of the Bathurst herd (Table 7.5-10). From 2000 to 2006, preferred habitat was reduced by about 1.2% on the spring range, 2.9% on the post-calving range, and 4.7% on the autumn range (Table 7.5-10). However, from 2006 to 2010, the availability of good and high quality habitats per seasonal range increased. These increases were associated with the expiration of permits for exploration sites (Figure 7.5-3b). As a result, there were no zones of influence from these sites, and only influences from direct disturbance from the physical footprints remained.

The application of the Project to the existing (2010) landscape resulted in less than 0.3% decreases in high quality habitats on the seasonal ranges (Table 7.5-10). The largest incremental change from the Project was a 1.4% decrease in good quality habitat on the autumn range. Similar incremental changes in preferred habitats were observed with the addition of reasonably foreseeable developments (i.e., Taltson Hydroelectric Expansion Project). The largest incremental change from the Taltson Hydroelectric Expansion Project was a 2.1% decrease in good quality habitat on the autumn range.

Cumulative changes from reference conditions through future conditions were similar to those estimated for the time period prior to 2006. Cumulative changes from the Project and other developments decreased preferred habitat by about

2.7% on the spring range, 3.2% on the post-calving range, and 7.3% on the autumn range (Table 7.5-10).

Compared to the Bathurst caribou herd, there were relatively small changes in the amount of different quality habitats between reference and 2010 baseline conditions for the Ahiak herd. The majority of Ahiak caribou habitat within the seasonal ranges has remained unchanged by human activity (Table 7.5-11). There was less than 1.1% decreases in high and good quality habitats from reference to future conditions per seasonal home range. In addition the availability of preferred habitat did not change with the addition of the Project to the 2010 landscape (i.e., the Project is not within these seasonal ranges for the Ahiak herd).

Table 7.5-10 Relative Changes in the Availability of Different Quality Habitats for Bathurst Caribou Seasonal Ranges from Reference to Reasonably Foreseeable Projects

Habitat Quality	Reference (ha)	% Change Reference to 2000	% Change 2000 to 2006[(a)]	% Change 2006 to 2010[(a)]	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
Spring / Calving							
High	6,443,478	-0.88	-0.41	0.19	-0.18	-0.43	-1.71
Good	3,858,966	-2.21	-0.78	1.25	0.26	0.54	-0.94
Low	4,186,354	-2.95	-2.61	2.56	-0.34	-1.86	-5.20
Poor	5,828,884	4.55	2.65	-2.56	0.25	1.35	6.25
Nil	*3,723,183*						
Total	*24,040,866*						
Post-Calving / Summer							
High	3,614,424	-1.03	-0.19	0.40	-0.29	-0.56	-1.67
Good	2,492,399	-1.80	-2.71	2.04	0.38	0.53	-1.56
Low	2,648,592	-5.43	-4.62	2.88	-0.32	-2.14	-9.63
Poor	1,603,986	14.07	10.32	-6.52	0.48	3.13	21.49
Nil	*1,602,840*						
Total	*11,962,240*						
Autumn / Rut							
High	4,449,531	-0.68	0.24	0.02	0.00	-0.03	-0.45
Good	3,912,304	-1.73	-4.93	3.29	-1.37	-2.03	-6.78
Low	3,102,575	-3.22	-2.23	1.49	-0.48	-1.72	-6.16
Poor	4,679,531	4.23	5.05	-3.22	1.33	2.55	9.94
Nil	*2,931,756*						
Total	*19,075,697*						

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the earlier time period (i.e., analyses exclude nil habitat). Cumulative values may not exactly sum due to rounding.

Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2000, 2006, and 2010 Baseline = incremental changes from previous and existing developments.

Application case = Gahcho Kué Project plus 2010 baseline conditions.

Future case = Taltson Hydroelectric Expansion Project plus application case.

(a) Increases in high or good quality habitats are due to expiration of exploration permits (i.e., only direct effects from footprint remain following exploration).

ha = hectares; % = percent; n/a = not applicable.

Table 7.5-11 Relative Changes in the Availability of Different Quality Habitats for Ahiak Caribou Seasonal Ranges from Reference to Reasonably Foreseeable Projects

Habitat Quality	Reference (ha)	% Change Reference to 2000	% Change 2000 to 2006[(a)]	% Change 2006 to 2010[(a)]	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
Spring / Calving							
High	798,803	0.00	0.00	0.00	0.00	0.00	0.00
Good	10,507,733	-0.24	0.03	0.00	0.00	-0.01	-0.22
Low	5,109,366	-1.84	-0.49	0.40	0.00	-0.49	-2.40
Poor	6,353,273	1.87	0.33	-0.30	0.00	0.39	2.29
Nil	*2,306,485*						
Total	*25,075,660*						
Post-Calving / Summer							
High	5,499,649	-0.07	-0.04	-0.11	0.00	0.00	-0.22
Good	5,772,676	-0.27	0.06	-0.13	0.00	0.00	-0.34
Low	5,307,362	-0.40	-0.32	0.13	0.00	0.00	-0.58
Poor	3,971,250	1.01	0.38	0.16	0.00	0.00	1.57
Nil	*2,380,913*						
Total	*22,931,849*						
Autumn / Rut							
High	6,270,014	-0.52	-0.41	0.23	0.00	-1.11	-1.81
Good	4,258,341	0.05	0.76	-0.95	0.00	0.86	0.71
Low	6,045,800	-0.48	0.08	-0.02	0.00	-0.34	-0.76
Poor	6,462,218	0.92	-0.17	0.42	0.00	0.81	1.99
Nil	*2,381,909*						
Total	*25,418,282*						

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the earlier time period (i.e., analyses exclude nil habitat). Cumulative values may not exactly sum due to rounding.

Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2000, 2006, and 2010 Baseline = incremental changes from previous and existing developments.

Application case = Gahcho Kué Project plus 2010 baseline conditions.

Future case = Taltson Hydroelectric Expansion Project plus application case.

(a) Increases in high or good quality habitats are due to expiration of exploration permits (i.e., only direct effects from footprint remain following exploration).

ha = hectares; % = percent; n/a = not applicable.

7.5.3.2.2 Effects on Behaviour, Energy Balance, and Calf Production

Reduced rates of calf survival and female fecundity (i.e., parturition or calf production) have been cited as key factors contributing to recent declines in the size of the Bathurst herd (Boulanger and Gunn 2007). There are a number of natural large-scale environmental factors that can influence the survival and reproduction of caribou through changes in behaviour, foraging, and energetics. Food abundance and quality on summer and winter ranges have been determined to be important elements in tundra caribou population dynamics (Reimers 1983; Skogland 1990; Post and Klein 1999). Snow conditions, such as depth and hardness, also affect the movement rate and food accessibility for caribou (Stuart-Smith et al. 1997). Extreme weather events such as late spring snowfall or late snowmelt can influence access to food and result in lower calf weights or delayed parturition (time of calving), which influences survival of young (Skogland 1984; Adamczewski et al. 1987; Cameron et al. 1993).

High insect abundance can also decrease forage intake, milk production, and calf growth and possibly survival (Helle and Tarvainen 1984; Russell et al. 1993; Hagemoen and Reimers 2002; Weladji et al. 2003). Factors that influence adult female food intake and energetics from summer through winter also determine pregnancy and calving rates. Finally, there is a complex interaction between habitat, and caribou foraging and movement patterns that is not well understood for barren-ground caribou herds. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

Loss of body weight in adult females due to interactions with zones of influence from development on the landscape also may result in reduced calf production, poor winter condition, and increases in the likelihood of predation. During the post-calving to autumn/rut periods, animals have the greatest potential for travelling through or encountering a number of developments on the landscape (Boulanger et al. 2004). In addition, these seasons or life stages have been identified as critical periods for foraging when animals must achieve satisfactory body weight and condition to increase the chance of becoming pregnant and producing a calf the following spring (Cameron and Ver Hoef 1994; Gerhart et al. 1997; Bradshaw et al. 1998; Cameron et al. 2005).

The objective in this section is to assess the energy implications of cumulative encounters with developments and insect harassment during the post-calving and fall/rut seasons on autumn body weight in female caribou, and ultimately, on the fecundity of individuals in the Bathurst herd. Fecundity is defined as the likelihood of a female becoming pregnant and successfully producing a calf in the spring. Although other factors can influence the body condition of caribou, such as food quality and accessibility on summer and winter ranges, effects related to human development and insect harassment are examined because they are commonly discussed as contributing factors to the recent population decline. Furthermore, data for zones of influence from mining activities and insect harassment indices are more available relative to the quality of food on seasonal ranges.

Information from satellite-collared caribou was used to quantify residency and encounter rates of female caribou with zones of influence of development (1996 to 2009). The analysis focused on satellite locations starting approximately from June 15 (post-calving range) though October 31 (autumn/rut range) . Statistical analysis was used to assess factors related to caribou residency in zones of influence, as well as encounter rates using multiple regression techniques.

A simple model was then constructed to estimate the energy cost (i.e., body weight loss) from a single encounter with disturbance caused by development activities using information in previously published literature (Bradshaw et al. 1998). An insect harassment index (IHI) was used to predict the energetic cost to female caribou and subsequent reduced fecundity for different levels of insect activity. The results were used to predict effects from disturbance associated with development and insects on caribou reproduction and population size (Gunn et al. 2001).

Methods

Zone of Influence Residency and Encounters

The West Kitikmeot Slave Study Partners identified caribou movement routes and calving ground protection as research priorities in 1995. Since 1996, satellite telemetry has been used to describe movements of collared caribou across their annual home range. Initially 10 transmitting collars were deployed in 1996, after which time the number of collars has varied among years. The collars transmit a signal to a satellite and the satellite's on-board software determines the collar's location as well as the accuracy associated with that location. To gain maximum battery duration, the majority of transmitters were programmed to transmit for 6 hours at 5-day intervals throughout the year. Starting in 2002, transmitters were also programmed to transmit at 1-day intervals from July 1 to August 15 to better describe post-calving movements.

In general, the caribou satellite data were based on a duty cycle that varied from every 7 days to every 1 day, and became more frequent during more recent years (Table 7.5-12). The locations for ten animals, including five from 1996, were recorded every 10 days or more. In 2009, the frequency of locations was increased to several hours during the summer to autumn period. When multiple locations were obtained for an individual caribou during a day, the best location each day was used as classified by on-board collar software. Satellite data examined here have been shown in annual reports from industry and government agencies (e.g., Gunn et al. 2001; Golder 2003; Boulanger et al. 2004; Johnson et al. 2004, 2005; DDMI 2008).

Table 7.5-12 Summary of Collared Caribou, Location Interval, and the Number of Linear Segments (Euclidean Path Lines between Successive Locations) for Female Bathurst Caribou (1996 to 2009)

Year	Number of Collared Animals	Mean Days Between Locations	Mean Number of Segments or Partial Paths per Animal
1996	10	6.5 (3.5-27.5)	28.1 (4-32)
1997	7	4.2 (4.1-4.2)	31.9 (31-32)
1998	20	9.6 (4.2-27.5)	7.0 (1-32)
1999	14	5.9 (4.2-9.2)	23.3 (6-32)
2000	13	5.6 (4.2-10.8)	23.5 (8-32)
2001	13	5.7 (5.0-9.4)	20.9 (6-27)
2002	11	3.5 (1.2-5.1)	41.3 (26-64)
2003	11	3.0 (1.8-6.8)	50.3 (4-65)
2004	15	5.0 (1.6-21.0)	19.5 (2-56)
2005	19	2.4 (2.1-5.1)	58.2 (1-64)
2006	15	2.2 (1.3-2.9)	58.7 (34-64)
2007	19	1.9 (1.4-2.7)	68.8 (30-88)
2008	14	1.9 (1.4-2.7)	63.0 (14-89)
2009	13	0.5 (0.2-1.5)	393 (89-465)

Note: Numbers in parentheses = minimum to maximum values.

Within a GIS platform, movement paths were created per animal and year by joining sequences of successive locations. Because the frequency of satellite collar re-locations has increased during the last eight years, the number of segments (distance intervals or partial paths) between success locations for each animal has also increased (Table 7.5-12). The analysis was restricted to the Bathurst herd, and for the combined post-calving and autumn (or rut) seasons (June 15 to October 31 [138 days]). The movement vectors were then combined with the development layer database that was used for the habitat analyses (Section 7.5.3.2).

The analysis was executed each year of the study so that a caribou path would only have the potential to intersect the zones of influence from developments that were determined to be present during that year (i.e., active mine sites and exploration permits). Because it is not possible to forecast the movement paths and correspondent number of interactions between caribou and the Project (and future developments),each path from 1996 to 2009 was combined with a landscape of only the Project and future developments (i.e., the Taltson Hydroelectric Expansion Project) to estimate the potential future encounter rate of caribou with these developments.

The analysis was used to calculate the residency time of female caribou in zones of influence, and the encounter rates with zones of influence. Specifically, the percentage of days that caribou resided within zones of influence (i.e., residency time) of the total possible days during the exposure period (i.e., 138 days) was calculated for each individual female movement path. It was assumed that for each day in a ZOI, an animal was exposed to one disturbance event, regardless of how close it was to development footprint or activity. To complement residency times, the number of animal encounters with zones of influence during the exposure period was also calculated for each female movement path. It was assumed that each time an animal entered a ZOI, the animal was exposed to one disturbance event (also independent of distance to disturbance).

Because some of the paths did not extend for the duration of the exposure period (i.e., on average, 112 of 138 possible coverage days), total encounters for incomplete paths were standardized to encounters per 138 days. For the assessment of encounter rates and energetics, 2009 was used as the year for describing current or existing (2010) baseline conditions. At the time of the analysis for the EIS, this was the most recent year where there was complete information on the movements of satellite-collared animals during the summer to autumn period.

The data also provided an opportunity to evaluate factors influencing movement parameters of caribou, specifically speed. The objective was to test the hypothesis that human development within the summer to autumn range may affect behaviour, for example, by agitating animals with sensory disturbances. Regression techniques were used to determine factors influencing movement rates of caribou (metres per hour [m/h]) as a surrogate measure of agitation and changes in behaviour. Independent factors included the percentage of home range in ZOI cover, encounter rate per 138 days, and percent residency time in ZOI. Year was excluded from the regression model because it was highly correlated with percentage of the seasonal range in ZOI cover (Pearson $r > 0.8$).

The insect harassment index (IHI; see next section) was included as an independent variable in preliminary analyses using a subset of data (i.e., paths during years with complete weather information for calculation of IHI). However, IHI was removed from the final analyses given that the parameter was weakly related to speed and that multiple paths lacked IHI values (30 paths). Additional independent factors were included to reduce the detection of spurious trends. These included the time (hours) interval between successive locations (which varied across animals and years), and the Julian end date of the path (because some animals were not monitored over the entire 138-day period). Statistical significance was identified at an alpha level of 0.05.

Energetics Model

Sensory Disturbance

The encounter rates with zones of influence and associated major sensory disturbance events (hereafter referred to as a disturbance event) on individual female caribou were used to estimate the change in caribou energetics and subsequent effects on fecundity (i.e., parturition rate). The hypothesis is that industrial developments affect parturition rates by creating sensory disturbances that alter caribou behaviour and energetics as they migrate from calving areas to the winter range (prior to the onset of freeze-up and unfavourable winter conditions) (Bergerud et al. 1984; Cameron et al. 2005). For example, an animal in close proximity to an active mine may encounter and respond to noise or visual disturbances from a human walking or working outside, a moving vehicle, blasting, and/or a plane flying overhead. Based on data collected at the Ekati Diamond Mine from 2001 through 2008, the fraction of caribou groups that showed a behavioural response to sensory disturbances was 55% (BHPB 2010).

The energetic model quantified costs for an encounter (i.e., a single sensory disturbance event), calculated as the sum of energetic costs (Mega Joules [MJ]) for the initial flight response, additional movements, plus the cost of excitement. Most of the analysis is based on an energy model for adult female caribou of the Denali Herd in Alaska (Boertje 1985). It was assumed that this model was applicable to caribou of the Bathurst herd.

Bradshaw et al. (1998) noted that disturbed caribou in the boreal forest of Alberta move rapidly from the source for about 15 minutes. It was assumed herein that, when animals exhibit a behavioural response, they are running away or trotting. This is an ecologically conservative assumption as responses can vary and be as negligible as only looking in the direction of the disturbance (BHPB 2009). Based on a trotting and galloping cost of 0.035 Mega Joules per kilogram per hour (MJ/kg/h) for 0.25 hours, the cost of the initial flight response was calculated to be 0.70 MJ (assuming an average-sized female of 80 kilograms (kg) body weight; Banfield 1974; Adamczewski et al. 2009). Next, it was determined that caribou travelled, on average, an additional 2.11 km after a disturbance event (Bradshaw et al. 1998). The cost of this extra distance was calculated as walking cost x body weight x distance travelled. Assuming that barren-ground caribou require 0.00264 Mega Joules per kilogram per kilometre (MJ/kg/km) for walking (Boertje 1985), an average-sized female caribou expends an additional 0.45 MJ of energy when disturbed.

An increase in metabolic rates can also result from prolonged excitement from a disturbance event (MacArthur et al. 1979). Nervousness and increased muscular tension can account for a 10% increase in fasting metabolic rates (Blaxter 1962).

It was assumed that animals are excited for a 12-hr period following a sensory disturbance event, even though prolonged excitement may not extend for that time period (Boertje 1985). Based on a daily fasting metabolic rate (FMR) of 0.403 $MJ/kg^{0.75}$ (McEwan 1970; Fancy and White 1987), the cost of excitement was calculated as 0.10 x $(80\ kg)^{0.75}$ x FMR x 0.5 days = 0.54 MJ. Thus, total cost of disturbance is approximately 1.69 MJ (0.45 MJ for walking + 0.70 MJ for flight response + 0.54 MJ for prolonged excitement).

To determine the energy equivalent of body weight of caribou, endogenous reserves were divided into two categories: loss by fat catabolism (90% of reserve) and loss by protein catabolism (10% of reserves; Boertje 1985). It was assumed that fat produces 39.3 MJ/kg and lean tissue produces 5.0 Mega Joules per kilogram (MJ/kg) (Boertje 1985). Mass loss associated with a behavioural response to disturbance was calculated as total cost of disturbance (1.69 MJ) divided by [(0.9 x 39.3 MJ/kg) + (0.1 x 5.0 MJ/kg)] = 0.0471 kg. The mean autumn mass loss resulting in no reproduction the following spring was set at 20% of an 80 kg female (i.e., 16 kg). It was assumed that the relationship between autumn body mass and parturition rate was linear. The proposed relationship is a simplified, but biologically conservative modification of that described in Cameron and Ver Hoef (1994). Thus, the total number of disturbance events resulting in no parturition the following the spring was calculated as 16 kg divided by 0.0471 kg (approximate mass loss from one disturbance event), which is 340 disturbance events and an expenditure of 575 MJ. In other words, each encounter with disturbance reduces the parturition rate (or fecundity and calf production) by 0.00294 units.

In summary, the coefficient for the rate of body weight loss from disturbance events is 0.0471 kg. The following is an example showing the possible consequences of encountering industrial developments across the summer to autumn range of caribou. There are 138 days that caribou may be potentially exposed to zones of influence during the post-calving and autumn/rut periods (June 15 to October 31). It was assumed that female caribou would be exposed to one disturbance event per day while remaining within a ZOI. For the complementary analysis of encounter rates, it was assumed that the animal experienced one disturbance event when entering a ZOI (regardless of how close it was to the development or activity). Of the total number of encounters, it was anticipated that 55% of them would result in a behavioural response that would decrease body weight (BHPB 2009). Thus, if caribou encounter 69 zones of influence or occupy a ZOI for 50% of the summer to autumn range (69 days of 138 days), then calf production is reduced by 11.2% the following spring, given the anticipated decrease in mean autumn body weight ({[69 disturbance events x 0.55 x 0.0471 kg] divided by 16 kg}) (Figure 7.5-4).

Figure 7.5-4 Model Summary for Effects from Disturbance Events and Insect Harassment on Caribou Fecundity Rate (i.e., Parturition Rate)

Relative Decrease in Parturition (Fecundity) Rates =

80 kg -[((IHI – 14)* x *0.148) + (Disturbance Events* x *0.55 x 0.0471 kg)] / 16 kg;

where:

i) *a disturbance event is a ZOI encounter (or a day in a ZOI)*
ii) *IHI (Insect Harassment Index) is measured as oesterid harassment days;*
iii) *total autumn weight loss of 20% of a 80 kg healthy cow (i.e., 16 kg) results in no calf the following spring; and*
iv) *reference parturition rate = 0.92.*

ZOI = zone of influence; kg = kilogram.

The model assumes that individuals do not compensate for weight loss by increasing quality food intake following a disturbance event (for example, see Dale et al. 2008), and do not become familiar to (habituate) similar disturbances (for example, see Stankowitch 2008). If caribou do increase the amount of food eaten after a disturbance and do not respond strongly to the same types of disturbance every time, then the model will overestimate the effect on the population.

Insect Harassment

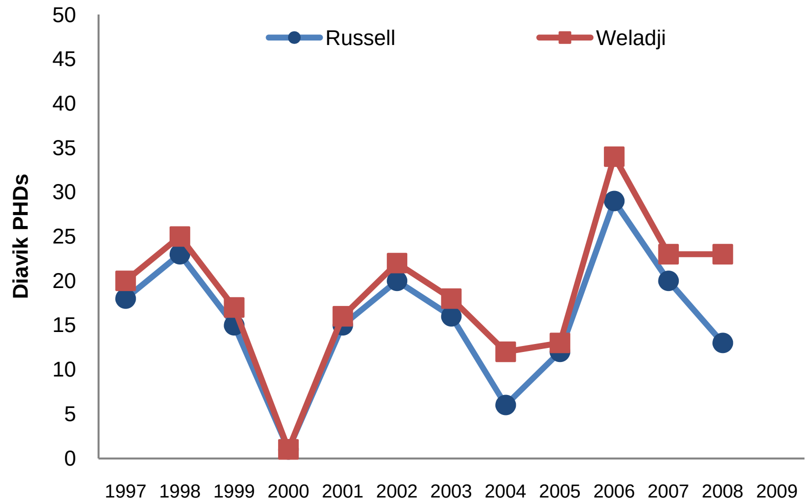
Insect harassment, particularly oesterid flies, can reduce the ability of caribou to feed optimally during the fall migration (Hagemoen and Reimers 2002) and have a negative effect on body condition and fecundity (Weladji et al. 2003). As insect harassment increases, travel rates increase and feeding rates decline (Bergerud et al. 2008). Bergerud et al. (2008) argues that the effect of sensory disturbances on caribou are relatively insignificant compared to the stress the animals sometimes face by oestrid flies. However, insect activity levels vary and are highly correlated with weather conditions. Overall insect activity levels are generally low and harassment is tolerable at times and locations that are relatively cool and windy. There is substantial behavioural evidence suggesting that harassment by insects is the most important causal link between warm summer temperatures and low body condition of caribou (reviewed in Weladji et al. 2003). Ideal weather conditions for caribou occur when mid-day ambient temperatures are less than 13 degrees Celsius (°C) and when wind speeds are greater than 6 metres per second (m/s) (Weladji et al. 2003).

An IHI was developed according to Weladji et al. (2003), and was used to predict changes in body condition under varying climatic scenarios. First, comparisons of the Weladji et al. (2003) index with the commonly used Russell et al. (1993) oesterid index were made using meteorological data from two mine sites in the summer to autumn range (Diavik Diamond Mine and Snap Lake Mine). Correlation analysis suggested that the indices were very similar (Pearson r = 0.9, n = 23; Figure 7.5-5). The proposed IHI was calculated as the number of potential harassment days (PHDs) having mid-day ambient temperatures greater than 13°C and wind speeds less than 6 m/s.

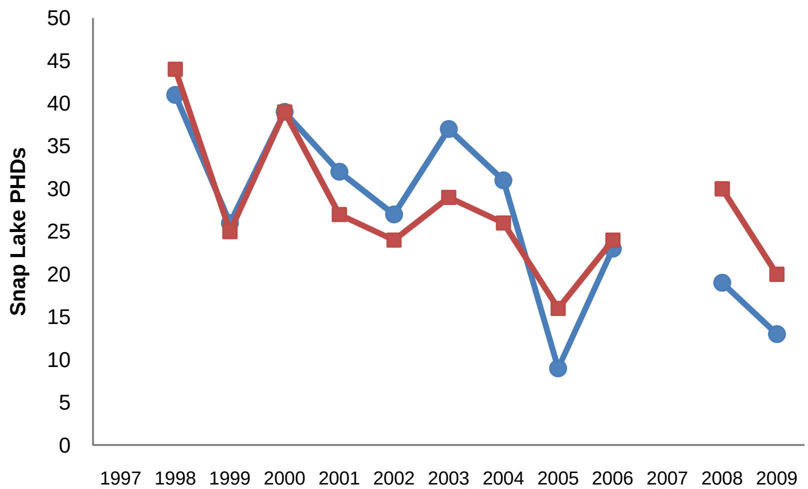
The IHI-autumn weight relationship was first described for reindeer calves (*Rangifer tarandus*) in Norway, which achieve maximum autumn weights of about 20 kg. In the Norway study, autumn weights of calves declined at approximate rates of 0.037 kg with every 1 unit increase in IHI (see Weladji et al. 2003). It was assumed that the percent change in autumn body mass for calves in the Norway study was similar for adult females in this assessment. Thus, for female caribou weighing 80 kg, it was predicted that there was a 0.148 kg decrease in body weight with every 1 unit increase in IHI (Weladji et al. 2003; Figure 7.5-4).

The proposed weight loss relationship was used in combination with regional trends in IHI to estimate effects of insect harassment levels on autumn weight of female caribou, and ultimately, fecundity rate (likelihood of getting pregnant and producing a calf). However, it was assumed that adult caribou can tolerate some level of insect activity where there are no implications for body condition. In this assessment, the IHI threshold at which insect activity levels begin to impair caribou energetics was determined to be 14. This was the 10th percentile of the range of values from long-term climate data at two mine sites describing daily weather conditions in two regions (Lac de Gras and Camsell Lake) within the summer to autumn range (effects study area).

Figure 7.5-5 Insect Harassment Indices Defined as Potential Harassment Days (PHDs) and Calculated with Meteorological Data from the Diavik Diamond Mine (a) and Snap Lake Mine (b)



a)



b)

Based on the relationship between the modified IHI and body weight loss in caribou, autumn body weight was defined as: 80 kg – [(IHI – 14) x 0.148]. Pooling meteorological data (1997 to 2009) from the Diavik and Snap Lake mine sites indicated that the mean annual IHI was 23 (range = 1 to 44) (Table 7.5-13). It was assumed that this value describes typical conditions on the summer to autumn range of Bathurst caribou. Based on the proposed weight loss-IHI relationship and mean IHI values, female caribou could lose as much as 1.33 kg from insect harassment during an average summer. Smaller body sizes and poorer body conditions, as indicators of habitat and weather, have direct consequences to reproduction and population dynamics (e.g., Bergerud et al. 2008). Assuming that the autumn mass loss resulting in no calf production the following spring is 20% of an 80 kg female (i.e., 16 kg), an IHI value of 23 would lower parturition rates by 8.3% (1.33 kg / 16 kg). The overall relative decrease in the parturition rate of caribou was related to both insect harassment and development-related disturbance events (Figure 7.5-4).

Table 7.5-13 Mean, Minimum, and Maximum Insect Harassment Index for the Diavik Diamond Mine and Snap Lake Mine, 1997 to 2009

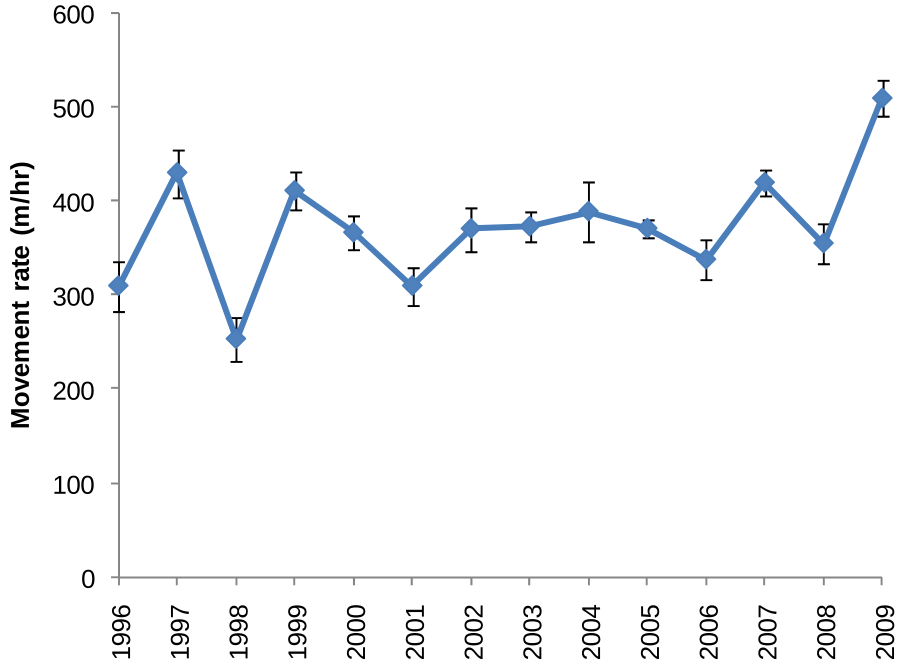
Site	Insect Harassment Index			
	Mean	Standard Deviation	Minimum	Maximum
Diavik	18.7	8.1	1	34
Snap Lake	27.6	8.0	16	44

Note: Measured as the number of potential insect harassment days based on Weladji's index (Weladji et al. 2003); excludes 2007 weather data for Snap Lake and 2009 weather data for Diavik.

Results

In total, 194 individual female caribou paths comprised of 12,133 partial paths or segments from the Bathurst herd were created from 7 to 20 animals per year from 1996 to 2009 (Table 7.5-12). On average, location data were obtained every 4.2 days per animal and year, with shorter intervals between successive locations for the latter years of the study. For example, in 2009, the mean number of days between successive location data was 0.5 days (n = 13 collared animals). In addition, the average duration of the total movement path (sum of all linear segments) was over 112 days and extended 989 km per animal and year (about 9 km per day). The overall mean speed of caribou movement was 367 m per hour (SD = 97.9), and was variable across years (Figure 7.5-6).

Figure 7.5-6 Annual Trends in Mean Movement Rate (± 1SE) for Female Caribou in the Bathurst Herd from June 15 to October 31.



Based on multiple linear regression and descriptions of 194 caribou paths, the speed of female caribou was positively related with encounter rate (t_{193} = 2.0, P = 0.044; Table 7.5-14). After controlling for effects of other independent variables, the model predicted that one more encounter with disturbance would be associated with an increase in speed of 1.6 m/h. Speed was negatively and weakly related to percent residency time within ZOIs (P = 0.16) and proportion of the seasonal (summer to autumn) range in ZOI cover (P =0.21; Table 7.5-14).

Table 7.5-14 Summary of Regression Predicting Caribou Speed using Paths Delineated from Collar Data during June 15 to October 31 (n = 194 paths).

Independent Variable	Coefficient	Standard Error	*t* -statistic	P-value	Lower 95% CI	Upper 95% CI
Encounters / 138 days	1.555	0.766	2.0	0.044	0.044	3.067
%residency time	-0.890	0.637	-1.4	0.164	-2.147	0.367
%seasonal range in ZOI	-11.589	9.103	-1.3	0.205	-29.547	6.369
Interval (hrs)	-0.4645	0.0746	-6.2	0.000	-0.6117	-0.3174
Julian date	-1.222	0.274	-4.5	0.000	-1.762	-0.681
Constant	825.5	97.6	8.5	0.000	633.0	1018.0

Note: model R^2 = 0.29;

ha = hectares; m/d = metres per day; % = percent; CI = confidence interval; ZOI = zones of influence; <= less than.

Residency

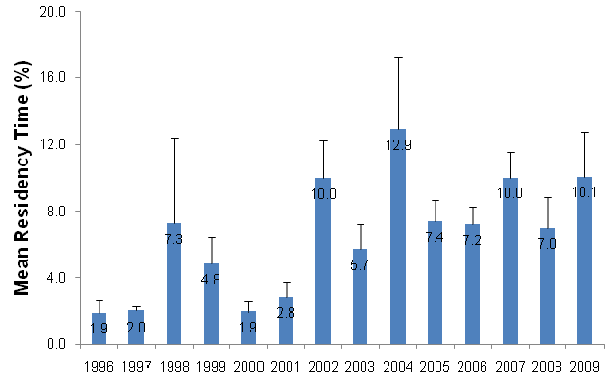
From 1996 to 2009, Bathurst caribou resided in zones of influence for an average of 9.6 days (SD = 14.3 days) or 6.9% of their time during the summer to autumn period (n = 194 paths). The amount of time spent by female caribou in zones of influence had increased from 1.9% in 1996 to 10.1% in 2009 (Figure 7.5-7a). The results suggest that residency time in zones of influence have increased 5-fold from 1996 to 2009. For comparison, the proportion of the summer to autumn range in ZOI cover has increased only 1.4 times during the same time period. The year with the highest mean residency rate was 2004 at 12.9% (or 17.8 days), whereas the year with the highest proportion of the summer to autumn range in ZOI cover was 2006 at 6.0%.

With the addition of the Project to the summer to autumn range, simulations predicted that caribou may reside in the Project ZOI for only a short duration (Figure 7.5-7b). The overall mean residency time was 0.6 days (SD = 2.1 days) or 0.4% of the 138-day summer to autumn period (n = 194 paths). The highest annual residency time approached 1.0% (based on paths created from 1996 data; n = 10 paths). The residency time at the Project using either 2008 collar data (n = 14 paths) or 2009 collar data was zero (n = 13 paths).

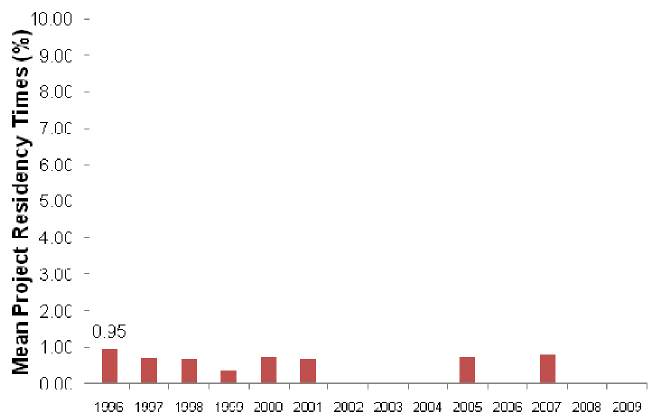
In contrast to the Project, the anticipated residency time in the ZOI for the Taltson Hydroelectric Expansion Project was longer in duration (Figure 7.5-7c). For the Taltson Hydroelectric Expansion Project, the overall mean residency time was 4.4 days (SD = 8.5 days), or 3.2% of the summer to autumn period (n = 194 paths). The highest annual residency time was 7.3% (based on paths created from 1998 data; n = 20 paths). Using 2009 collar data, residency time was 5.3% (n = 13 paths).

With the addition of both the Project and the Taltson Hydroelectric Expansion Project, the overall mean residency was 5.0 days (SD = 9.1 days) or 3.6% of the summer to autumn period (138 days). The highest annual residency time was 7.9% (based on paths created using 1996 data). Using 2009 collar data, residency time within the zone of influence of potential future developments was 5.3%.

Figure 7.5-7 Temporal Trend in Mean Percent Time (± 1SE) in Zones of Influence for Female Caribou in the Bathurst Herd from 1996 to 2009 (a), and Predicted residency times for the Project (b) and the Taltson Hydroelectric Expansion Project (c)

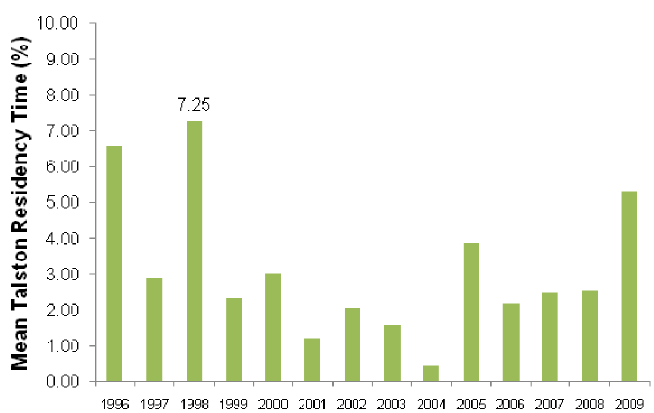


a)



b)

Note: anticipated residency times (% of 138 day period) were calculated using only the Project location combined with previous paths of migrating caribou (194 paths in total).



c)

Note: anticipated residency times (% of 138 day period) were calculated using only the Taltson Hydroelectric Expansion Project location combined with previous paths of migrating caribou (194 paths in total).

Encounter Rates

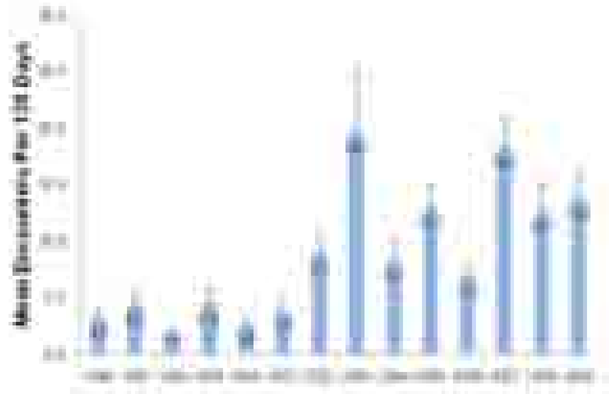
Caribou paths monitored from 1996 to 2009 were used also to calculate the number of caribou encounters with zones of influence. Caribou residency time (i.e., percent time in zones of influence) and encounter rates were moderately correlated with each other (Pearson r = 0.40). Across all years combined, the mean encounter rate with a ZOI was 9.0 encounters per 138 days (SD = 9.5) for female caribou. Mean encounter rates have increased from 2.9 encounters per 138 days during baseline conditions in 1996 to 13.8 encounters per 138 days in 2009 (Figure 7.5-8a). Mean annual encounter rates have increased 4.5-times from 1996 to 2009. For comparison, the proportion of the summer to autumn range in ZOI cover has increased only 1.4-times during the same time period. Further, mean annual encounter rates with ZOIs peaked in 2003 at 19.7 encounters per 138 days, whereas the proportion of summer to autumn range in ZOI cover peaked in 2006 at 6.0%.

With the addition of the Project to the summer to autumn range, simulations predicted that a small number of caribou may encounter the ZOI associated with the Project (Figure 7.5-8b). Of the 194 paths that were created from 1996 to 2009, only 21 encountered the Project ZOI. Across all years combined, the overall mean encounter rate was 0.2 encounters per 138 days (SD = 0.8). The highest annual mean encounter rate was 0.5 per 138 days (based on paths created from 1998 data; n = 20 paths). The projected encounter rate with the Project using either 2008 collar data (n = 14 paths) or 2009 collar data (n = 13 paths) was zero.

In contrast to the Project, the anticipated encounter rate with the Taltson Hydroelectric Expansion Project ZOI was higher (Figure 7.5-8c). Of the 194 paths that were created from 1996 to 2009, 139 intersected with the Taltson Hydroelectric Expansion Project ZOI. Pooling data from all years, the overall mean encounter rate was 2.1 encounters per 138 days (SD = 2.9 days). The highest mean annual encounter rate was 3.5 encounters per 138 days (based on paths created from 1998 data; n = 20 paths). Using 2009 collar data, the encounter rate for the exposure period was 2.8 encounters per 138 days (n = 13 paths).

With the addition of both the Project and the Taltson Hydroelectric Expansion Project, the overall mean encounter rate with a ZOI across all years was 2.3 encounters per 138 days (SD = 3.3). The highest mean annual encounter rate was 3.7 encounters per 138 days (based on paths created using 2005 data; n = 19). Using 2009 collar data, the encounter rate with potential future developments was 2.8 encounters per 138 days.

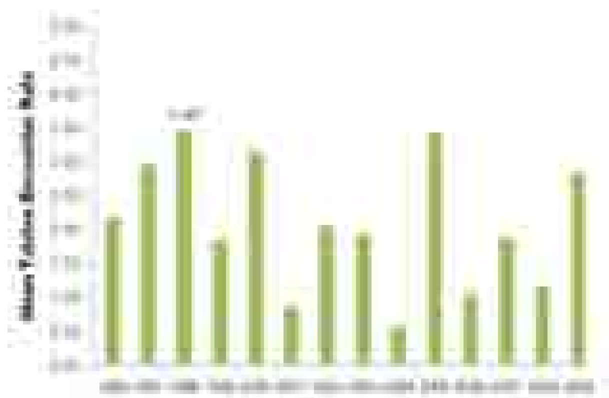
Figure 7.5-8 Temporal Trend in Mean Encounter Rates (± 1SE) with Zones of Influence for Female Caribou in the Bathurst Herd from 1996 to 2009 (a), and Predicted encounter rates for the Project (b) and the Taltson Hydroelectric Expansion Project (c)



a)

b)

Note: anticipated encounter rates (for 138-day period) were calculated using only the Project location combined with previous paths of migrating caribou (194 paths in total).



c)

Note: anticipated encounter rates (for 138-day period) were calculated using only the Taltson Hydroelectric Expansion Project combined with previous paths of migrating caribou (194 paths in total).

Energetic Costs from Development and Insect Harassment

Assuming that caribou are exposed to one major disturbance event per day when residing within a ZOI, then residency times from 1996 to 2009 suggest that caribou encounter an average of 9.6 disturbance events during summer and autumn movements. Under current baseline conditions, residency time with ZOIs predict that caribou can encounter 13.9 disturbance events. In contrast, the analysis of caribou paths entering zones of influence predicted that the mean number of disturbance events was 9.0 from 1996 to 2009. Under current baseline conditions, encounter rates predict that female caribou may be influenced by 13.8 disturbance events. For both analyses, it was assumed that when an animal entered or resided in a ZOI, the animal experienced a disturbance event regardless of how close it was to the development or activity.

For energetics modelling and analyses, estimated residency times in ZOIs (Figure 7.5-7) were used to predict the number of disturbance events encountered by female caribou under different landscape scenarios (number of disturbance events = %residency time x 138 days). Residency time typically generated a higher number of disturbance events than encounter rate. Using mean values for 2000, 2006, and 2009 (Figure 7.5-7a), it was predicted that female caribou encounter 3, 10, and 14 disturbance events, respectively, during the summer to autumn period under previous and current (2010) baseline conditions (Table 7.5-15). Under reference baseline conditions, the number of disturbance events encountered would be zero. The number of encounters with the Project and future developments (i.e., Taltson Hydroelectric Expansion Project) was based on the average residency time (3.6%) predicted from overlaying caribou paths from 1996 to 2009 on a landscape simulating the location of these two developments (5 disturbance encounters).

In a landscape with negligible disturbance from insects and development (i.e., ideal conditions) the fecundity rate in the population may theoretically approach 1.0 or 100%. However, even with no development, individuals are subject to other natural factors that can cause stress and associated loss of energy reserves so that they do not achieve ideal autumn body weight (e.g., fluctuations in forage quality, and avoiding predators). Ideal conditions provide a null model for determining the independent effects from development and insects.

With low insect harassment and no development, the model predicts an 8% decrease in fecundity for some females and in some years (i.e., parturition rate = 0.92 and fecundity rate in Leslie Stage Matrix = 0.416; Table 7.5-15) relative to ideal conditions. The reference values for parturition and fecundity rates are within the range of upper values observed for caribou (Cameron et al. 2005; Boulanger and Gunn 2007). In a year with severe insect harassment and no development on the landscape, fecundity may be reduced by 27.8%.

Table 7.5-15 Modelled Effects of Various Landscape Developments and Insect Harassment Intensities on Fecundity Rates of Caribou

Scenario	Insect Harassment Index	Disturbance Encounters[(a)]	% Decrease in Parturition / Fecundity[(b)]	Parturition Rate for Females at Prime Age[(c)]	Fecundity Rate in Leslie Matrix[(c)]
Reference, low IHI	14	0	0.00	0.920[(e)]	0.416[(e)]
Reference, average IHI	23	0	8.33	0.843	0.381
Reference, high IHI	44	0	27.75	0.665	0.301
2000 baseline, low IHI	14	3	0.49	0.916	0.414
2000 baseline, average IHI	23	3	8.81	0.839	0.379
2000 baseline, high IHI	44	3	28.24	0.660	0.299
2006 baseline, low IHI	14	10	1.62	0.905	0.409
2006 baseline, average IHI	23	10	9.94	0.829	0.375
2006 baseline, high IHI	44	10	29.37	0.650	0.294
Current (2010) baseline, low IHI	14	14	2.27	0.899	0.407
Current (2010) baseline, average IHI	23	14	10.59	0.823	0.372
Current (2010) baseline, high IHI	44	14	30.02	0.644	0.291
Application-future[(d)], low IHI	14	19	3.08	0.892	0.403
Application-future[(d)], average IHI	23	19	11.40	0.815	0.369
Application-future[(d)], high IHI	44	19	30.83	0.636	0.288

(a) Cause caribou to increase movement, run, become excited and metabolize stored energy (=mean residency time in ZOIs x 138 days [Figure 7.5-7]).

(b) Reduction = 80 kg - [((IHI – 14) x 0.148) + (disturbance events x 0.55 x 0.471] / 16 kg (Figure 7.5-4).

(c) reference value* – (percent decrease[(b)] x reference value*)

(d) Includes existing developments on landscape plus the Project and Taltson Hydroelectric Expansion Project.

(e) Assumed reference rate of fecundity in stage matrix of population viability analyses (Table 7.5-17).

IHI = Insect Harassment Index; % = percent.

To be consistent with the habitat suitability modeling and results, landscape development scenarios included the following: reference (no development), 2000 baseline conditions, 2006 baseline conditions, current (2010) baseline conditions, and an application-future scenario (which included the Project and the Taltson Hydroelectric Expansion Project). The Project and Taltson Hydroelectric Expansion Project were combined because the incremental changes from each development were negligible, and separating the two projects would provide no additional ecological understanding of the effects on caribou. The rationale was to capture the widest range of possible effects from previous to existing and future conditions (i.e., the proportion of the summer to autumn range in ZOI cover).

For example, under the 2000 baseline scenario with three disturbance encounters and average levels of insect harassment, the decrease in parturition rates relative to a landscape with no development and low insect levels was predicted to be 8.8% (Table 7.5-15). For current (2010) baseline conditions with low levels of insect harassment, the model predicted a reduction in fecundity by 2.3% relative to ideal conditions. With the application of the Project and the Taltson Hydroelectric Expansion Project to a landscape with previous and existing developments and low insect harassment, the fecundity rate was reduced by 3.1% relative to ideal conditions (Table 7.5-15). Thus, the incremental decrease in fecundity from the Project and the Taltson Hydroelectric Expansion Project relative to current (2010) conditions was predicted to be 0.8% (difference between 3.1% and 2.3%). The energetic model predicts that insect levels have the largest influence on fecundity.

For those summers when insect harassment is low, female encounters with disturbance would be required to exceed 600 disturbance events so that there is an expenditure of 20% of 80 kg (i.e., 16 kg), and no calf production the following year. If considering the effects from both severe insect harassment and disturbance encounters, then approximately 400 disturbance events would result in no calf production. Based on the expected number of disturbance encounters for current landscape conditions with the Project and future developments (about 20), female caribou would have to increase their encounter rate per day by approximately 20-times to result in no calf production the following spring.

7.5.4 Effects on Population Viability

Another objective of this assessment was to evaluate the incremental effects of the Project, and cumulative effects of human land-use and natural disturbances on the viability of the Bathurst caribou herd using population viability analyses (PVA) in RAMAS 5.0® (Akçakaya 2005). The models were based on a commonly used software package (i.e., RAMAS) that provides transparency and repeatability of methods.

Population viability analysis is an increasingly important modelling tool in the conservation and management of species (Akçakaya et al. 2004). In this assessment, previously published estimates of age-specific survival and fecundity rates, and considerations of internal population mechanisms were used to quantify the relative contribution of natural and human factors on a caribou population. Selection of values for vital rates was based on anticipated projections in population sizes. Projections considered the current herd size and previous fluctuations in herd sizes over the past 30 years (Figure 7.3-5). Further, the approach considered the latest information on pregnancy rate, body condition and herd composition, all of which have suggested that recruitment rates are increasing (Adamczewski et al. 2009). It is emphasized that the models are not used to predict the number of caribou in 5 years, 10 years, or 30 years from now.

Based on the lack of information for survival and reproductive rates for the all phases (increase, decrease, and no change) of the population cycle, the model should not be used to estimate future population sizes.

The focus of the PVA models is to determine the relative changes in the risk to population viability (i.e., the likelihood of population persistence) for different environmental scenarios. Local and regional effects from the Project and other developments on habitat quantity and quality, and caribou behaviour and vital rates were incorporated into model simulations. For example, results from the habitat quality analysis, which includes direct and indirect habitat effects from development (Table 7.5-10) and the energetics model (Table 7.5-15) were linked to parameter inputs in the population models. The PVA was used to estimate the incremental effect from the Project, and the relative contribution of natural factors (insects, deep snow) and human activities (previous, existing, and future developments, and hunting) on the population size and persistence of caribou.

7.5.4.1 Methods

7.5.4.1.1 Structure of Initial (Reference Baseline) Model and Alternate Simulations

A 30-year projection was used to simulate both an increasing phase and a decreasing phase of the population size cycle that characterizes the Bathurst caribou herd (Figure 7.3-5; ENR 2010a, internet site; Adamczewski et al. 2009). Input parameters included survival and fecundity rates (vital rates), carrying capacity, initial population size, an extreme weather-related event, and a management action. In subsequent models (e.g., 2010 baseline and application-future conditions) and sensitivity analyses, input parameters were changed through different modifier variables (Table 7.5-16).

Table 7.5-16 Input Parameters and Associated Modifier Variables for Simulations in the Population Models

Input Parameters	Modifier Variables
Survival, fecundity	habitat insect harassment index residency time in zones of influence
Carrying capacity (K)	habitat
Initial population size	current size reported in literature
Extreme weather-related event	frequency and intensity of insects, deep and hard snow
Management actions	harvest rate

The models projected population sizes for one population (i.e., not separate sub-populations). All simulations were run over a 30-year period and replicated 1,000 times (expected lifetime of the Project is 22 years). At each time step, the number of calves, yearlings, sub-adults, and adults were projected, using a set of vital rates drawn from a random normal distribution with mean values taken from the stage matrix and standard deviations taken from the standard deviation matrix. Standard deviations indicated both measurement error (uncertainty) in estimates and environmental variation associated with natural and human-related factors.

Temporal trends in calf survival and fecundity rates were also included using the ‘relative fecundity’ and ‘relative survival’ functions in RAMAS 5.0® (see below). These rates were anticipated to change over a 30-year period from those that characterize a growing population to those that describe a declining population. However, this assessment assumed that adult survival remained constant over time (except for random environmental fluctuations) as there are limited data on long-term temporal trends in survival rates of adult caribou (also see Boulanger and Gunn 2007).

Survival and Fecundity

A Leslie matrix was used to model an age-structured caribou herd (16 x 16-dimension life stages): female calves (young-of-year), yearlings (age 1), sub-adults (age 2) and reproductively mature adults (ages 3 to 13) (Table 7.5-17). The Leslie matrix was based on a “post-breeding” census of caribou, with no mortality between breeding and the census. A “birth-pulse” population was used in which all breeding takes place in a short period of time. Modelling focused on the adult female segment of the population as this segment most directly influences herd productivity (Caughley 1977; Boulanger and Gunn 2007).

Vital rates for the stage matrices in the reference baseline (reference) model were taken from variety of sources (Case et al. 1996; Gunn et al. 2005; Boulanger and Gunn 2007; Adamczewski et al. 2009; Table 7.5-17). The objective was to obtain and use rates that reflect not only increasing and decreasing phases of the Bathurst herd population cycle, but also reflect a landscape with little industrial development (i.e., rates prior to 2000; Figure 7.5-3b). Vital rates had an approximate coefficient of variation (CV = standard deviation / mean) equal to that reported for individual variation in Boulanger and Gunn (2007). The matrix did not include traditional and non-traditional harvests as these were implemented under various scenarios using the ‘population management’ tool in RAMAS 5.0®. Annual harvest rates for reference simulations were set at 4% for adult female caribou (mean = 4.1%, range = 1.4 to 7.0% [Boulanger and Gunn 2007]). If the total population of female caribou was less than 10,000 animals, then harvesting of caribou in the model was stopped (or approached zero animals).

Table 7.5-17 Stage Matrix Comprised of Fecundity (first row of table) and Survival Rates (± 1 SD) of Female Bathurst Caribou for the Reference Model

Age Class	Calf	Yearling	Sub-adult	Adult (3-13 yr)	Adult (14 yr)	Adult (15 yr)
Calf	0	0	0.27 (0.009)[a]	0.416 (0.014)[a,c]	0.312 (0.01) [a]	0.312 (0.01) [a]
Yearling	0.804 (0.102)*	0	0	0	0	0
Sub-adult	0	0.905 (0.115)[b]	0	0	0	0
Adult	0	0	0.905 (0.009) [b]	0	0	0
Adult	0	0	0	0.905 (0.009) [b]	0	0
Adult	0	0	0	0	0.905 (0.009) [b]	0

Note: Reference simulations refer to conditions of no development, low insect harassment, and 4% harvest rate; the initial growth rate (lambda; λ) in the above stage matrix was calculated as 1.117.

(a) Calf survival and fecundity rates changed through time (from high to low); rates were based, in part, on calf:cow ratios ranging from 0.74 to 0.21 (Case et al. 1996; Gunn et al. 2005; Boulanger and Gunn 2007).

(b) Starting adult survival rates followed Boulanger and Gunn (2007) and Adamczewski et al. (2009).

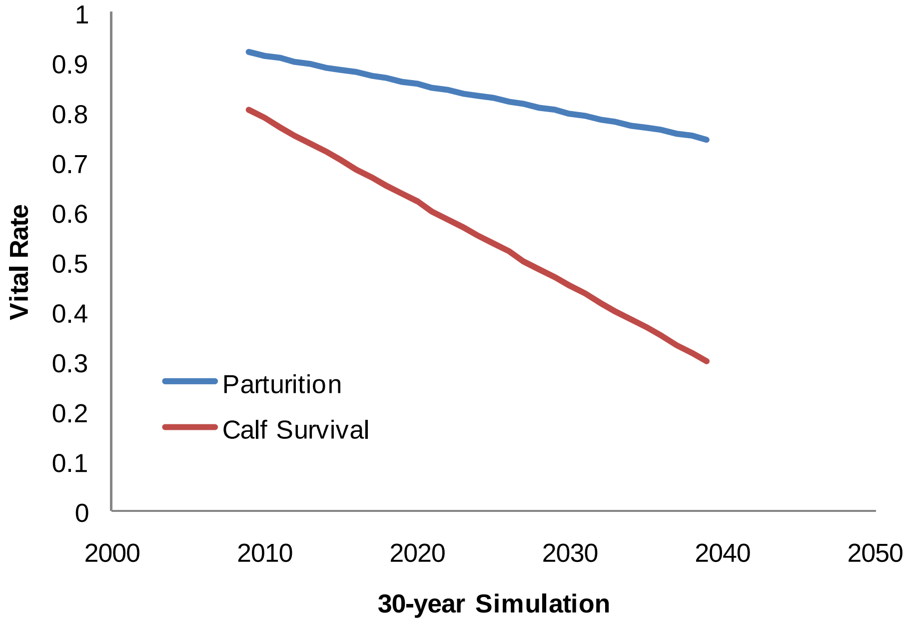
(c) Value is product of estimated fecundity rate for no development and low insect harassment (see Table 7.5-15) multiplied by 0.5 (i.e., female population only assuming a 1:1 sex ratio at birth) and adult survival rate.

SD = standard deviation; yr = years.

The mating system of the herd was assumed to be polygynous, where each male is capable of mating with up to two or more female caribou. The sex ratio at birth was equal and the minimum age of reproduction was two years. Age-2 productivity was estimated as being 65% of that for prime-age females (Bergerud et al. 2008); whereas age-14 and age-15 females were estimated to be 75% as productive as prime-age females (Adams and Dale 1998). Fecundity rates were based on no development and annual average low IHI during the simulation period (Tables 7.5-17 and 7.5-18). However, for the stage matrix in RAMAS, fecundity rates were multiplied by adult female survival rate and by 0.5 (because simulations were for the female population only and assumed a 1:1 sex ratio at birth [Akçakaya et al. 2004]).

To simulate a 30-year phase in the cycle of Bathurst herd, rates for calf survival and fecundity were modified over time. Specifically, parturition (fecundity) rates were modeled to decline linearly from 0.92 to 0.74, and calf survival rates were modeled to decline linearly from 0.80 to 0.28 (Figure 7.5-9). These values were based on the range of demographic values reported for the Bathurst herd (Case et al. 1996; Gunn et al. 2005; Boulanger and Gunn 2007) and the Porcupine herd (Fancy et al. 1994). Further, calf survival rates were estimated using reported maximum and minimum values of parturition rates (0.92 to 0.74), and spring calf:cow ratios for the Bathurst herd (0.74 to 0.21) (Case et al. 1996; Gunn et al. 2005).

Figure 7.5-9 Temporal Trend in the Relative Rate of Calf Survival and Fecundity for Female Bathurst Caribou



Stochasticity

Random events associated with environmental variation and the unpredictable nature of demographic variation can also influence population size. Demographic stochasticity is the sampling variation in the number of survivors and the number of offspring that occurs (even if survival rates and fecundities were constant) because a population is made up of a finite, integer number of individuals. Thus, the demographic stochasticity option in RAMAS was used for all models (Akçakaya et al. 2004). In addition, environmental stochasticity was modelled by drawing values randomly from lognormal distributions described by fecundity and survival values and their associated standard deviations (Table 7.5-17).

The effects of stochasticity on fecundity, survival, and carrying capacity (K) were assumed to be correlated within the herd. Modelling incorporated a CV of 0.20 on population size (N) to increase confidence that the temporal variation in N was not underestimated. In addition, an extreme weather-related event (e.g., very high densities of oesterid flies, or deep, hard-packed snow years) was modelled as reducing the abundance of calves and older females (age 14 to 15) by 50% once every 10 years (Tews et al. 2007). It was assumed that the effect of an extreme weather-related event on the Bathurst herd was less severe than that observed for insular populations, such as the Peary caribou (*Rangifer tarandus pearyi)* (Bergerud et al. 2008).

Density Dependence and Carrying Capacity

Some studies have shown that density-dependent effects of overgrazing on calving, summer, and winter home ranges can result in periodic range shifts and population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). In this assessment, a simple ceiling model was used that affected all vital rates and was based on the abundance of all stages (Akçakaya et al. 2004). Under the ceiling type of density dependence, the population grows exponentially until it reaches carrying capacity. A population that reaches carrying capacity remains at that level until a factor or set of factors causes the abundance of animals to drop below carrying capacity.

Bergerud et al. (2008) proposed that a density of five caribou per km^2 on the summer range (100,000 km^2) is the point at which calf recruitment of a caribou herd could be affected. Assuming that the proportion of females in a stable or increasing population is 64% (see Bergerud et al. 2008), then the carrying capacity of the annual range of the Bathurst herd may be as high as 320,000 female caribou. However, the approximate size of the largest recorded population of female caribou is 259,000 female caribou (in 1986; see Boulanger and Gunn 2007). Thus, for this assessment, a carrying capacity of 290,000 caribou was selected, which was the approximate mid-point between the largest recorded population size and the density proposed by Bergerud et al. (2008).

A coefficient of variation equal to 0.20 was applied to K to increase confidence that potential variation in K was captured in the models. Carrying capacity was reduced in the landscape simulations (see below) to reflect combined losses of good and high quality habitats (e.g., reference conditions with little or no development versus existing conditions [Table 7.5-10]). The reduction in K was based on the season with the highest levels of preferred habitat disturbed by development. All simulations started with 23,000 female caribou, which was the current estimate of the population of greater than one year old caribou on the calving grounds in 2009 (23,273) (Adamczewski et al. 2009).

7.5.4.1.2 Sensitivity and Effects Analyses

A suite of models describing various landscape conditions and insect harassment levels were examined (Table 7.5-18). To determine the relative influences of model parameters on population viability, sensitivity analyses were conducted on parameter inputs for the current (2010) baseline model with low insect harassment (i.e., baseline model #1). Sensitivity simulations were performed by varying specific model inputs (e.g., adult survival rate) while holding others constant to evaluate the relative influences of model parameters on the probability of population decline.

Table 7.5-18 Candidate Simulation Scenarios for Population Viability Analysis of Bathurst Caribou Herd

Simulation	Input Parameters	Condition of Modifier Variable
Reference baseline - low insect harassment - no development	survival fecundity carrying capacity (K) initial abundance weather event management action	no change from stage matrix no change from stage matrix 290,000 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 4% harvest rate
Current (2010) baseline #1[a] - low insect harassment	survival fecundity carrying capacity (K) initial abundance weather event management action	no change from stage matrix decrease by 2.3%[b] decrease by 3.8%[c] 23,000 50% decrease in abundance of calves and 14 and 15 3 year old individuals once every 10 years 4% harvest rate
Current (2010) baseline #2 - high insect harassment	survival fecundity carrying capacity (K) initial abundance weather event periodic high insect levels management action	no change from stage matrix decrease by 2.3[b] decrease by 3.8%[c] 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 27.8% decrease in fecundity once every 5 years[d] 4% harvest rate
Current (2010) baseline #3 - low insect harassment - increase harvest	survival fecundity carrying capacity (K) initial abundance weather event management action	no change from stage matrix decrease by 2.3%[b] decrease by 3.8%[c] 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 8% harvest rate
Application-future #1 - includes the Project and the Taltson Hydroelectric Expansion Project - low insect harassment	survival fecundity carrying capacity (K) initial abundance weather event management action	no change from stage matrix decrease by 3.1%[b] decrease by 7.3%[e] 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 4% harvest rate
Application-future #2 - includes the Project and the Taltson Hydroelectric Expansion Project - high insect harassment	survival fecundity carrying capacity (K) initial abundance weather event periodic high insect levels management action	no change from stage matrix decrease by 3.1%[b] decrease by 7.3%[d] 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 27.8% decrease in fecundity every 5 years[d] 4% harvest rate
Application-future #3 - includes the Project and the Taltson Hydroelectric Expansion Project - low insect harassment - increase harvest	survival fecundity carrying capacity (K) initial abundance weather event management action	no change from stage matrix decrease by 3.1%[b] decrease by 7.3%[e] 23,000 50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years 8% harvest rate

[a] Scenario used for sensitivity analyses.

[b] Arithmetic (relative difference) decrease based on energetic cost estimates from development (Table 7.5-15).

[c] Arithmetic decrease to habitat quality from previous and existing developments (Table 7.5-10).

[d] Geometric (multiplicative) decrease based on energetic cost estimate from high insect harassment (Table 7.5-15).

[e] Arithmetic decrease to habitat quality from the Project and previous, existing and future developments (Table 7.5-10).

K = carrying capacity; % = percent.

All comparisons were made using two measurements of the viability or likelihood of persistence of the population: 1) the projected final abundance at the end (year 30) of the simulation; and 2) threshold abundance probabilities and associated risk curves (Akçakaya et al. 2004). Threshold abundance probability is defined as the probability that the number of caribou will be below a range of abundances at the end of the simulation. The Kolmogorov-Smirnov test statistic (D) was used for identifying statistical significance ($P < 0.05$), which is the maximum reported difference in the probability of population decline between risk curves for each simulation. High values of D suggest that the shapes and slopes of two risk curves are different.

Based on the current (2010) baseline model with low insect harassment (baseline model #1; Table 7.5-18), the following sensitivity analyses were completed:

- Sensitivity of vital rates was examined by i) decreasing survival rates of sub-adults, yearlings, and calves by 10% (i.e., by 0.10 units), ii) decreasing survival rates of adults by 10% (i.e., by 0.10 units), and iii) decreasing fecundity rates by 10% (by 0.10 units). These changes may reflect a reduction in habitat quality on the landscape, as well as increases in hunting and predation.
- Carrying capacity was decreased by 10% (i.e., by 27,898 animals) to demonstrate the relative influence of direct and indirect habitat loss caused by human development on the landscape. The incremental loss of preferred habitat due to the Project (plus future developments) was estimated to be 3.5%, and the cumulative loss of preferred habitat due to the Project, and previous, existing, and future developments was 7.3% (Table 7.5-10).
- The sensitivity of extreme weather-related inputs was examined by increasing the probability of events by 10% (i.e., to once every 5 years) and by increasing the intensity of the event by 10% (i.e., to 60% reductions in abundance of calves and 14 and 15 year old individuals).

Effects analyses (tests) also were completed to evaluate the relative change in population viability from different scenarios of development, insect harassment, and harvest rate (Table 7.5-18). For example, the incremental effects from the Project on the viability of the population were examined by comparing threshold abundance probabilities and associated risk curves between the application-future condition and current (2010) baseline conditions. The application-future scenario includes the Project and the Taltson Hydroelectric Expansion Project, which was included in the analysis of direct and indirect habitat effects (Sections 7.5.2 and 7.5.3). The Project and the Taltson project were combined to reduce the number of PVA comparisons. In addition, preliminary results indicated that the incremental changes from each development were negligible and separating the two projects would provide no additional ecological understanding of the effects on caribou.

Cumulative effects from the Project and other developments on caribou were evaluated by comparing viability measurements from application-future simulations to reference simulations. Effects from changes to insect harassment and harvest levels also were tested to determine the relative contribution of these factors to the population persistence of caribou (Table 7.5-18). The effect of insect harassment was based on the frequency of occurrence of moderate to high insect levels in the Lac de Gras region, and the magnitude of the predicted decrease in fecundity under high insect harassment during reference conditions (27.75%; Table 7.5-15). Estimates of potential harassment days from the Diavik Diamond Mine weather data suggest that moderate to high insect levels occur every 4 years, and the time between the highest values during the 12 year period was 8 years (Figure 7.5-5a). Effects from high insect levels were modelled with a 20% probability of occurring over the 30 year simulation (i.e., once every 5 years) and a 27.8% decrease in fecundity across all reproductive age classes (Table 7.5-18).

Similar to sensitivity tests, differences between final abundance projections and threshold abundance probabilities and associated risk curves were reported. The Kolmogorov-Smirnov test statistic was used for identifying statistical significance (P <0.05) of the maximum reported difference in the probability of threshold abundance between risk curves (i.e., D statistic).

Again the reader is reminded that the intent of the PVA is to estimate the relative contribution of different natural and human disturbance factors on changes to the population abundance and persistence of caribou. The consensus among many population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among landscape scenarios, are more reliable for assessing effects than absolute results (McCarthy et al. 2003; Schtickzelle et al. 2005).

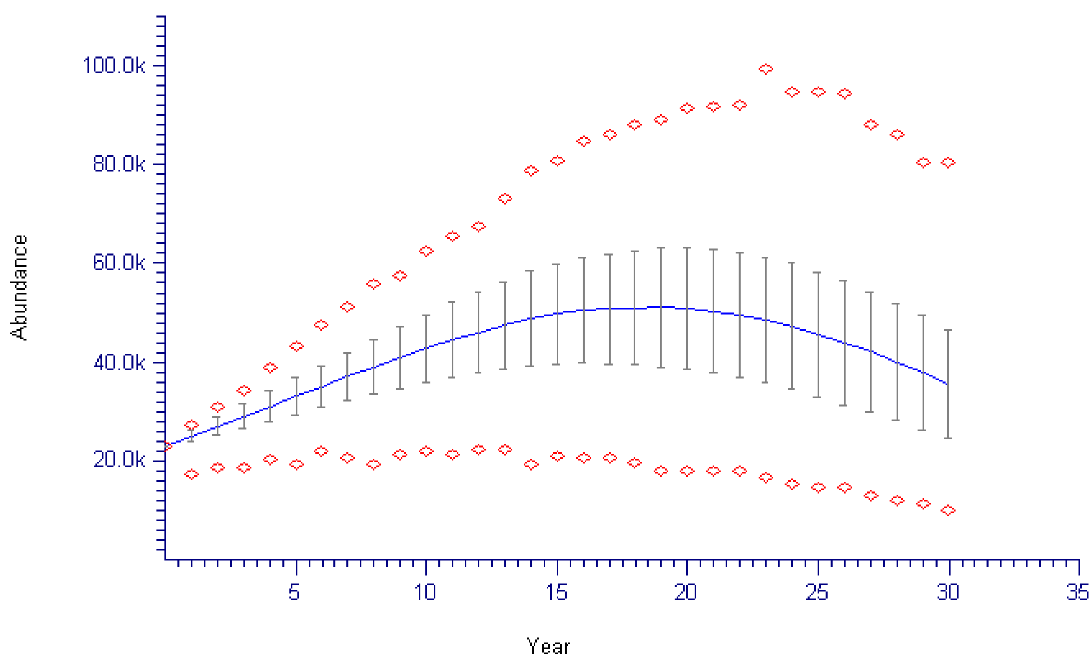
The problem with interpretation of absolute results, such as estimated final abundance or growth rate, is that they are almost always biased because of inaccurate or incomplete data for vital rates in the stage matrix. In other words, predicting future population size with incomplete data on survival and reproduction rates will likely lead to incorrect conclusions, especially in populations that exhibit natural cycles over decades like caribou. For the Bathurst herd, there is not enough information on vital rates during the phases when caribou population size is increasing, decreasing, or remains stable to accurately predict the number of animals in the near or distant future. In this assessment, 30-year final abundance projections and threshold abundance probabilities were used only for relative comparisons of input parameters among models.

7.5.4.2 Results

Using the input parameters for the reference condition with low insect harassment (Table 7.5-18) resulted in a population trajectory that fluctuates and generally increases, then begins to decline over the 30 year simulation period (Figure 7.5-10). The model projected a final abundance of 35,556 female caribou (range = 10,097 to 80,445 animals). The risk curve showed that, in 30 years, the probability of the population dropping below the current number of animals was approximately 0.108 (0.080 to 0.136 [95% CI]). The total harvest of caribou over the 30-year simulation was 28,315 (range 14,684 to 46,112 animals).

The structure of the reference model simulated the increasing phase, and to a lesser extent, the declining phase of a 30-year cycle in herd sizes. A modest increase in population size during the first 20 years of the trajectory curve was observed. By changing the initial abundance input from 23,000 to 70,000 female caribou, the simulation projected a population trend more closely resembling one that characterizes the Bathurst herd during the 1980s (results not shown; but see Figure 7.3-5).

Figure 7.5-10 Reference Population (no development, low insect harassment) Trajectory of Mean Abundance of Female Bathurst Caribou for a 30-Year Cycle (± 1 SD)



Circles represent minimum and maximum projections per year of simulation. k = 1,000 animals.

Sensitivity tests provided insight on how natural and human disturbance factors may influence the viability of the caribou herd (Table 7.5-19). The most sensitive parameter in the Leslie stage matrix was adult survival. A 10% decrease in adult female survival rate (to 0.805) resulted in a 0.99 maximum difference in decline probability between the sensitivity risk curve and the existing baseline risk curve (D; Table 7.5-19). This simulation also resulted in the largest percent decline in final abundance (78%). Boulanger and Gunn (2007) also showed that population decline in the Bathurst herd was more sensitive to variation in adult female survival than the production and survival of calves.

Survival of individuals less than 3 years of age and fecundity also were highly sensitive parameters in the Leslie stage matrix. In both cases, the D-values for the risk curves were greater than 0.9. The frequency of poor weather (i.e., catastrophic) events was a moderately sensitive parameter (D = 0.29) and produced a 19% change in final abundance. The least sensitive parameters were intensity of poor weather events (D = 0.08) and carrying capacity (D = 0.05). The relative change in final population abundance for these parameters was less than 5%. The only parameter that was identified as being statistically non-sensitive was carrying capacity (Table 7.5-19). A 10% decrease in carrying capacity from 278,980 individuals to 251,082 individuals failed to produce a risk curve that was significantly different than that of the current baseline. Further, a comparison of baseline and carrying capacity simulations showed the smallest relative decline in final abundance at 0.4%.

The current baseline model with low insect harassment (baseline #1) projected a final abundance of 32,169 female caribou (range = 11,498 to 77,446 animals; Table 7.5-19). The risk curve showed that, in 30 years, the probability of the herd declining below the current abundance was approximately 0.169 (0.141 to 0.197 [95% CI]). The total harvest by the end of the simulation was 27,888 animals (range = 12,952 to 52,283).

Incremental effects from the application of the Project (and the Taltson Hydroelectric Expansion Project) on herd viability were examined by modifying the current baseline #1 simulation. The application-future #1 model included a further reduction in carrying capacity (by 7.3%) and fecundity rate (by 3.1%), which were related to a decrease in habitat quality and associated increase in energetic costs from the Project. A comparison of outputs between the two simulations showed negligible incremental changes to the persistence of the caribou herd (Table 7.5-19). Specifically, the relative decrease in final abundance was 1.5% and the difference between the risk curves was not statistically different (D = 0.04, P = 0.34).

Table 7.5-19 Sensitivity Analyses of Parameter Inputs and Effects Analyses of Various Landscape Scenarios and Insect Harassment Levels for the Bathurst Herd Population Viability Analysis

Simulation	Projected Final Abundance	% Change in Final Abundance	Maximum Difference in Probability of Threshold Abundance between Risk Curves (D)	Kolmogorov-Smirnov P-value[a]
Baseline Sensitivity Tests				
Current (2010) baseline #1 (low insect harassment)	32,169	n/a	n/a	n/a
10% decrease in adult survival	7,108	-77.90	0.992	<0.0001
10% decrease in fecundity	10,501	-67.36	0.949	<0.0001
10% decrease in survival for ages <3 years old	8,912	-72.30	0.972	<0.0001
10% increase in weather event frequency	25,901	-19.48	0.287	<0.0001
10% increase in weather event intensity	30,618	-4.82	0.079	0.0039
10% decrease in carrying capacity	32,027	-0.44	0.046	0.2406
Incremental Effects Tests				
Null model = current (2010) baseline #1 (low insect harassment)	32,169	n/a	n/a	n/a
Application- future #1 (low insect harassment) versus baseline #1	31,703	-1.45	0.042	0.3410
Current (2010) baseline #2 (high periodic insect harassment) versus baseline #1	17,587	-45.33	0.655	<0.0001
Current (2010) baseline #3 (low insects, increased harvest) versus baseline #1	15,305	-52.42	0.794	<0.0001
Cumulative Effects Tests				
Null model = reference baseline (no development, low insect harassment)	35,556	n/a	n/a	n/a
Application-future #1 (low insect harassment) versus reference	31,703	-12.15	0.166	<0.0001
Application-future #2 (high periodic insect harassment) versus reference	17,326	-51.27	0.716	<0.0001
Application-future #3 (low insect harassment, increased harvest) versus reference	14,733	-58.56	0.839	<0.0001

Note: Reference baseline = no development, low insect levels, and a harvest rate of 4%. Current (2010) baseline = previous and existing developments (1996 to 2010). Application-future = previous and existing developments plus the Project and the Taltson Hydroelectric Expansion Project.

[a] statistical significance accepted at an alpha level of 0.05.

n/a = not applicable; % = percent; <= greater than.

The influence of the Project on the likelihood of population persistence was less than increases in insect activity levels or increases in harvest rates (Table 7.5-19). For example, a comparison of current baseline models with low insect activity levels (IHI = 13; baseline #1) and high insect activity levels (IHI = 44; baseline #2) resulted in a statistical difference in risk curves (D = 0.66, P <0.01) and a 45% reduction in final abundance. The influence of changes in insect activity levels on the relative change in projected final abundance was almost 30 times greater than the influence of the Project. An increase in harvest rate (from 4% to 8%; baseline #3) resulted in a 52% reduction in final herd abundance relative to the existing baseline #1 simulation (D = 0.79, P <0.01). The influence of increasing harvest rates on the relative change in projected final abundance was 36-times greater than the influence of the Project (Table 7.5-19).

Cumulative effects from the Project and previous, existing and future developments on herd viability were examined by comparing the simulation results from application-future #1 model with the reference baseline model (Table 7.5-18). Both models have similar insect activity and harvest levels. The application-future #1 model included the cumulative reduction in carrying capacity (7.3%) and fecundity rate (3.1%) from the decrease in habitat quality and associated increase in energetic costs from the Project and all other developments on the landscape. A comparison between the simulation results indicated that cumulative effects from development have a moderate influence on the likelihood of persistence of the caribou population. Specifically, cumulative effects from development resulted in a 12.2% reduction in projected final herd abundance relative to reference conditions, and the difference between risk curves was statistically significant (D = 0.17, P <0.01) (Table 7.5-19).

Cumulative effects were larger when including either increases in insect activity levels (i.e., from 14 to 44 IHI) or increases in harvest rates (i.e., from 4 to 8%). Based on the application-future #2 model with high periodic levels of insect activity and 4% harvest rates there was a 51% decrease in final abundance and statistically different risk curves (D = 0.72, P <0.01) relative to reference conditions (Table 7.5-19). Similarly, based on the application-future #3 model with low levels of insect activity but high harvest rates (8%), there was a 59% decrease in projected final abundance and statistically different risk curves (D = 0.84, P <0.01).

7.5.5 Related Effects on People

7.5.5.1 Access to Caribou

The Winter Access Road and the Tibbitt-to-Contwoyto Winter Road may increase access to caribou when the winter roads are in operation (approximately eight to 12 weeks each year). Although no harvest data exists for the Tibbitt-to-Contwoyto Winter Road, Ziemann (2007) tracked the level of hunting activity for 2004 through 2006. The number of vehicles travelling for hunting on the Tibbitt-to-Contwoyto Winter Road showed a decline from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann 2007). Decreases in hunting traffic may be due to high volumes of mine-related vehicles on the road (e.g., 2,543 loaded trucks in 1998 versus 11,656 in 2007 [Section 11.8]). De Beers will have a no firearms and no hunting policy for staff and contractors on-site. Thus, during the winter road season, people at site will not benefit from increased access to the region for the harvesting of caribou. The number of caribou harvested in the region from improved access due to the Winter Access Road for the Project is predicted to be within the range of baseline conditions.

7.5.5.2 Availability of Caribou

Availability of caribou for human use is related to population size and distribution. Analyses in Sections 7.5.2 to 7.5.4 examined the cumulative effects from the Project, other developments, natural factors, and harvest rates on caribou population size. The incremental change from the Project on caribou abundance and persistence was not statistically measurable relative to current (2010) baseline conditions. The cumulative changes from the Project and other developments on habitat and fecundity had a moderate influence on abundance, which resulted in a statistically significant change in population persistence relative to a landscape with no development. Insect harassment levels and harvest rate also contributed significantly to the likelihood of population decline.

Therefore, relative to reference conditions (no development), previous and existing development has likely been associated with lower encounter rates between caribou and humans, particularly on the summer to autumn range. The magnitude of the effect is anticipated to approach or exceed the limits of baseline values. However, the addition of the Project is not expected to result in a detectable change in encounter rates between caribou and people relative to current (2010) baseline conditions.

There is good information on the local and regional effects from development on caribou distribution. A review of the literature in combination with GIS-based modelling suggested that direct and indirect effects may influence the distribution of animals within zones of influence (e.g., 10 to 30 km) around the Project and other developments (Boulanger et al. 2004; Cameron et al. 2005; Johnson et al. 2005; Golder 2008a, b; Boulanger et al. 2009). This may result in an increase in the density of caribou where habitat is suitable and there are a lower number of developments (Cameron et al. 1992; Nelleman and Cameron 1998; Cameron et al. 2005).

Other studies have found little effect from development on caribou movement and distribution. For example, data from collared caribou suggest that the Ekati and Diavik diamond mines have had a negligible influence on the post-calving movements of animals through the Lac de Gras region. In 9 of 12 years the majority of collared females travelled east of Lac de Gras during the southern migration, which was predicted from baseline conditions (Golder 2008a). Cronin et al. (1998), found that occurrence of caribou that do use areas near development was not related to distance from infrastructure.

The expected change in the regional distribution of caribou associated with the ZOI from the Project and other developments may affect hunting success at nearby outpost camps. In particular, Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project, and may experience small decreases in caribou encounters. In contrast, Artillery Lake Adventures has a camp situated on the west side of Artillery Lake, about 70 km east of the Project, and may experience an increase in the number of caribou from avoidance of the Project and other developments. These changes in distribution are expected to be within the range of baseline conditions.

In contrast, there is little known about the long-term effects from development on caribou movement and distribution at the scale of the seasonal ranges. Factors that influence changes in migration routes and habitat use within seasonal ranges typically occur across large spatial scales and over many years, or decades. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

The spatial extent of current development is likely large enough to have some influence on caribou movement and distribution within their post-calving, summer, and autumn ranges. However, it is not known if the duration of effects from development has been long enough to cause a shift in a seasonal range of caribou relative to natural factors. Natural environmental factors that operate on large spatial scales and over long periods of time include climate-related changes to fire regimes, snow and rainfall, and food abundance and quality (Tyler 2010).

7.5.5.3 Human Health

An ecological risk assessment was completed to evaluate the potential for adverse effects to individual animal health associated with exposure to chemicals from the Project. Emission sources considered in the assessment included those outlined above (i.e., fugitive dust, air emissions, surface water runoff and seepage, leaching of PAG rock, and exposed sediments), and potential exposure pathways included changes in air, water, soil, and vegetation quality. The result of the assessment was that no impacts were predicted for caribou. Similarly, based on the results from a human health risk assessment, no health impacts associated with the consumption of caribou are expected for human receptors.

7.6 RESIDUAL EFFECTS SUMMARY

The effects analysis considered all primary pathways that result in expected changes to the population size and distribution of caribou from the Project, after implementing environmental design features and mitigation. Thus, the analysis was based on the residual effects from the Project, and determined both the cumulative and incremental changes from the Project on the landscape, caribou, and the use of caribou by people.

The time period for cumulative effects represents the sum of all changes to the landscape or seasonal ranges of caribou from reference conditions (no development) through application of the Project and reasonably foreseeable developments. The spatial scale for cumulative effects considers the seasonal ranges of the population (i.e., spatial boundary of the assessment as required by the Terms of Reference [Gahcho Kué Panel 2007]). This is because caribou travel large distances during their seasonal and annual movements and can be affected by the Project, and several other developments. In other words, the combined local and regional effects from the Project and other developments overlap with the distribution of the population, and each has an incremental influence on caribou population size and distribution.

The incremental effects from the Project represent the Project-specific changes to seasonal ranges relative to baseline values in 2010 (current or existing conditions). Project-specific effects typically occur at the local scale (e.g., habitat loss due to the Project footprint) and regional scale (e.g., combined habitat loss, dust, noise, and sensory disturbance from Project activities [i.e., ZOI]) within the seasonal ranges of caribou. For species like caribou, the incremental effect from each project influences a portion of the seasonal ranges, which can affect caribou population size and distribution.

In summary, key components of the effects analysis on caribou population size and distribution were:

- to provide quantitative measurements of direct loss and fragmentation of habitat due to the Project footprint and other human developments within the seasonal ranges;
- to calculate the loss and degradation of preferred habitat due to noise, dust, and other sensory disturbances near the Project and other developments on the landscape (i.e., zones of influence);
- to quantify the effects from the zones of influence from the Project and other developments on caribou movements, energy budgets, and fecundity rate; and

- to model the viability of the population by considering the incremental and cumulative effects of the Project, other developments, harvest rate, and natural factors on the carrying capacity of the landscape, energy budgets, and fecundity rates.

7.6.1 Habitat Quantity and Fragmentation

Approximately 68% of the Project footprint is aquatic habitat and 32% is terrestrial habitat. At the local scale, the Project footprint will alter 4.4% of the baseline LSA. Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA (and RSA). Other terrestrial habitats altered by the Project footprint include heath tundra, heath tundra with bedrock or boulders, birch seep, and riparian tall shrub (all decreased by less than 0.4% relative abundance in the LSA). No esker is expected to be altered.

Although progressive reclamation will be integrated into mine planning, arctic ecosystems are slow to recover from disturbance. In addition, not all the areas will be reclaimed. For example, as a result of locally expressed concerns, the mine rock cap will not be vegetated to prevent the reclaimed Fine PKC Facility from becoming attractive to wildlife. Therefore, the mine rock piles, Coarse PK Pile, and Fine PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha.

The analysis classified 12 habitat types within the seasonal ranges of the Bathurst and Ahiak herds, which were approximately 124,185 km^2 to 253,908 km^2 in area. Development footprints on the landscapes were assumed to be permanent (i.e., irreversible within the temporal boundary of the assessment). Winter roads and mineral exploration camps have the largest cumulative footprint on the landscape. However, the footprint size for exploration camps (500 m radius) and width or winter roads (200 m) likely overestimate the effects from direct habitat loss and fragmentation. In the Bathurst range, the number of active mineral exploration camps and the overall cumulative footprint (including anticipated zones of influence) peaked in 2006, following a steady increase in new developments beginning in 2000. From 2006 to 2010, the number of active land use permits decreased, and resulted in an increase in habitat quality on the seasonal ranges.

The magnitude of habitat-specific (excluding burns) decreases from reference to current (2010) baseline conditions among caribou seasonal ranges varied from less than 0.01 to 0.4%. Decreases in the amount of forage habitat (i.e., heath tundra, sedge association, riparian shrub, and lichen veneer) on the summer and autumn ranges were no greater than 0.2%. During winter, forest habitat decreased by 0.2% and less than 0.1% within the Bathurst and Ahiak caribou ranges, respectively. Previous and existing developments have physically altered about 1.1% of the seasonal ranges for the Bathurst and Ahiak caribou herds.

Overall, the Project is expected to disturb less than 0.1% of landscape in the caribou seasonal ranges. The magnitudes of habitat-specific incremental changes from the Project footprint were estimated to be less than 0.09% per seasonal range for the Bathurst and Ahiak herds. For many habitats, the change from the Project relative to the seasonal range of the herd was so small that it was not measurable (i.e., <0.01%). The cumulative direct disturbance to the landscape from the Project and other previous, existing, and future developments is predicted to be 1.7% or less of the seasonal ranges, relative to reference conditions. This estimate is well below the 40% threshold value identified for habitat loss associated with predicted declines in bird and mammal species (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). Decreases in available habitat cover to less than 60% can result in noticeable changes in the configuration of the landscape (i.e., habitat fragmentation; Swift and Hannon 2010).

Increasing development from reference to current (2010) baseline conditions has also resulted in habitat fragmentation or changes to the number and location of habitat patches in the seasonal ranges of caribou. For example, the magnitude of habitat-specific decreases in the number of patches and mean nearest neighbour distances ranged from less than 0.01% to 1.0% for foraging habitats (i.e., heath tundra, sedge association, riparian shrub, and lichen veneer) in the northern migration, summer, and autumn ranges of the Bathurst herd. From reference to baseline (2010) conditions, the numbers of patches have generally increased, and the mean distances between nearest neighbouring patches have generally decreased.

The addition of the Project to the 2010 baseline landscape generated incremental changes to the configuration of Bathurst and Ahiak caribou habitats. For example, habitat-specific changes to the number of patches across seasonal ranges varied from -0.4% to 1% for the Bathurst herd, and from 0% to 0.6% for the Ahiak herd (excluding burns). Changes in mean distance to nearest neighbour ranged from -0.7% to 0.7% for the Bathurst herd, and from -0.4% to 0% for the Ahiak herd. The Project and previous, existing and future developments resulted in habitat-specific cumulative changes to the number and distance between similar habitat patches ranging from 0 to 5%. These small changes are predicted have little influence on the carrying capacity of the landscape, and the movement and distribution of caribou.

On the winter range, development (which includes the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads) has also changed the configuration of habitats on the baseline landscapes for the caribou herds. The magnitude of changes in the number of forest patches from reference to current conditions was no more than 1.7% in either the Bathurst or Ahiak ranges. Also, the change in the mean distances to nearest neighbour for forest patches was no more than 1.3%. Although the presence of the Tibbitt-to-Contwoyto Winter Road may represent a partial barrier to caribou and lead to fragmentation of the population within the winter range (Trombulak and Frissell 1999), the road is only in operation for approximately eight to 12 weeks each year. The winter road may in fact be a “leaky barrier” (where some animals manage to cross successfully) but it may still restrict the landscape-scale movements of caribou short periods of time (Treweek 1999). Direct effects of habitat fragmentation to caribou movement from the Winter Access Road are regional and predicted to be reversible within five years following initial closure (i.e., near the end of final closure).

7.6.2 Habitat Quality, Movement, and Behaviour

7.6.2.1 Local and Regional Effects from the Project

Local and regional effects from the Project on caribou movement, and behaviour were associated with dust deposition, noise, and other sensory disturbances (e.g., presence of humans and vehicles). Air quality modelling predicted that the maximum predicted dust deposition rate would occur within 100 m of the Project footprint. Walker and Everett (1987) and Everett (1980) reported that the largest effects from dust are associated with primary sources (e.g., haul roads), and typically confined to a 50-m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that the majority of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road.

Noise will be generated from mobile and stationary mining equipment, blasting, and aircraft at the Project. The analysis of blasting activity indicates the maximum distances at which the criteria for peak ground (12.5 mm/s) and airborne vibration levels (120 dBL) would be met are 596 and 730 m, respectively. The distance for noise attenuation to reach background for mining operations (including blasting) is predicted to be 3.5 km. Results from monitoring studies at the Ekati Diamond Mine showed that the proportion of time spent feeding by groups with calves significantly increased with distance from the mine (BHPB 2004). More recent analysis has not detected mine-related effects on caribou activity budgets, but strong instantaneous responses to blasting and aircraft were more frequent than other activities (BHPB 2007). Other studies have found caribou to be reasonably tolerant of human activities (Bergerud et al.

1984; Davis et al. 1985), especially during periods of insect harassment (Cronin et al. 1998; Murphy and Lawhead 2000).

Aircraft noise will be limited to a few minutes during takeoff and landings and a maximum of two round-trip flights per day are expected during Project construction and operations. The distance for noise attenuation to reach background levels from the airstrip is predicted to be 5.5 km. However, disturbance from large aircraft is expected to be infrequent and short-term (less than five minutes in duration). The effects from noise and other sensory disturbances on the movement and behaviour of caribou will likely last a few years after closure of the Project. The magnitude of local effects from dust and noise on caribou movement and behaviour is predicted to be within the range of baseline conditions.

Noise from the Winter Access Road is predicted to diminish to background noise levels within 3.0 km, based on traffic volume during the construction period, and in 500 m during the operations phase. Some studies have found caribou were displaced within 2 to 4 km of roads (Dau and Cameron 1986; Cameron et al. 1992, 2005). Other studies have observed that resting and feeding behaviour was common for caribou near airstrips or roads (Gunn et al. 1998; BHPB 2007). The magnitude of incremental changes in caribou movement and behaviour near the Winter Access Road is expected to be within the range of baseline conditions when the road was in operation during exploration.

Traffic associated with the Project along the Tibbitt-to-Contwoyto Winter Road (from Tibbitt Lake to MacKay Lake) and the Winter Access Road is predicted to affect the behaviour and movement of caribou. However, the frequency and duration of effects from winter roads occurs once per year for eight to 12 weeks. Part of the effect from winter roads was estimated in the analysis of habitat fragmentation (Section 7.6.1), which considered changes in habitat patch number and connectivity from development. These changes can influence the winter range movements of caribou. Based on the current literature and noise modelling results, the spatial extent of changes to the behaviour and movement of caribou from activity along winter roads is predicted to be within 5 km of a road. Cumulative changes to caribou movement and behaviour from winter roads is predicted to approach the limits of baseline values. Use of the Winter Access Road is predicted to stop in year two of closure, and effects should be reversed before the end of closure (i.e., reversible within 5 years).

7.6.2.2 Effects Beyond the Regional Scale of the Project

The combination of direct (physical footprint) and indirect (noise, dust, and other sensory disturbances) effects can create a ZOI around the Project that can change the behaviour and occurrence of caribou. This ZOI appears to be greater than the estimated spatial extent of the independent effects from infrastructure, activities, dust, air emissions, or noise. Most studies show that the estimated ZOI of diamond mines on caribou distribution may range from 10 to 30 km (Boulanger et al. 2004; Johnson et al. 2005; Golder 2008a, b). More recent analyses have estimated the ZOI to be 11 to 14 km near the Ekati-Diavik mine complex during the operation phase (Boulanger et al. 2009). At the smaller Snap Lake Mine, a weaker ZOI of 6.5 km was detected (Boulanger et al. 2009). It was predicted that the ZOI (geographic extent) from the combined changes of the footprint, dust deposition, noise, and sensory disturbance on habitat quality would be 15 km around the Project and other active mine sites. Specifically, active mines were estimated to reduce habitat quality by 95% within a 1 km radius, 50% from 1 to 5 km, and 25% from 5 to 15 km.

7.6.2.2.1 Amount of Quality Habitat

Although the combined direct and indirect changes from the Project on habitat are local to regional in geographic extent, the effects extend to the population as animals interact with the Project and other developments during their seasonal movements. Using a combination of spatially-explicit databases and RSFs, availability of preferred habitat (combined high and good quality habitats) was calculated for several landscape scenarios from reference to future conditions. In general, the amount of high and good quality habitats in the seasonal ranges decreased from reference to 2010 baseline conditions. Most of the decline in habitat quality occurred from 2000 to 2006 and was associated with the increasing number of exploration sites on the landscape. Relative to 2006, the availability of quality habitats in the seasonal ranges increased in 2010, which was due to the decrease in the number of active developments.

The application of the Project to the current (2010) landscape resulted in less than 0.3% decreases in high quality habitats on the seasonal ranges for the Bathurst herd. The largest incremental change from the Project was a 1.4% decrease in good quality habitat on the autumn range. Similar incremental changes in preferred habitats were observed with the addition of reasonably foreseeable developments (i.e., Taltson Hydroelectric Expansion Project). The largest incremental change from the Taltson Hydroelectric Expansion Project was a 2.1% decrease in good quality habitat on the autumn range.

Cumulative changes from reference conditions through future conditions were similar to those estimated for the time period from reference conditions to 2006. Cumulative changes from the Project and other developments decreased preferred habitat by about 2.7% on the spring range, 3.2% on the post-calving range, and 7.3% on the autumn range. Adamczewski et al. (2009) calculated that the zones of influence from operating mines on the Bathurst summer range resulted in a 4% reduction in habitat availability. If the amount of preferred habitat is proportional to carrying capacity of the seasonal range, then a 7.3% decline in preferred habitats from development may reduce the carrying capacity of the landscape for the Bathurst herd from 290,000 to 269,120 animals.

Compared to the Bathurst caribou herd, there were relatively small changes in the amount of different quality habitats between reference and 2010 baseline conditions for the Ahiak herd. The majority of Ahiak caribou habitat within the seasonal ranges has remained unchanged by human activity. There was less than 1.1% decreases in high and good quality habitats from reference to future conditions per seasonal home range. In addition, there were no changes in the availability of preferred habitat with the addition of the Project to the 2010 landscape (i.e., the Project is not located within these seasonal ranges for the Ahiak herd).

At the regional scale, reductions in preferred habitats due to the zone of influence from development also may result in an increase in the density of caribou where habitat is suitable and there are a lower number of developments (Cameron et al. 1992; Nellemann and Cameron 1998; Cameron et al. 2005). However, the cumulative effects from development are not predicted to result in measurable shifts (e.g., east or west) or contractions in the distribution of caribou at the scale at which population processes operate (i.e., seasonal and annual ranges). The change in the distribution of caribou associated with the ZOI from the Project and other developments is expected to be within the range of baseline conditions. There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance, and quality) that likely have greater influences on seasonal distributions of caribou relative to the effects from the Project and other developments. The duration of indirect changes to preferred habitat and in seasonal distribution of caribou from the cumulative effects of the Project and other developments is anticipated to occur over a period of 27 to 32 years (i.e., effects should be reversed within 5 to 10 years following Project closure).

7.6.2.2.2 Behaviour, Energy Balance, and Calf Production

Using satellite collar data from the summer through autumn (rut) period (138 days), 194 paths of female Bathurst caribou were obtained from 1996 to 2009. The objective was to better understand the degree to which animals interacted with human developments. An interaction was measured as either the proportion of time a female resides in a ZOI, or the number of encounters (or entrances) with zones of influence per caribou path. To determine possible interactions between the Project and future developments (i.e., the Taltson Hydroelectric Expansion Project), locations of paths from 1996 to 2009 were used to predict (simulate) the increase in encounter rates and residency times under future landscape conditions. These analyses were completed in a GIS platform.

Results showed that from 1996 to 2009, Bathurst caribou resided in zones of influence for an average of 9.6 days or 6.9% of their time during the summer to autumn period. The amount of time spent by female caribou in zones of influence has increased from 1.9% in 1996 to 10.1% (13.9 days) in 2009. Based on paths from 1996 to 2009, the mean predicted residency was 3.6% (5 days) for both the Project and the Taltson Hydroelectric Expansion Project combined.

From 1996 to 2009, the mean encounter rate with zones of influence was 9.0 encounters per 138 days. Mean encounter rates have increased from 2.9 encounters per 138 days during 1996 baseline conditions to 13.8 encounters per 138 days in 2009 baseline conditions. Simulations based on the same paths for 1996 to 2009 predicted that the mean encounter rate for the Project and Taltson Hydroelectric Expansion Project combined was 2.3 encounters per 138 days.

Whether a female caribou encounters multiple zones of influence or resides for periods of time in a ZOI, disturbance from development has been implicated as a possible cause in the decline of caribou populations (Bradshaw et al. 1998). To assess the effects from disturbance on caribou, a simple model was constructed to estimate the energy costs of multiple encounters of disturbance. The energetics analyses incorporated disturbance event data from the residency time analyses. It was assumed that caribou are exposed to one disturbance event per day while residing within a ZOI, regardless of how close the animal was to the development footprint or activity. A disturbance event is defined as an event that may cause caribou to walk, run, and become excited, and results in a loss of body weight and condition. In addition, to quantify the effects of oesterid fly harassment on caribou, the range in annual values for an IHI was used to estimate body weight loss. The IHI was determined from weather data (temperature and wind speed) for the Lac de Gras and Snap Lake regions in the summer to autumn range.

With low insect harassment and no development, the energetics model predicts an 8% decrease in calf production for some females in some years (i.e., parturition rate = 0.920) relative to ideal conditions (i.e., parturition rate = 1.0). The reference values for parturition and fecundity rate are maximum values within the range of those reported for caribou (Cameron et al. 2005; Boulanger and Gunn 2007). In a year with severe insect harassment and no development on the landscape, fecundity may be reduced by 27.8%.

Under the 2000 baseline scenario with three disturbance encounters and average levels of insect harassment, the decrease in parturition rates relative to a landscape with no development and low insect levels was predicted to be 8.8%. For current (2010) baseline conditions with low levels of insect harassment, the model predicted a reduction in fecundity by 2.3% relative to ideal conditions. With the application of the Project and the Taltson Hydroelectric Expansion Project (combined) to a landscape with previous and existing developments and low insect harassment, the fecundity rate was reduced by 3.1% relative to ideal conditions. Thus, the incremental decrease in fecundity from the Project and the Taltson Hydroelectric Expansion Project relative to current (2010) conditions was predicted to be 0.8% (difference between 3.1% and 2.3%). The landscape models predict that insect levels have the largest influence on fecundity.

Clearly, caribou calf production can be affected by both human and natural disturbances to caribou behaviour. For summers when insect harassment is low, over 600 disturbance events would be required to result in the expenditure of 20% of the average weight of a female, 80 kg (i.e., 16 kg), and no calf production the following spring. If considering effects from both severe insect harassment and disturbance encounters, about 400 disturbance events are predicted result in no calf recruitment by a female caribou. Based on the expected number of major disturbance encounters for a landscape with the Project and Taltson Hydroelectric Expansion Project (about 20), female caribou would have to increase their encounter rate per day by at least 20-times to not produce a calf the following spring.

7.6.3 Population Viability

Population viability analyses (PVAs) were used to quantify cumulative effects of development, hunting, and natural factors on Bathurst caribou throughout the annual range of the herd. The focus of the PVA models was to determine the relative changes in the risk to population viability (i.e., the likelihood of population persistence) for different landscape scenarios. Local and regional effects from the Project and other developments on habitat quantity and quality, and caribou behaviour and vital rates were incorporated into model simulations. For example, results from the habitat quality analysis, which includes direct and indirect habitat effects from development and the energetics model were linked to parameter inputs in the population models. The PVA was used to estimate the incremental effect from the Project, and the relative contribution of natural factors (insects, deep snow) and human activities (previous, existing, and future developments, and hunting) on the population size and persistence of caribou.

It is emphasized that the models are not used to predict the number of caribou in 5 years, 10 years, or 30 years from now. Based on the lack of information for survival and reproductive rates for all phases (increase, decrease, and no change) of the population cycle, the model should not be used to estimate future population sizes. The consensus among many population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among landscape scenarios, are more reliable for assessing effects than absolute results (McCarthy et al. 2003; Schtickzelle et al. 2005). In this assessment of caribou, two measures of herd viability were used for comparing reference, baseline and application scenarios: relative change in the final projected abundance at year 30, and the maximum difference in probability of threshold abundance between risk curves.

Using the input parameters for the reference condition (no development, low insect harassment, and 4% harvest rate) resulted in a population trajectory that increases and then begins to decline during the 30-year simulation. The modest increase in the population trajectory may be due to the high variance inputs for calf and yearling survival, and population size. For example, high variation often results in projections that are lower than the average, which can either overestimate population declines or underestimate population increases (Akçakaya et al. 2004; Boulanger and Gunn 2007).

To better understand the dynamics underlying trends in herd viability, a sensitivity analysis was conducted using the current (2010) baseline model. The most sensitive parameter in the model was adult female survival. Boulanger and Gunn (2007) also showed that population decline in the Bathurst herd was more sensitive to variation in adult female survival than the production and survival of calves. However, adult survival, sub-adult survival (i.e., individuals less than 3 years in age), and calf production (i.e., fecundity) were all highly sensitive parameters. All parameters, with the exception of carrying capacity, were identified as being sensitive when changing their inputs by 10%, while holding other input values constant.

Incremental effects tests failed to detect statistically significant changes from the application of the Project and the Taltson Hydroelectric Expansion Project on herd viability relative to current conditions. In addition, the simulations demonstrated that most of the change to herd viability from development has occurred during the previous 10 to 14 years. For example, the incremental change from the Project decreased projected final abundance by 1.5% (at year 30). Alternately, the cumulative changes from the Project and previous, existing, and future developments decreased terminal abundance by 12.2% relative to reference conditions. Such tests modelled similar insect harassment levels and harvest rates from one scenario to the next.

Cumulative effects were larger when there were increases in insect activity levels (i.e., from 14 to 44 IHI) or increases in harvest rates (i.e., from 4% to 8%). Based on the application-future scenario with high levels of insect activity and 4% harvest rates, cumulative changes to herd viability included an 51% decrease in terminal abundance and statistically different risk curves of threshold abundance ($D = 0.72$, $P < 0.01$). Similarly, based on the application-future scenario with low levels of insect activity but high harvest rates (at 8%), cumulative changes to herd viability included a 59% decrease in terminal abundance and statistically different risk curves ($D = 0.84$, $P < 0.01$).

Sensitivity and effects tests showed that disturbance to caribou habitat from development (i.e., carrying capacity) had a statistically non-measurable effect on population size and persistence. Similarly, the incremental change from the Project did not significantly change the likelihood of caribou population persistence. Increases in insect harassment (low to high) and harvest rate (4 to 8%) had a much stronger effect on final abundance and risk curve projections, relative to the incremental and cumulative effects from the Project and other developments. The duration of the cumulative effects from the Project on population persistence is expected to occur over a period of approximately 27 to 32 years (i.e., effects should be reversed within 5 to 10 years following Project closure).

7.6.4 Related Effects on People

The Winter Access Road and Tibbitt-to-Contwoyto Winter Road may increase access to caribou within the region when the winter roads are in operation (approximately eight to 12 weeks each year). De Beers will have a no firearms and no hunting policy for staff and contractors on-site so that people at site will not benefit from increased access to the region for the harvesting of caribou. Thus, the number of caribou harvested in the region from improved access due to the Winter Access Road for the Project is expected to be within the range of baseline conditions. Use of the Winter Access Road is predicted to stop in year two of closure, and any effects should be reversed before the end of closure (i.e., reversible within five years).

The incremental change from the Project on caribou abundance and persistence was not statistically measurable relative to current (2010) baseline conditions. The cumulative changes from the Project and other developments on habitat and fecundity had a moderate influence on abundance and viability relative to a landscape with no development. Insect harassment levels and harvest rate also contributed to the population abundance and viability of caribou. The addition of the Project is not expected to result in a detectable change in encounter rates between caribou and people relative to current (2010) baseline conditions.

The expected change in the regional distribution of caribou associated with the ZOI from the Project may affect hunting success at nearby outpost camps. In particular, Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project, and may experience small decreases in caribou encounters. In contrast, Artillery Lake Adventures has a camp situated on the west side of Artillery Lake, about 70 km east of the Project, and may experience an increase in the number of caribou from avoidance of the Project and other developments. There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance, and quality) that likely have greater influences on regional distributions of caribou relative to effects from the Project and other developments. Changes in distribution due to the Project are expected to be within the range of baseline conditions. Effects are expected to last from construction until five to ten years after Project closure (i.e., 27 to 32 years).

In contrast, there is little known about the long-term effects from development on caribou movement and distribution at the scale of the seasonal ranges. Factors that influence changes in migration routes and habitat use within seasonal ranges typically occur across large spatial scales and over many years, or decades. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

The spatial extent of current development is likely large enough to have some influence on caribou movement and distribution within their post-calving, summer, and autumn ranges. However, it is not known if the duration of effects from development has been long enough to cause a shift in a seasonal range of caribou relative to natural factors. Natural environmental factors that operate on large spatial scales and over long periods of time include climate-related changes to fire regimes, snow and rainfall, and food abundance and quality (Tyler 2010).

7.7 RESIDUAL IMPACT CLASSIFICATION

The purpose of the residual impact classification is to describe the residual effects from the Project on caribou using a scale of common words (rather than numbers or units). The use of common words or criteria is a requirement in the Terms of Reference for the Project (Gahcho Kué Panel 2007). The following criteria must be used to assess the residual impacts from the Project:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency;
- likelihood; and
- ecological context.

Generic definitions for each of the residual impact criteria are provided in Section 6.7.2.

7.7.1 Methods

In the EIS, the term “effect”, used in the effects analyses and residual effects summary, is regarded as an “impact” in the residual impact classification. Therefore, in the residual impact classification for this section, all residual effects are discussed and classified in terms of impacts to caribou.

The effects analyses and residual effects summary presented both the incremental and cumulative changes from the Project and other developments on the environment, caribou, and use of caribou by people. Incremental effects represent the Project-specific changes relative to baseline values in 2010. Project-specific effects typically occur at the local scale (e.g., habitat loss due to the Project footprint) and regional scale (e.g., combined habitat loss, dust, noise, and sensory disturbance from Project activities [i.e., ZOI]).

Cumulative effects are the sum of all changes from initial baseline (i.e., reference conditions) values through application of the Project and future developments. In contrast to Project-specific (incremental) effects, the geographic extent of cumulative effects is determined by the distribution of the defined population. For example, caribou travel over large distances during their seasonal and annual movements and can be influenced by the Project and other developments on the landscape.

For caribou, the assessment and classification of residual impacts were based on the predicted cumulative changes from reference conditions through application of the Project (and into the future case). The spatial boundary of the assessment is at the scale of the seasonal ranges (population level), which is a requirement in the Terms of Reference (Gahcho Kué Panel 2007). The incremental effects from the Project relative to 2010 baseline conditions are also classified. Essentially, the only difference in the outcome of impact criteria between incremental and cumulative effects from the Project is in the magnitude and geographic extent of impacts. The magnitude for cumulative impacts involves changes from reference conditions through application of the Project (and into the future case), while incremental impacts are based on changes from the Project relative to 2010 baseline values. Cumulative impacts from the Project and other developments influence the entire seasonal ranges (i.e., beyond regional scale effects). In contrast, the geographic extent of incremental impacts from the Project typically has a local and regional influence on the seasonal ranges of caribou.

The predicted scales for the remaining impact criteria (direction, duration, reversibility, frequency, likelihood, ecological context) are equivalent for assessing the incremental and cumulative effects from the Project. The results from this impact classification are then used to determine environmental significance from the Project on the persistence of caribou populations and the continued opportunity for traditional and non-traditional use of caribou (Section 7.8).

Effects statements are used to focus the analysis of impacts to caribou that are associated with one or more primary pathways. The residual effects summary (Section 7.6) presents a numerical assessment for criteria such as magnitude, geographic extent, duration, and frequency. From the summary of residual effects, pathways associated with each effects statement are then classified using scales (categorical values such negligible, low, or high) for each impact criterion (e.g., magnitude).

To provide transparency in the EIS, the definitions for these scales were ecologically or logically based on caribou. Although professional judgement is inevitable in some cases, a strong effort was made to classify impacts using scientific principles and supporting evidence. The scale for the residual impact criteria for classifying effects from the Project are specifically defined for caribou, and definitions for each criterion are provided in Table 7.7-1. More detailed explanations for magnitude, geographic extent, and duration are provided below.

Table 7.7-1 Definitions of Criteria Used in the Residual Impact Classification of Pathways for Effects to Population Size and Distribution of Caribou

Direction	Magnitude[(a)]	Geographic Extent	Duration	Frequency	Reversibility[(b)]	Likelihood
Negative: a decrease relative to baseline values **Positive:** an increase relative to baseline values	**negligible:** no expected detectable change from baseline values **low:** impact is expected to be within the range of baseline values **moderate:** impact is expected to be at or slightly exceeds the limits of baseline values **high:** impact is expected to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**local:** small-scale direct and indirect impacts from the project (e.g., footprint, physical hazards, dust deposition, and lake dewatering) **regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects **beyond regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**short-term:** impact is reversible at end of construction **medium-term:** impact is reversible at end of closure (i.e., upon completion of refilling Kennady Lake) **long-term:** impact is reversible within a defined length of time (e.g., animal life spans) beyond closure	**isolated:** impact confined to a specific discrete period **periodic:** impact occurs intermittently but repeatedly over the assessment period **continuous:** impact will occur continually over the assessment period	**reversible:** impact will not result in a permanent change of state of the population compared to “similar” environments not influenced by the project **irreversible:** impact is not reversible (i.e., duration of impact is unknown or permanent)	**unlikely:** the impact is likely to occur less than one in 100 years **possible:** the impact will have at least one chance of occurring in the next 100 years **likely:** the impact will have at least one chance of occurring in the next 10 years **highly likely:** the impact is very probable (100% chance) within a year

(a) Baseline includes range of expected values from reference conditions (no development) through 2010 baseline conditions.

(b) “Similar” implies an environment of the same type, region, and time period.

> = greater than; % = percent

7.7.1.1 Magnitude

Magnitude (i.e., intensity of the impact) for Project-specific (incremental) effects is scaled to the predicted change (quantified or qualified) from 2010 baseline conditions to application of the Project. Magnitude for cumulative effects is scaled to the predicted quantified and/or qualified cumulative change from reference conditions (no development) through application of the Project and reasonably foreseeable developments. Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in caribou. Environmental selection pressures include both natural (e.g., rainfall, snowfall, insect harassment, and predation) and human-related factors (e.g., mineral development, traditional harvest, and sport hunting).

Depending on which selection pressures are currently driving changes in caribou and the system, baseline conditions typically fluctuate within a range of variation through time and space. Relative to ecological time and space, baseline conditions are in a constant state of change due to the pushing and pulling of environmental selection pressures. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the trajectory of the caribou population.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on scientific literature and professional opinion, and incorporated conservatism. Other environmental assessments often use the universal effect size approach for categorizing magnitude such as negligible changes (0 to 10%), small changes (10 to 25%), and medium changes (25 to 40%) (Munkittrick et al. 2009). Ideally, effect threshold values would be known, and measurement endpoints could be quantified accurately with a high degree of confidence. However, little is known about ecological thresholds, and biological parameters are typically associated with large amounts of natural variation. Therefore, the classification of magnitude included a level of conservatism so that the impacts would not be underestimated.

The definition of magnitude provided in Table 7.7-1 is applicable for more qualitative results (e.g., impacts on caribou movement and behaviour, and related impacts to people). For quantitative analyses and results (e.g., loss and fragmentation of habitat, changes to habitat suitability, and changes to population viability), the following definition for magnitude is applied:

- negligible: less than a 1% change from the Project relative to baseline values;

- low: 1% to 10% change from the Project relative to baseline values;;
- moderate: greater than 10% to 20% change from the Project relative to baseline values; and
- high: more than 20% change from the Project relative to baseline values.

The proposed scale is consistent with the 20% rule for the severity of effects from chemical exposure on varying spatial scales of ecological effects (i.e., a 20% change in a measurement endpoint constitutes an ecological effect) (Suter et al. 1995). The scale is also consistent with and below thresholds identified by empirical and theoretical work on the relationship between loss of suitable habitat and the likelihood of population decline (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). These studies suggested that critical thresholds for population parameters of non-tropical bird and mammal species occur between 10% and 60% of original habitat. In other words, a measurable decrease in species abundance and diversity may be observed when the amount of suitable habitat that is lost exceeds a threshold value of 40%. In a recent review, Swift and Hannon (2010) found that most empirical studies demonstrate a critical threshold of 10% to 30% habitat cover (i.e., more than 70% habitat loss), where a critical threshold refers to an abrupt, nonlinear change that occurs in some parameter (e.g., population size) across a small range of habitat loss.

7.7.1.2 Geographic Extent

Geographic extent is the area or distance influenced by the direct and indirect effects from the Project, and is different from the spatial boundary (i.e., effects study area) for the effects analysis and impact assessment. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement (i.e., population boundary or seasonal ranges) of caribou (Section 7.1.3).

However, the geographic extent of impacts can occur on a number of scales within the spatial boundary of the assessment. As defined in Table 7.7-1, geographic extent for classifying impacts is based on three scales: local, regional, and beyond regional. Local-scale impacts mostly represent incremental (Project-specific) changes to caribou population size and distribution that are directly related to the Project footprint and activities (e.g., physical disturbance to vegetation [habitat], mortality of individual animals). Local impacts may also include small-scale indirect effects such as dust deposition on vegetation.

Changes at the regional scale are largely associated with incremental indirect impacts from the Project on caribou and are defined by the predicted maximum distance or area (i.e., ZOI) of the effect from the Project (e.g., combined direct and indirect effects on caribou distribution). However, at the scale of the population, the cumulative local and regional impacts from the Project and other developments, and natural factors are beyond regional (which is the effects study area or spatial boundary for the assessment). Individuals within the population travel large distances during their daily and seasonal movements and can be affected by the Project, and additional projects. Cumulative effects from the Project also occur beyond the regional scale for traditional and non-TLU of caribou.

7.7.1.3 Duration

Duration has two components. It is the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the impact to be reversible. Essentially, duration is a function of the length of time that caribou are exposed to Project activities, and reversibility.

Although it is common to describe construction, operation, and closure as discreet phases, these activities will overlap at Kennady Lake. For example, there is less than one year when construction activities are the only activities at the Project site. Progressive closure and reclamation activities will begin during operation, and continue for eight years at the end of operation, which will include the initial refilling of Kennady Lake. The time from construction to initial closure is 16 years. The total length of the Project (i.e., end of final closure) is 22 years.

By definition, impacts that are short-term, medium-term, or long-term in duration are reversible. Project activities may cease at closure, but the impact on caribou may continue beyond Project closure. Some impacts may be reversible soon after removal of the stressor, such as effects to air quality from power generation and equipment operation (e.g., medium-term impact).

For caribou, the amount of time required for the impact to be reversed (i.e., duration of the effect) is presented in context of the number of life spans that caribou are influenced. The anticipated duration of effects to caribou are then used to determine the number of human generations that may be affected by the related changes to traditional and non-TLU practices (e.g., availability of caribou). In this manner, the impact assessment links the duration of Project impacts on caribou to the amount of time that human use of ecological resources may be influenced.

For impacts that are permanent, the duration of the effect is determined to be irreversible. Examples of irreversible impacts include the expected localized loss of vegetation and habitat due to the mine rock and Coarse PK piles and Fine PKC Facility.

7.7.2 Residual Impacts to Population Size and Distribution of Caribou

7.7.2.1 Impacts to Caribou

The directions of the five primary pathways influencing population size and distribution of caribou are predicted to be negative. The scale of impacts, in terms of geographic extent and magnitude, will generally be larger for cumulative than incremental changes. Magnitudes of impacts are predicted to be negligible to moderate for the pathways, whereas geographic extent varied from local to beyond regional (Table 7.7-2). All pathways are classified as being medium to long-term in duration and reversible, with the exception of the impacts from physical footprints that will be permanent and irreversible. The frequency of impacts from the use of winter roads is anticipated to be periodic (impacts occur for eight to 12 weeks each year), whereas impacts from other the pathways are expected to be continuous (Table 7.7-2).

The magnitude of the impact from the Project footprint on caribou populations is predicted to be low at the local scale (i.e., the Project will alter 4.4% of the landscape in the LSA). Progressive reclamation will be integrated into mitigation and management plans for the Project.. However, not all the areas of the Project footprint will be reclaimed. The mine rock piles, Coarse PK Pile, and Fine PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha.

The incremental influence from the Winter Access Road for the Project on caribou habitat is anticipated to be negligible to low in magnitude, and regional in geographic extent. The use of best construction and operation practices has proven to be successful at limiting changes to soil and vegetation for the Tibbitt-to-Contwoyto Winter Road, and these practices will be applied to the Winter Access Road. Direct impacts from the Winter Access Road on caribou are expected to be reversible within five years after initial closure (medium-term) (Table 7.7-2).

At the scale of the seasonal ranges, which is the scale where population processes operate for caribou, the Project is expected to disturb less than 0.1% of the landscape (negligible magnitude). The cumulative direct disturbance to the landscape from the Project and other previous, existing, and future developments is predicted to be less than or equal to 1.7% of the seasonal ranges relative to reference conditions (low magnitude).

The addition of the Project to the 2010 baseline landscape is also expected to result in incremental changes to the spatial configuration (fragmentation) of Bathurst and Ahiak caribou habitats. For example, habitat-specific changes to the number of patches across seasonal ranges varied from -0.4% to 1% for the Bathurst herd, and from 0% to 0.6% for the Ahiak herd (excluding burns in the analysis). Changes in mean distance to nearest neighbour ranged from -0.7% to 0.7% for the Bathurst herd, and from -0.4% to 0% for the Ahiak herd. The Project and previous, existing and future developments are predicted to result in habitat-specific cumulative changes to the number of patches and the distance between similar habitat patches ranging from 0 to 5% (low magnitude). These changes are expected to have a negligible influence on the carrying capacity of the seasonal ranges and the movement and distribution of caribou.

Cumulative impacts from direct habitat loss and fragmentation are predicted to be beyond regional in geographic extent as the impact occurs throughout the seasonal ranges of caribou. Direct changes to caribou habitat are highly likely to occur. Development footprints and related loss of habitat to the landscapes are assumed to be permanent (i.e., not reversible within the temporal boundary of the assessment) (Table 7.7-2).

The cumulative direct impact of habitat fragmentation on caribou movement from the Winter Access Road and Tibbitt-to-Contwoyto Winter Road (from Tibbitt Lake to MacKay Lake) is predicted to be low in magnitude (i.e., within the range of baseline values), and beyond regional in geographic extent (Table 7.7-2). The magnitude of changes in the number of forest patches from reference to current conditions is predicted to be no more than 1.7% in either the Bathurst or Ahiak ranges. Also, the change in the mean distances to nearest neighbour for forest patches was no more than 1.3% in the analysis. Although the presence of the winter roads may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range, the roads are in operation for approximately eight to 12 weeks each year. Thus, the impact on caribou population size and distribution will be periodic and is likely to occur. Use of the Winter Access Road is anticipated to stop in year two of initial closure, and impacts should be reversed before the end of closure (medium-term).

Other primary pathways from the Project include the impacts from dust deposition, noise, vehicles, and people on caribou habitat quality, movement, and behaviour. These Project-specific impacts have local and regional influences on the seasonal ranges, and the abundance and distribution of caribou (Table 7.7-2). For example, dust deposition is anticipated to alter habitat within 100 m of the Project footprint. Noise from blasting is predicted to decrease to background levels within 1 km of the Project, while noise from general mining operations and aircraft should reach background levels within 3.5 km and 5.5 km of the Project, respectively. Traffic on the Tibbitt-to-Contwoyto Winter Road and Winter Access Road from the Project also will have indirect impacts on caribou habitat, movement, and behaviour (Table 7.7-2). All of these Project pathways can combine with similar impacts from other developments and decrease the amount of preferred habitat on seasonal ranges for supporting caribou populations (i.e., carrying capacity).

The geographic extent of combined incremental changes from noise, dust deposition, and other sensory disturbances on habitat quality is predicted to be within 15 km from the Project footprint (i.e., the ZOI). Analysis indicated that the largest incremental change from the Project was a 1.4% decrease in good quality habitat on the autumn range of the Bathurst herd relative to current baseline conditions (low magnitude and regional geographic extent) (Table 7.7-2). The magnitude of cumulative declines in preferred habitat across seasonal ranges of the Bathurst herd is predicted to be low (ranged from 2.6% to 7.3%). For the Ahiak herd, less than 1.1% decreases in high and good quality habitats from reference to future conditions are predicted to occur per seasonal home range. Sensitivity analyses also showed that a 10% reduction in carrying capacity (preferred habitat) had no statistical effect ($P = 0.24$) on population abundance and persistence of caribou.

Reductions in preferred habitats due to development may result in an increase in the density of caribou where habitat is suitable and there are fewer developments. The change in the distribution of caribou associated with the ZOI from the Project and other developments is expected to be within the range of baseline conditions (low magnitude). There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance and quality) that likely have greater influences on seasonal distributions of caribou relative to impacts from the Project and other developments. The duration of indirect impacts to caribou distribution from changes in preferred habitat from the Project is expected to occur over a 27 to 32 year period or two caribou life spans (estimated life span for a caribou is 11 to 15 years [Boulanger and Gunn 2007]). Impacts should be reversed within 5 to 10 years following Project closure (Table 7.7-2).

Table 7.7-2 Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects from the Project on Population Size and Distribution of Caribou

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes habitat fragmentation, which changes behaviour and movement, and reduces carrying capacity.	Negative	negligible to low	low	local	beyond regional	permanent	continuous	irreversible	highly likely
Winter road footprint causes habitat fragmentation, which changes behaviour and movement, and reduces carrying capacity.	Negative	negligible to low	low	regional	beyond regional	medium-term	periodic (winter season only)	reversible	likely
Dust deposition covers vegetation and changes the amount of different quality habitats, which alters movement and behaviour, and decreases carrying capacity.	Negative	negligible to low	low	local	beyond regional	long-term	continuous	reversible	likely
The combined indirect effects (i.e., dust deposition, noise, and human activity- sensory effects) from the Project change the amount of different quality habitats, and alter movement and behaviour, and decrease carrying capacity, and survival and reproduction.	Negative	negligible to low	low to moderate	regional	beyond regional	long-term	continuous	reversible	highly likely
Sensory effects (e.g., noise, presence, lights, smells) of vehicles on the Winter Access Road and Tibbitt-to-Contwoyto Winter Road. changes the amount of different quality habitats, alters movement and behaviour, and decrease carrying capacity, and survival and reproduction.	Negative	low	moderate	regional	beyond regional	medium-term	periodic (winter season only)	reversible	highly likely

Traffic associated with the Project along the Tibbitt-to-Contwoyto Winter Road (from Tibbitt Lake to MacKay Lake) and the Winter Access Road is predicted to affect the behaviour and movement of caribou, which may influence vital rates. However, the frequency and duration of impacts from winter roads occurs once per year for an eight to 12 week period. Part of the impact from winter roads was estimated in the analysis of habitat fragmentation, which considered changes in habitat patch size, number, and connectivity from associated barrier effects of development. These changes in the landscape can influence the winter range movements of caribou.

Based on the current literature and noise modeling results, the spatial extent (i.e., ZOI) of changes to the behaviour and movement of caribou from activity along winter roads is predicted to be within 5 km of a road. The magnitude of the incremental impact from the Winter Access Road is predicted to be low (i.e., within the range of current baseline conditions). The impact should occur on the regional scale (Table 7.7-2). Cumulative impacts are predicted to approach or slightly exceed the limits of reference baseline values (i.e., moderate magnitude). The geographic extent is beyond regional as traffic from the Project and other developments on the winter roads extends over part of the winter range (Table 7.7-2). Use of the Winter Access Road is predicted to stop in the second year of closure, and impacts should be reversed before the end of closure. Thus, the duration is medium term, and is expected to impact one to two life spans of caribou.

Human development and natural factors (e.g., insect harassment, deep and hard snow) can affect the behaviour and energy balance in female caribou, which can decrease survival and reproduction, and impact population size and distribution. The energetic model predicted that the decrease in fecundity (calf production) from the Project (and the Taltson Hydroelectric Expansion Project) is 0.8% relative to current baseline conditions (negligible magnitude). The magnitude of the cumulative decrease in fecundity from the Project and other developments is predicted to be low (3.1%). In comparison, a year with severe insect harassment and no development on the landscape reduced fecundity by 27.8% in the model.

Population models predicted that the incremental impacts from the Project and the Taltson Hydroelectric Expansion Project had little influence on the persistence of the caribou herd relative to reference conditions. Specifically, the relative decrease in final abundance was 1.5% (low magnitude) and the difference between the risk curves was not statistically different ($P = 0.34$) in the model. Cumulative impacts from development are predicted to have a moderate influence the likelihood of persistence of the caribou population. Changes in habitat and fecundity from the Project and other developments resulted in a 12.2% reduction in projected final herd abundance relative to reference conditions, and the difference between risk curves was statistically significant (*P* <0.01).

Not surprisingly, cumulative impacts were larger when increases in insect activity levels or increases in harvest rates were included in the population projections. Thus, the overall magnitude of cumulative impacts from development on caribou population size is predicted to be moderate, and dependent on the level of insect harassment and harvesting in the future. The duration of the impacts from the Project and other developments on population size and distribution is expected to occur over a period of 27 to 32 years (i.e., long term). It is predicted that impacts should be reversed within two caribou life spans (i.e., impacts should be reversed within 5 to 10 years following Project closure).

7.7.2.2 Related Impacts to People

Availability of caribou for human use is related to changes in the population size and distribution of caribou. Therefore, the geographic extent of cumulative impacts from development on the use of caribou by people is beyond regional (Table 7.7-3). The magnitude of the cumulative impacts from development on caribou is predicted to range from low to moderate (Table 7.7-2). Changes related to habitat quantity and quality are expected to be low, and changes related to survival and reproduction are predicted to be low to moderate depending on natural factors such as insect levels (Section 7.7.2.1). Harvest rate of female caribou was a key parameter shown to affect population trajectories in models. The duration of the impact to caribou is predicted to last two caribou life spans (27 to 32 years), which is equivalent to about 1.5 human generations (based on a human generation time of 20 years). The impact is reversible in the long-term (Table 7.7-3).

Table 7.7-3 Summary of Residual Impact Classification of Pathways for Cumulative and Incremental Effects to Traditional and Non-traditional Use of Caribou

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Effects on population size and distribution changes the availability of animals	negative	negligible	low	regional	beyond regional	long-term	continuous	reversible	likely
Winter roads provide increased access for harvesting	positive	low	low	regional	beyond regional	medium-term	periodic (winter season only)	reversible	likely

The impact from the Project and other developments on the distribution of caribou across their seasonal ranges is expected to be low in magnitude (i.e., changes should be within the range of baseline conditions) (Table 7.7-3). There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance and quality) that likely have greater influences on seasonal distributions of caribou relative to impacts from the Project and other developments. The regional incremental impact from the Project is not expected to result in a detectable change in caribou distribution on their seasonal ranges. Impacts are anticipated to be reversed within 5 to 10 years after closure. Thus, the duration of the impact (27 to 32 years) should last for 1.5 human generations.

Increased access for harvesting caribou from the Tibbitt-to-Contwoyto Winter Road and Winter Access Road (a positive impact for hunters) is beyond regional in geographic extent, and predicted to be low in magnitude (Table 7.7-3). The independent influence (incremental impact) of the Winter Access Road for the Project on hunting caribou is regional in geographic extent, and also expected to be within the range of baseline conditions (low magnitude). De Beers will have a no firearms and no hunting policy for staff and contractors on-site (i.e., people at site should not benefit from increased access to the region for the harvesting of caribou). The duration of impact should be medium term, as use of the Winter Access Road will stop in year two of closure, and impacts should be reversed before the end of closure. Thus, increased access to caribou is anticipated to impact approximately one human generation.

7.8 ENVIRONMENTAL SIGNIFICANCE

7.8.1 Approach and Method

The Terms of Reference require that "the developer must provide its views on the significance of impacts" (Section 3.2.2; Gahcho Kué Panel 2007). Environmental significance was used to evaluate the significance of incremental and cumulative impacts from the Project and other developments on caribou, and by extension, on the use of caribou by people. The evaluation of significance was based on ecological principles, to the extent possible, but also involved professional judgement and experienced opinion.

The classification of residual impacts on primary pathways provides the foundation for determining environmental significance from the Project on the persistence of caribou populations and the continued opportunity for traditional and non-traditional use of caribou. Magnitude, geographic extent, and duration are the principal criteria used to predict significance (Section 6.7.3). Other criteria, such as frequency, ecological context, and likelihood are used as modifiers (where applicable) in the determination of significance.

Frequency may or may not modify duration, depending on the magnitude of the impact. Because the EIS assesses impacts to key VCs of concern, the ecological context is high, by definition. However, ecological context may be used to modify the environmental significance if the societal value is associated with TLU.

Likelihood will also act as a modifier that can influence environmental significance. Environmental impact assessment considers impacts that are likely or highly likely to occur; however, within the definition of likelihood there can be a range of probabilities that impacts will occur. In special circumstances, the environmental significance may be lowered if an impact is considered to have a very low likelihood of occurring, and increased for impacts with a very high likelihood of occurring.

Duration of impacts, which includes reversibility, is a function of ecological resilience, and these ecological principles are applied to the evaluation of significance. Although difficult to measure, resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses (Section 6.7.3). Resilience includes resistance, capability to adapt to change, and how close the system is to a threshold before shifting states (i.e., precariousness). Resistance is the ability of a population or system to retain the same path or trajectory following a disturbance.

The adaptive capability of a system is related to the evolutionary history and adaptations accumulated by communities, species, and populations while experiencing a range of disturbances and fluctuations through space and time (Section 6.7.3). If the frequency, duration, geographic extent, and/or intensity (magnitude) of a disturbance are beyond that historically encountered by the system, and outside the adaptive capability of a species, then the likelihood of a regime shift increases. Regime shifts and changes in state of the population or ecosystem can be reversible or irreversible.

Reversibility is a function of resilience. Due to the complex relationships among biophysical components and unpredictable events, the recovery of the system following disturbance can result in the same or an altered state (Section 6.7.3). In other words, the exact nature of ecosystem properties and services, and human uses may be different following recovery from the disturbance. In some cases, the shift in ecological properties and services may not be reversible and will have a consequence to socio-economics and land use.

The evaluation of significance for caribou considers the entire set of primary pathways that influence the assessment endpoint (i.e., persistence of caribou populations). The relative contribution of each pathway is used to determine the significance of the Project on caribou, which represents a weight of evidence approach (Section 6.7.4). For example, a pathway with a high magnitude, large geographic extent, and long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative impact from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the persistence of caribou populations would also be assumed to contribute the most to the determination of environmental significance.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to caribou. The following definitions are used for assessing the significance of impacts on the persistence of caribou populations, and the associated continued opportunity for traditional and non-traditional use of caribou.

Not significant – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population persistence.

Significant – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population persistence. A number of high magnitude and irreversible impacts at the population level would likely be significant.

7.8.2 Results

Overall, the impacts from the Project should be reversible (except for the physical footprint), and not have a significant adverse effect on the persistence of caribou populations. There is a moderate degree of uncertainty associated with this prediction, which is primarily related to the duration of impacts and the variability inherent in making long-term predictions in ecological systems. Confidence in the prediction is based on the consistent low effect sizes (i.e., magnitudes of change) that were determined from the incremental and cumulative effects analyses for habitat quantity and quality, energetics, vital rates, and population trajectories. The magnitudes for the five primary pathways influencing caribou population size and distribution ranged from negligible to moderate, but most of the incremental and cumulative impacts were negligible to low in magnitude (Table 7.7-2).

Population models predicted that the incremental impacts from the Project and the Taltson Hydroelectric Expansion Project had little influence on the persistence of the caribou herd relative to reference conditions. Specifically, the relative decrease in projected final abundance was 1.5% (low magnitude) in the model. Cumulative changes in habitat and fecundity from the Project and other developments resulted in a 12.2% (moderate magnitude) reduction in projected final herd abundance relative to reference conditions. Traffic associated with the Project along the Tibbitt-to-Contwoyto Winter Road (from Tibbitt Lake to MacKay Lake) and the Winter Access Road is predicted to have a moderate impact on the behaviour and movement of caribou, which may influence vital rates. However, the frequency and duration of impacts from winter roads occurs once per year for an eight to 12 week period.

Energetic and population models also indicated that insect harassment and harvest levels had much stronger effects on caribou populations relative to the changes from the Project and other developments. Levels of human development on the landscape, measured as a percentage of seasonal ranges covered by zones of influence, peaked in 2006 at approximately 6% cover and have since declined. A recent review by Adamczewski et al. (2009) also indicates that effects from the mines are limited and unlikely a major contributing factor in the decline of the Bathurst caribou herd. Thus, cumulative impacts from development are also predicted to not have a significant adverse impact on the seasonal movements and distribution of caribou relative to reference conditions.

There are natural environmental factors that operate over large scales of space and time that likely have greater influences on seasonal distributions of caribou relative to the incremental and cumulative impacts from the Project and other developments. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000; Tyler 2010). Climate change can also influence the seasonal distribution of caribou by modifying insect levels, food abundance (primary productivity), snow depth and hardness, predator numbers (and alternative prey), and burns (Sharma et al. 2009; Vors and Boyce 2009). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

Duration of the impacts to caribou, and the associated impacts on human use of caribou, represents a primary component of uncertainty in predictions of environmental significance. In particular, the amount of time required for the impacts to become reversed following closure was estimated to be within one caribou life span (total duration of impacts is two caribou life spans). This prediction assumes that the magnitude and geographic extent of the cumulative impacts from development on caribou population size and distribution have not been underestimated. Throughout the caribou assessment, conservative estimates were used in conceptual and quantitative models to increase confidence that impacts were not underestimated (see Sections 7.5, 7.6, and 7.9). Input parameters for models were based on the most recent and best available information. Similarly, the spatial boundary of the assessment (effects study area) was based on the calculated seasonal ranges of caribou, and included all known previous, existing, and future developments.

Barren-ground caribou populations have natural cycles of high and low numbers, and their distributions change through time (Adamczweski et al. 2009; Tlicho Government and ENR 2010; Tyler 2010). Currently, the Bathurst herd may be nearing the end of the decline phase of the population cycle, and recently, has displayed encouraging signs of increased recruitment to the population (Adamczweski et al. 2009). Populations have also declined in other caribou herds across the Arctic on ranges with little human development (R. Case and R. Morrison, ENR biologists, unpublished data). For example, the Cape Bathurst herd declined from 17,500 in 1992 to an estimate of 1,800 in 2006. The Bluenose West herd declined from an estimate of 74,000 in 2000 to 18,000 in 2006, and the Bluenose East herd declined from an estimate of 104,000 in 2000 to an estimate of 66,200 in 2006. A recent post-calving survey of the Bluenose East herd in 2010 estimated that the population has increased to 98,600 animals.

The weight of evidence from the analysis of the primary pathways predicts that the incremental impacts from the Project and cumulative impacts from the Project and other developments will not have a significant negative influence on the resilience and persistence of caribou populations. Most of the incremental and cumulative impacts were predicted to be negligible to low in magnitude and reversible. The persistence of caribou herds during large fluctuations in population size indicates that the species has the capability to adapt to different disturbances and environmental selection pressures (Holling 1973; Gunderson 2000; Walker et al. 2004). Migration routes, and survival and reproduction rates appear to have the flexibility to respond to changes through time and across the landscape. This resilience in caribou populations suggests that the impacts from the Project and other developments should be reversible and not significantly affect the future persistence of caribou populations. Subsequently, cumulative impacts from development also are not predicted to have a significant adverse effect on continued opportunities for use of caribou by people that value the animals as part of their culture and livelihood.

7.9 UNCERTAINTY

The purpose of the uncertainty section is to identify the key sources of uncertainty and to discuss how uncertainty has been addressed to increase the level of confidence that the impacts are not worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- model inputs (e.g., survival and reproduction rates);
- incomplete understanding or simplified representation of a system being modelled either numerically (e.g., caribou population model), or conceptually (e.g., behavioural response to a stressor);
- understanding of Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence caribou); and
- knowledge of the effectiveness of the environmental design features (i.e., mitigation) for reducing or removing impacts (e.g., revegetation of habitat).

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and current knowledge of the system. It is anticipated that the baseline data is sufficient for understanding current conditions and future changes not related to the Project, and that there is a moderate to high level of understanding of Project-related impacts on the ecosystem. During the past 10 to 12 years, monitoring studies at operating diamond mines, and government and university research programs have provided good information on the Bathurst caribou population and development-related effects. Traditional knowledge studies and recommendations from elders about how to mitigate impacts from roads and other mine facilities has also increased during this time. This information increased the confidence in model inputs, caribou-Project interactions, and the understanding of the success of mitigation policies and practices for limiting impacts to caribou. Although direct disturbance to habitats from development footprints were calculated to represent less than 1% per habitat type and seasonal range, there remains a high degree of uncertainty in the effectiveness of revegetation techniques for reversing the impact of direct disturbance from development to wildlife habitat.

7.9.1.1.1 Reasonably Foreseeable Developments

Adding to the challenges of understanding complex systems is the difficulty of forecasting a future that may be outside the range of observable baseline environmental conditions such as factors related to climate change (Walther et al. 2002). Potential future developments such as the Taltson Hydroelectric Expansion Project and East Arm National Park also generate uncertainty in impact predictions.

The Taltson Hydroelectric Expansion Project will be a transmission line linking the Twin Gorges hydroelectric station on the Taltson River with the existing and proposed mines north of Great Slave Lake. The transmission line would be about 700 km long. Infrastructure required for the Taltson Hydroelectric Expansion Project includes the placement of transmission towers, several substations, and the clearing of a 30 m corridor in areas where trees have the potential to interfere with the transmission line. The magnitude of incremental changes to caribou habitat quantity and quality from the Taltson Hydroelectric Expansion Project was predicted to be negligible to low. Most impacts from the Taltson Hydroelectric Expansion Project should be associated with localized changes in movement and behaviour of caribou during the construction phase.

The proposed national park at the East Arm of Great Slave Lake is representative of the North Western Boreal Uplands. At its closest point, the study area for the proposed park comes to within 1 km of the Project. Depending upon the length of time for the feasibility study, and the time to negotiate the remaining stages of the park planning process, the proposed East Arm National Park may not be created until the Project is well into the operations phase. There is also uncertainty in predicting the status of the existing fishing and hunting lodges and camps in the proposed park. The assessment assumes that the existing lodges would no longer allow hunting, but would remain as tourist lodges. Overall, the proposed East Arm National Park would likely be beneficial to caribou from a conservation perspective.

There are four additional reasonably foreseeable developments that could affect caribou population size and distribution:

- Yellowknife Gold Project;
- Nechalacho Project;
- Damoti Lake Gold Project; and
- NICO Project.

Except for the Taltson Hydroelectric Expansion Project (for which the anticipated footprint is known), effects analyses for the future case are mostly qualitative due to the large degree and number of uncertainties. There are uncertainties in the direction, magnitude, and spatial extent of future fluctuations in the abiotic and biotic components of the environment, independent of Project effects. There are also uncertainties associated with the rate, type, and location of developments in the seasonal ranges of caribou. For example, the Yellowknife Gold Project (Tyhee NWT Corporation), and the Damoti Lake Gold Project (Merc International Minerals Inc.) currently have no operation start date, an assessment of the economic feasibility of the project or a mine plan. Life spans of the proposed developments may range from 8 to 18 years or longer.

Impacts from the Yellowknife Gold Project and the Nechalacho Project (Avalon Rare Metals Inc.) are difficult to anticipate, but may be negligible in magnitude and may specifically impact the behaviour and movement of animals in their autumn and winter ranges. The Yellowknife Gold Project is located 90 km north of the City of Yellowknife on the former Discovery Mine site, an existing contaminated area (Tyhee 2010, internet site). Access would be via the Winter Access Road route and by air. Use of a pre-existing footprint and transportation infrastructure would be a key design feature that will assist with limiting impacts to caribou. For the Nechalacho Mine, a rare elements deposit, the footprint will be limited by using underground mining. This property will be located approximately 100 km southeast of the City of Yellowknife near Hearne Channel on the East Arm of Great Slave Lake. A key design feature for limiting the reduction in caribou habitat quality and quantity will be the use of Great Slave Lake for transportation. Mining products will be loaded into bulk transport containers, hauled to the seasonal dock facility along the north shore of Great Slave Lake and barged during the summer to a purpose-built hydrometallurgical plant, possibly located near the site of the old Pine Point mine on the south shore of Great Slave Lake (Avalon 2010 internet site).

The property for the Damoti Lake Gold Project is located approximately 20 km south of the Colomac Mine (Merc 2010, internet site), and will be accessed via the winter road to Colomac and Wekweètì. As the Project is currently in the exploration stage and a mine plan has not yet been developed, there is uncertainty regarding the size and duration of the Project. However, the impact of this development may be similar to that anticipated for the NICO Project (Fortune Minerals Ltd.). The NICO Project is a cobalt, gold and bismuth deposit located in the Tłįchǫ region, approximately 50 km northwest from the community of Whatì. Mining will follow open-pit and underground methods. The NICO Project would require an all-season road connection to Highway 3 near Behchokǫ̀. Gold would be extracted from the ore at the NICO site, but cobalt and bismuth concentrate would be trucked to a purpose-built smelter in Saskatchewan (Fortune 2010, internet site). The NICO Project is currently undergoing an environmental assessment by the MVEIRB. It is anticipated that most impacts to wildlife populations should be negligible-to-low in magnitude.

7.9.1.1.2 Ecological Conservatism

Understanding and predicting the behaviour of populations within ecosystems requires the aggregation and simplification of available knowledge, retaining what is essential and disregarding that which is not essential at the particular scale of interest. Ecological models (conceptual or quantitative) represent an attempt to create a simplified approximation of reality that can be used as a predictive tool. These models are essential for anticipating how caribou may respond to a changing landscape, and for predicting residual impacts from the Project and other developments. However, the complexity of the dynamics of populations and the environment means that processes are not completely reducible to their components, and that predictions contain uncertainty (Boyce 1992; Walther et al. 2002; Wu and Marceau 2002).

A critical approach to this assessment was to link spatial patterns of the natural and human-developed landscapes to the population dynamics of caribou. Conceptual and quantitative habitat models were used to determine the direct and indirect changes from development on caribou habitats. An energetics model estimated the impacts of zones of influence, development-related disturbance events, and insect harassment on the behaviour and calf production in individual female caribou. Results from these models were used as input parameters in a population model. The population model was used to determine the relative contribution of the cumulative effects from development, incremental effects from the Project, and other factors (insects, extreme weather events, and harvesting) on changes in caribou population size and persistence.

Although quantitative and less biased than habitat models based on expert opinion, the RSF-based habitat maps used in this assessment have sources of uncertainty. These include the structure of the models, the accuracy and precision of underlying data layers, and biases associated with the chosen GIS algorithms (Burgman et al. 2005). Further, habitat maps were a static view between caribou and the environment, ignoring changes over time with ecological succession and natural disturbances such as climatic events. However, sources of uncertainty were reduced by using multiple habitat mapping methods (Burgman et al. 2005) and population viability analysis. For example, the assessment included both fragmentation analyses and the use of habitat quality models, which together limit bias and imprecision in predictions. In addition, the following conservative assumptions were applied to the habitat models:

- footprint (area of direct habitat disturbance) for all exploration sites was a 500 m radius (78.5 ha);
- a 5 km ZOI was applied to all active exploration permits for the entire five-year period, and over the entire year;
- a 15 km ZOI was applied to all active mine sites (including the Project), regardless of the size of the footprint or the level of activity for each mine; and
- disturbance coefficients (used for reducing habitat quality in the zones of influence) with the greatest effect were applied in cases where zones of influenced overlapped, rather than using the average of two or more coefficients.

Ecologically conservative assumptions and factors also were applied to the energetics and population models:

- The average time caribou spend in a ZOI (residency time) was used to estimate the number of major disturbance events caribou receive during summer and autumn. This value was higher than the estimated number of encounter rates with zones of influence.
- A major disturbance event from development that resulted in the loss of body weight in females was assumed to occur once per day while the animal was within the ZOI. This assumption was applied to all individuals in the ZOI, regardless of how close they were to a project. Thus, even an animal that was 15 km away from a mine was considered

to have been influenced by a major disturbance event that resulted in a decrease in body condition.

- Animals do not become accustomed (habituated) to repeated encounters with similar types of disturbances. Thus, each time an individual comes near a drill rig or hears a helicopter, they have the same response, which is to run, become excited, and lose body weight.
- Reductions in body weight from encounters with development or insect harassment are not compensated for by an increase in food intake. In other words, once an animal loses weight from insect harassment or an encounter with a ZOI, the individual does not gain back the weight (during summer and fall) by increasing the amount or quality of food eaten.
- Large variances in parameters were used in the population model to account for uncertainty in the estimates, and temporal changes in previous and future environmental conditions. This can result in either underestimating population growth or overestimating population decline.

Thus, throughout the caribou assessment, conservative estimates were used in conceptual and quantitative models to increase confidence that impacts were not underestimated. In addition, the spatial boundary of the assessment (geographic extent) was based on the calculated seasonal ranges of caribou, and included all known previous and existing developments that may influence the population. Within seasonal ranges, smaller scale impacts were also modelled such as individual responses to estimated zones of influence. The temporal scale ranged from a few days within zones of influence around projects to changes in habitat and other environmental factors (insects, hunting), and population parameters during the past 12 to 14 years. All of these attributes provide confidence that the assessment has not underestimated the environmental significance of the incremental and cumulative impacts from the Project and other developments on caribou, and the people that value caribou as part of their culture and livelihood.

7.10 MONITORING AND FOLLOW-UP

Upon approval of the Project, a wildlife effects monitoring program (WEMP) will be implemented to test impact predictions and reduce the level of uncertainty related to each prediction. The principal goal of the WEMP is to provide information required for the Project's Environmental Management System to adaptively manage the Project to protect wildlife and wildlife habitat. In this context, data collected on measurement endpoints will be used to evaluate the impacts from the Project on the persistence of caribou populations, and the continued opportunity for traditional and non-traditional use of caribou (i.e., assessment endpoints). Based on the definitions of monitoring in the Terms of Reference (Section 3.2.7, Gahcho Kué Panel 2007), the WEMP would consist of environmental monitoring and follow-up programs.

Measurement endpoints for testing impact predictions (i.e., monitoring effects) from the Project will likely include:

- direct habitat effects (changes in habitat quantity from Project footprint);
- indirect habitat effects (changes in habitat quality, and animal abundance and distribution from sensory disturbance within the predicted ZOI); and
- direct mine-related mortality (i.e., number of interactions, injuries, mortality) linked to Project infrastructure and activities.

Specific objectives of the WEMP would be:

- to verify the accuracy of impact predictions made in the EIS, and identify unanticipated effects;
- to implement a wildlife effects mitigation and management plan designed to reduce the risks and disturbance to wildlife and wildlife habitats;
- to determine the effectiveness of the wildlife effects mitigation and management plan;
- to consider and incorporate, where possible, TK into the WEMP;
- to design studies and data collection protocols that are consistent with other monitoring programs in the Arctic (e.g., Snap Lake Mine, Diavik Diamond Mine, and Ekati Diamond Mine), and can be used to understand and manage cumulative effects, and participate in regional and/or collaborative programs;
- to develop and review the WEMP in collaboration with the ENR, Canadian Wildlife Service (Environment Canada), and the communities; and
- to provide an annual report that will satisfy all interested and concerned stakeholders, and will provide the opportunity for feedback from communities, governments, and the public.

Species selected for effects monitoring would be based on recent and current environmental assessments and monitoring programs in the NWT and Nunavut, and would likely include caribou. Following the principals of adaptive management, species selected for monitoring may be periodically reviewed by government, community, and regulatory agencies, and changed as necessary.

Similarly, study designs and sampling protocols would follow the current methods accepted for monitoring effects on wildlife and habitat at mine sites in Nunavut and the NWT. By consistently using standardized and up-to-date methods, direct comparisons can be made among projects that differ in the spatial extent of the footprint and level of mining activity. Such a meta-analysis can be used to help understand and manage the cumulative effects from development on wildlife population size and distribution.

The WEMP represents an adaptive approach to understanding the effects of the Project on the landscape and the species that live there. In this context, the WEMP is considered as a continually evolving process that relies not only on the efficiency of data collection and analytical results, but is also dependent on feedback from the communities, government, and the public. Having an adaptive and flexible program allows for appropriate and necessary changes to the design of monitoring studies, and the mitigation and management plans. Some changes may come about through the observation of unanticipated effects. Other changes may result from ecological knowledge acquired through working with Aboriginal community members.

De Beers is committed to considering and incorporating TK into the WEMP. The incorporation of TK would occur throughout all stages of the WEMP, including identification of mitigation practices and policies, data collection, and follow-up programs to obtain feedback Results of any relevant community-based monitoring studies would be incorporated into the annual WEMP report (with permission from the communities). As with all aspects of the WEMP, the incorporation of TK would be a continuously evolving process.

Community members will be invited to participate in data collection programs. This includes specific species monitoring programs (e.g., surveys for caribou, grizzly bears, and wolverine). The involvement of community members in field data collection is expected to contribute to overall efficiency as well as provide feedback and ideas. For example, sampling methods may be changed based on knowledge of wildlife behaviour or ecology provided by community participants during the field programs. Where appropriate, elders may be brought on site to further contribute to field monitoring programs.

7.11 REFERENCES

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7.12 ACRONYMS AND GLOSSARY

7.12.1 Acronyms

CCME	Canadian Council of Ministers of the Environment
CI	confidence interval
dBA	A-weighted decibels
dBL	linear decibels
DC	Disturbance coefficients
De Beers	De Beers Canada Inc.
DKFN	Deninu Kué First Nation
EIS	Environmental Impact Statement
ELC	Ecological Landscape Classification
ENR	Environment and Natural Resources
FMR	fasting metabolic rate
GIS	geographic information system
GNWT	Government of the Northwest Territories
IHI	insect harassment index
INAC	Indian and Northern Affairs Canada
L_{eq}	equivalent continuous sound and noise level
LKDFN	Łutselk'e Dene First Nation
L_{max}	maximum sound and noise level
LSA	Local Study Area
max	maximum
min	minimum
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N	sample size
n/a	not available
n/c	not collected
NAG	non-acid generating
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
NRCAN	Natural Resources Canada
NTDB	national topographic database
NWT	Northwest Territories
P	probability
PAG	potentially-acid generating
PAI	potential acid input
PHDs	potential harassment days
PK	Processed Kimberlite
PKC	Processed Kimberlite Containment
PM	particulate matter

$PM_{2.5}$	fine particles in the (ambient) air 2.5 micrometres or less in size
Project	Gahcho Kué Project
PVAs	Population viability analyses
RSA	Regional Study Area
RSF	resource selection function
SD	standard deviation
SE	standard error
SGP	Slave Geological Province
SO_2	sulphur dioxide
Terms of Reference	*Terms of Reference for the Gahcho Kué Environmental Impact Statement*
TK	traditional knowledge
TLU	traditional land use
TSP	total suspended particulate
VC	valued component
ZOI	zone of influence

7.12.2 Units of Measure

%	percent
$\chi 2$	chi-square
<	less than
>	greater than
±	plus or minus
#	number
°C	degrees Celsius
µg/m3	micrograms per cubic metre
ha	hectare
keq/ha/y	kiloequivalent per hectare per year
kg	kilograms
kg/ha/y	kilograms per hectares per year
km	kilometre
km^2	square kilometres
m	metre
m/h	metres per hour
m/s	metres per second
MJ	Mega Joules
MJ/kg	Mega Joules per kilogram
MJ/kg/h	Mega Joules per kilogram per hour
MJ/kg/km	Mega Joules per kilogram per kilometre
mm/s	millimetres per second

7.12.3 Glossary

Activity budget scan sampling	A common technique used to quantify the activities of individual animals. A group of animals is scanned and the behaviour of each individual is recorded.
Aggregated Populations	An ecological term for dispersion in which the individuals of a species are closer together than if they were randomly dispersed.
Ambient air	The surrounding air of the environment, open or outdoor air.
Annual home range	The area traversed by animals in its normal activities of food gathering, mating and caring for young. Occasional sallies outside the area, perhaps exploratory in nature, should not be considered part of the home range. An alternative, statistical explanation is the smallest sub-region which accounts for a specified proportion of its total utilization over the course of the year.
Anthropogenic	Human-related, often referring to an activity, development or disturbance on the landscape.
Asymptote	The point where a curve levels off and become flat, the threshold of a curve. Indicates the critical distance of a response or the zone of influence.
A-weighted decibel	A unit of sound or noise that has been filtered so the result is similar to the frequency response of the human ear.
Barren kimberlite	Kimberlite that does not contain diamonds.
Baseline	The case that includes existing environmental conditions as well as existing and approved projects or activities, prior to the construction of the Project in question, acts as reference against which data from construction and operational phases of development will be compared.
Berms	a level space, shelf, or raised barrier separating two areas
CALPUFF	California puff model, a air quality model used to develop a three-dimensional meteorological parameters field to emulate the spatial transport, dispersion and chemical transformation of emitted substances.
Calve	Birth, caribou give birth (calve) their calves in the spring on the calving grounds
Carnivore	An animal that preys on other animals; especially any mammal of the Order Carnivora including wolves, bears, and wolverine.
Carrying Capacity	The maximum population of a given organism that a particular environment or habitat can sustain; implies continuing yield without environmental damage.
Coefficient of Variation for Patch Area	The ratio of standard deviation divided by the mean for a given sample; used to measure the spread of the data or the distribution around the mean for patch area.
Conifers	Trees which produce their seeds in cones and have needles; evergreens such as pines, firs, spruces, or larches.
Country foods	traditional foods obtained through hunting, fishing, or other traditional methods (including caribou, muskox, fish, and birds).
Covariate	An independent variable, or predictor variable, in a statistical model. Also, a secondary variable that can affect the relationship between the dependent variable and independent variables of primary interest in a statistical model.
Cratering	When caribou dig down through snow and ice to access lichen.

Critical load	A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.
Drawdown	A lowering of the water level in a reservoir or other body of water.
Drumlins	A long narrow hill, made up of till, which points in the direction of the glacier movement.
Ecozone	A broad level biogeographical division as part of an ecological land classification (ELC) used across Canada that describes a given set of environmental and ecological conditions that function as a unique system as they are often separated from other ecozones by geographic or climatic barriers. The ecozone most relevant to the Project is the Taiga Shield.
Endogenous reserve	Energy reserves stored within the body, generally as lipids (fat) or protein (muscle).
Energetics	Refers to the metabolic rate and energy consumption of a given animal. Energetics are often measured based on behavioural observations of animal activity and proportion of time spent doing different activities (e.g., resting, walking, running, feeding) and are presented as an Energy Budget, typically a pie chart.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental impact of a project.
Esker	Linear structures of loose sand and gravel, formed by glacial rivers. They provide critical habitat for carnivores and ungulates in the arctic.
Eutrophication	The process whereby a body of water becomes rich in dissolved nutrients through natural or man-made processes. This often results in a deficiency of dissolved oxygen, producing an environment that favours plant over animal life.
Exposure ratio	Health risks are estimated by comparing the predicted exposure(s) to the acceptable toxicity reference values. For threshold-acting contaminants, the human and non-human risk estimate is expressed as an exposure ratio (ER). ER = (predicted exposure)/(exposure limit).
Fecundity	Fecundity rates were a function of the annual natality rate (i.e., birth rate) multiplied by adult survival rate
Focal individual sampling	A behavioural sampling technique where a single animal (the focal individual) is observed closely and all behaviours recorded for a standardized amount of time.
Freshnet	A sudden overflow of a stream caused by heavy rain or nearby thawing of snow or ice.
Friction modelling	A type of optimal path analysis that deals with finding the least-cost route between two locations, based on the measurements of resistance or friction related to physical or environmental conditions. It is a type of GIS model often used when the application requires finding a path across a terrain that may not have any predefined paths. Also known as least cost path analysis.
Fugitive dust	Particulate matter suspended in the air by wind action and human activities.
Glaciofluvial deposits	Glaciofluvial deposits were left behind by rivers that helped drain melting glaciers.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.

Habitat	The physical space within which an organism lives, and the abiotic and biotic entities (e.g., resources) it uses and selects in that space.
Habitat fragmentation	A process by which habitats are increasingly subdivided into smaller units, resulting in their increased restriction as well as an overall loss of habitat area and biodiversity.
Headwater	The source or upper part of a stream or river; where a river begins
Heath tundra	A closed mat plant community that grows on moderate to well-drained soils, covering most of the upland areas. Plants generally belong to the heath family, the Ericaceae. The vegetation layer forms a mat of low shrubs dominated by dwarf birch and Labrador tea.
Inukshuks	A stone landmark, or rocks piled up to look like a person from a distance, used as a milestone or directional marker by the Inuit of the Canadian Arctic.
Kames	Steep-sided mounds of stratified material deposited against an ice-front.
Key Line of Inquiry	Areas of the greatest concern that require the most attention during the environmental impact review and the most rigorous analysis and detail in the environmental impact statement. Their purpose is to ensure a comprehensive analysis of the issues that resulted in significant public concern about the proposed development.
Keystone species	A species that plays a larger or more critical role in supporting the integrity of its ecological community or in maintaining ecosystem function than would be predicted based on its abundance.
Landscape	Mosaic of patches that differ in ecologically important properties.
Least cost path analysis	A type of optimal path analysis that deals with finding the least-cost route between two locations, based on the measurements of resistance or friction related to physical or environmental conditions. It is a type of GIS model often used when the application requires finding a path across a terrain that may not have any predefined paths. Also known as friction modelling.
Lichen veneer	A continuous mat of lichen that appears as a "veneer". These sites are windswept and dry, allowing very little other plant growth. Lichen veneer consists mainly of Iceland moss, several other species of Cetraria, green and black hair lichens, grey mealy lichen, worm lichens and other species.
Mean encounter rates	Average number of times (encounters) a caribou collar location occurs within a zone of influence associated with a given development (e.g., mine, exploration camp, etc).
Open-water season	Summer season when lakes, rivers and streams are free of ice (generally June or July to October).
Outliers	Data points that fall outside of a given trend line and associated confidence interval, but are part of the original dataset and can have a strong influence on the trend line.
PAH	Class of large aromatic molecules composed of several benzene rings fused together; a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances.

PAI	Potential Acid Input (PAI) is an air quality indicator (calculated from numerous atmospheric, ground/vegetation surface characteristics, and chemical variables – all requiring model input assumptions, or actual field sampling and analysis and measurements) to collectively express the acidification potential resulting from sulphur (mainly SO_2) and nitrogen (mainly NO_X) depositions to water and soil, including the countering acidification effects of alkaline constituents in the exhaust and in the ambient air. PAI is not a directly measurable property of emissions or ambient air characteristics.
Parturient	Of or relating to or giving birth.
Patch	A particular unit of habitat with identifiable boundaries that differs from its surroundings in one or more ways. These can be a function of vegetative composition, structure, age or some combination of the three.
Peat bog	Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks. Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.
Point location or satellite location	Refers to the specific location in space, generally denoted by GPS coordinates. Satellite telemetry tracks the movements and locations of animals remotely when GPS locations from the collar are transmitted to a satellite and then downloaded to a computer.
PVA	Population viability analysis is a comprehensive analysis of the many environmental and demographic factors that affect survival of a population. It brings together species characteristics and environmental variability to forecast population health and to ensure that the population of a species is self-sustaining over the long term.
Quadratic term	A variable that is squared (i.e., distance^2 is a quadratic distance variable that is used to determine the critical threshold of caribou distribution and results in an estimate for the zone of influence).
Recruitment	The influx of new organism members into a population due to reproduction (i.e., the number of caribou calves born and surviving to reproductive age).
Regression Analysis	A statistical technique used to determine the relationship between a response (dependent) variable and one or more explanatory (independent) variables.
Resource Selection Models or resource selection functions (RSFs)	Statistical functions that quantify the relationship between the observed distribution of a focal species and covariates representative of habitats and human disturbance. The models are used to identify critical resources for animal populations and to predict species occurrence. Typically, the model consists of a number of coefficients that quantify selection for or avoidance of some environmental feature.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Runoff	The portion of precipitation or irrigation water that moves across land as surface flow and enters streams or other surface receiving waters.
Rut	A general term that refers to the breeding period of mammals, especially the ungulates. During the rut, males exhibit specific behaviours to establish harems or to attract females to mate with.

Seasonal home range	The area traversed and/or used by animals in its normal activities during a specific season (e.g.: the calving range is used when cows give birth, the rutting range is the area used during the breeding season).
Sedge	A grass-like plant with a triangular stem often growing in wet areas. Sedge wetland habitats are typically wet sedge meadows and other sedge associations of non-tussock plant species. Sedge species such as *Carex aquatilis* and *C. bigelowii*, and cotton grass (*Eriophorum angustifolium*) are the dominant vegetation types. Plant species occupy wet, low lying sites where standing water is present throughout much of the growing season.
Sedimentation	The process by which suspended particles in waste water settle to the bottom
Sensitive	1. Sites or organisms that are particularly vulnerable to harmful effects. 2. A general status rank for a species with one or more of the following indicators: a small population size or restricted distribution, a declining population trend and/or moderate threats to its population of habitats. 3. in statistics, parameter sensitivity refers to a series of tests in which different parameter values are set to see how a change in the parameter causes a change in the dynamic behaviour of the system in question (e.g., how much does a change in adult female survival affect population growth of a caribou herd).
Standard deviation (SD)	A measure of the spread or dispersion of a set of data. It is calculated by taking the square root of the variance.
Standard error (SE)	A measure of the sampling variability or precision of an estimate. The SE of an estimate is expressed in the same units as the estimate itself. It is calculated as the standard deviation divided by the square root of the number of observations.
Stochastic	Involving or containing a random variable or variables; involving chance or probability.
Swale	An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water.
Tailings	Residue of raw material or waste separated out during the processing of mineral ores.
Terms of Reference	Written requirements governing environmental impact assessment implementation, consultations to be held, data to be produced and form/contents of the environmental impact assessment report.
Till	Unstratified soil deposited by a glacier; consists of sand and clay and gravel and boulders mixed together.
Total Edge	The perimeter of a patch, or the total distance of the edge of a patch of habitat.
Traditional Knowledge	The knowledge, innovations, and practices of indigenous people; refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities.
Traditional Land Use	The practices and traditions of land use and resource harvesting by regional, indigenous, and local communities.
Treeline	An area of transition between the tundra and boreal forest to the south.
Tundra	A type of ecosystem dominated by lichens, mosses, grasses, and woody plants; a treeless plain characteristic of the arctic and subarctic regions.

Tussock - hummock	A tussock is a tuft of grass or grasslike plants like sedges. Tussock –hummock refers to a type of tundra consisting of acre upon acre of sedge tussocks, usually located on flat, poorly drained land or gentle slopes.
Ungulate	A hoofed, grazing mammal (e.g., caribou, muskox, deer, moose).
Upland areas	Ground elevated above the lowlands along rivers or between hills; highland or elevated land; high and hilly country.
Valued Component	Represent physical, biological, cultural, and economic properties of the social-ecological system that are considered to be important by society.
Vegetation type	Habitat types classified based on the plant community present.
VOCs	Volatile Organic Compound (that boils below a temperature of about 100°C), excluding methane.
Watershed	A region draining into a river, river system, or other body of water.
Wetlands	An area of land where the water table is at or above the mineral soil for the entire year.
Yearling	An animal in its second year.
Young-of-year	An animal younger than one year of age (i.e., born within the year).
Zone of Influence	The surrounding area of a development site in which animal occurrence is reduced, possibly due to avoidance of sensory disturbances or low-quality habitats.

APPENDIX 7.I

WILDLIFE EFFECTS MITIGATION AND MANAGEMENT PLAN

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7.I.1 INTRODUCTION

7.I.1.1 CONTENT AND OBJECTIVES

This draft Wildlife Effects Mitigation and Management Plan outlines the policies, practices, designs, and procedures that De Beers Canada Inc. (De Beers) plans to implement to reduce Project-related effects to wildlife abundance and distribution at the Gahcho Kué Project (Project). The intent is to reduce effects to wildlife populations, and maintain safety for wildlife and humans. The Wildlife Effects Mitigation and Management Plan has three audiences: people and communities with concerns about Project effects to wildlife, government agencies that enforce environmental regulations; and De Beers environmental staff who carry out the mitigation. The effectiveness of mitigation and management practices and policies is determined through the annual analysis of the wildlife effects monitoring program. The Wildlife Effects Mitigation and Management Plan is conceptual at this stage, and detailed Operating Procedures and data sheets would be developed during the Project permitting stage. The objectives of this draft document include the following.

- To provide an initial list of mitigation and management policies, designs, practices and procedures to limit Project-related effects to wildlife.
- To provide a means for regulators and communities to participate in the development of mitigation relevant to wildlife.

It is essential that communities are involved with wildlife mitigation and monitoring so that they can judge for themselves how well De Beers is doing at reducing effects to wildlife, and finding additional ways to improve environmental effects management. This will be achieved by:

- developing mitigation, management, and monitoring plans that include input from communities;
- hiring local residents as environmental staff;
- ongoing visits to the Project by community representatives; and
- providing continuous updates to communities as the Project progresses.

The final Wildlife Effects Mitigation and Management Plan will contain the following elements:

- lessons learned from other operating mines in the region;

- consideration and incorporation of traditional knowledge, and responses from other individuals and organizations with an interest in the Project;
- mitigation and management policies, designs, practices, and procedures to reduce the risks and disturbance to wildlife and wildlife habitat;
- detailed written instructions on mitigation practices and procedures for environmental staff; and
- regular review of the mitigation and Operating Procedures during feedback from communities, government, environmental staff, and the results of the wildlife effects monitoring, and subsequent implementation of changes to current procedures and/or additional mitigation (i.e., adaptive management).

7.I.1.2 SPECIES AT RISK

The Mackenzie Valley Environmental Impact Review Board (MVEIRB) has prepared draft guidelines outlining their expectations for considering effects to species at risk for the environmental effects assessment process in the Mackenzie Valley (MVEIRB 2010, internet site). This includes the need to outline the proposed mitigation and monitoring for all species at risk.

The guidelines also outline the criteria used to determine the species at risk for a project, which includes:

- species listed as Endangered, Threatened, or of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and
- species listed as Endangered, Threatened, or of Special Concern under Schedule 1 of the *Species At Risk Act* (SARA).

Although not required by the guidelines, species listed as At Risk in the General Status Ranks in NWT were also considered.

The resulting list of wildlife species at risk for the Project included two mammals and four birds. In all cases it is the federal COSEWIC listing that lead to the inclusion of the species, as no species considered At Risk in the NWT have been observed in the vicinity of the Project. This indicates that the risk of extirpation for NWT populations of the species is less than populations elsewhere in Canada.

Table 7.I-1 Wildlife Species at Risk for the Project

Common Name	COSEWIC Status[(a)]	SARA Status[(a)]	NWT Status[(b)]
Grizzly bear	special concern	no schedule	sensitive
Wolverine	special concern	no schedule	sensitive
Peregrine falcon	special concern	no schedule	sensitive
Short-eared owl	special concern	schedule 3	sensitive
Rusty blackbird	special concern	schedule 1	may be at risk
Horned grebe	special concern	no schedule	secure

[(a)] Species at Risk Public Registry (2010, internet site).

[(b)] Working Group on General Status of NWT Species (2006).

COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = *Species At Risk Act*; NWT = Northwest Territories.

7.I.2 LIMITING PROJECT EFFECTS TO WILDLIFE

The mitigation and management policies, practices, designs, and procedures that De Beers plans to implement to reduce Project-related effects to wildlife abundance and distribution are collectively referred to here as mitigation. This document divides mitigation into three categories, which are the principal Project-related effects that can influence wildlife populations:

- direct habitat effects;
- indirect habitat effects; and
- direct Project-related mortality.

7.I.2.1 DIRECT HABITAT EFFECTS

Direct effects to wildlife populations includes the physical disturbance and loss of habitat (e.g., upland and riparian vegetation, wetlands, and water), which results in the direct displacement of wildlife. Direct habitat disturbance occurs through the construction of the Project footprint, such as the creation of roads, mine rock piles, core mine facilities, and changing water levels in lakes and streams. Mitigation proposed to reduce direct habitat loss includes the following.

- Keep mine footprint as compact as possible.
- Promote natural re-vegetation and practice progressive reclamation as the mine develops.
- Remediate and close the site when mining operations are complete.

- Backfilling the mined-out pits with processed kimberlite and mine rock will decrease the on-land Project footprint.
- At closure, the entire site area will be stabilized and contoured to blend with the surrounding landscape.
- Maintain downstream flows within baseline levels.

7.I.2.2 INDIRECT HABITAT EFFECTS

Indirect effects to wildlife are associated with changes in habitat quality that can alter the movement and behaviour of individuals. Examples of sensory disturbance variables include dust on vegetation reducing forage quality and noise from the Project leading to avoidance by wildlife. Although habitat is still intact, sensory disturbance can reduce the quality of habitat for wildlife. The mechanisms of indirect effects are poorly understood, but are probably related to dust, noise, smells, lights, human activity, changes in nutrients, changes to vegetation communities, and memory of previous encounters. The following mitigation is proposed to reduce indirect habitat effects to wildlife populations.

- Regular application of water (or alternative dust suppression products) to roads, airstrip, and laydown areas to limit fugitive dust emissions.
- Enforcing speed limits should assist in reducing production of dust.
- Enclose processes that create dust (such as rock crushing), where feasible.
- Maintain a minimum flying altitude of 300 metres (m) above ground level (except during takeoff and landing) for cargo and passenger aircraft outside of the Project site.
- Helicopters will fly above 300 m whenever possible.
- The amount of noise from the mine site will be limited with the use of appropriate exhaust mufflers (i.e., fit diesel generator units with high-performance engine exhaust silencers).
- Limit as many equipment noise sources as possible by locating them inside buildings.
- Establish site rules for recreational walking on and off-site.
- Recreational use of all vehicles will be prohibited.
- Manage all water seepage and effluent from the site to control release of nutrients and contaminants to the environment.
- Environmental sensitivity training for personnel.

7.I.2.3 DIRECT PROJECT-RELATED MORTALITY

Occasionally, mining operations lead to the direct mortality of wildlife. This may be either accidental (such as vehicle collisions with wildlife), or the deliberate removal (re-location or intentionally destroyed) of problem wildlife to protect worker safety. The most effective way to reduce the cases of wildlife mortality is to reduce the availability of food or shelter for wildlife, thus limiting the attraction and presence of individuals within the Project site. Specific mitigation proposed to reduce direct Project-related wildlife mortality includes the following:

- Report all relevant observations of wildlife (particularly caribou, fox, wolverine, and bear) to environmental technicians on-site.
- Communicate presence and location of wildlife on-site through radio.
- Complete land clearing for all facilities outside of the breeding season for migratory birds (15 May to 15 September).
- Prevent upland breeding birds and raptors from nesting on mine infrastructure and man-made structures. If nest is found and eggs are present, then the nest will be monitored and efforts will be made to avoid the area.
- Skirt all buildings to limit opportunities for animals to find suitable shelter.
- Isolate or remove any physical or chemical hazards to wildlife.
- Report to the Department of Environment and Natural Resources (ENR) any raptor nesting activity observed on Project infrastructure or within 1.5 kilometres (km) of the Project.
- Hunting, trapping, harvesting and fishing by employees and contractors will be prohibited.
- Blasting will be temporarily suspended if caribou are within the danger zone.
- Many site buildings will be connected by corridors, reducing the need for staff to go outdoors.
- All wildlife will have the right-of-way on roads.
- Speed limits will be established and enforced.
- Drivers will be warned with signage and radio when caribou are moving through an area.
- At closure, the entire site area will be re-contoured to reduce hazards to wildlife.

- Problem wildlife will only be destroyed as a last resort, and with the approval of ENR.
- Contact ENR to receive additional direction regarding new issues that arise.
- Isolate or remove any physical or chemical hazards to wildlife.

7.I.2.3.1 Management of Toxic Substances

The following are mitigation policies and procedures to decrease the risks to wildlife from ingestion of toxic substances or encounters with toxic spills during all phases of activity on the Project site.

- Adhere to and regularly update the Emergency Response and Contingency Plan.
- Follow the procedures outlined in the Hazardous Material Management Plan.
- Designate and train a spill response team consisting of on-site personnel.
- Provide spill containment supplies at fuel transfer and storage areas.
- Immediately isolate, clean and report any spills.
- Keep spill response equipment readily available and maintained.
- Maintain vehicles and equipment.
- Store fuel in double-walled containers or single-walled containers in lined containment areas.

7.I.2.3.2 Waste Management

Carnivores observed at or near the Project include grizzly bear, black bear, wolf and fox. Carnivores have a keen sense of smell and can be attracted from long distances to a Project if food items are frequently present. This may increase predator numbers and increase predation risk for prey populations. Carnivores are also attracted to aromatic waste material such as oil and aerosols, in addition to infrastructure that can serve as a temporary refuge to escape extreme heat or cold. Further, scavenging birds (particularly gulls and ravens) attracted to a landfill may have an effect on surrounding bird populations (CWS 2007).

Based on the results from monitoring programs for other mining projects in the NWT and Nunavut, it is anticipated that wildlife and waste cannot always be successfully managed. For example, wildlife effects monitoring programs completed at the Ekati Diamond Mine, the Diavik Diamond Mine, the Jericho Diamond Mine, and the Snap Lake Mine have reported attractants in the landfill (such as non-burned food items, oil products, and food packaging). Most of the animals and sign observed during landfill surveys were associated with foxes and gulls. Grizzly bears, wolverine, and wolf tracks were occasionally observed.

The most important element in reducing interactions between the Project and wildlife is preventing carnivores from being attracted to food and food wastes. To reduce this problem, food wastes will be collected from the food waste bins in the accommodations complex, service complex, and other facilities, and then placed in sealed plastic bags. The plastic bags will be stored in sealed containers and transported directly to the incinerator storage area for immediate incineration. Dual-chamber, diesel oil-fired incinerators will incinerate combustible waste, and will be located in a fenced area or inside a building. Inert solid waste (including incinerator ash) will be deposited into a landfill that will be located within a small area of the mine rock pile or processed kimberlite facility. The inert solid waste will be frequently buried to keep it inaccessible to wildlife.

The Waste Management Plan for the Project closely follows the procedures and practices presently in place at the other mines in the region, and incorporates the lessons learned from those mines. The following policies and practices are included in the Waste Management Plan to reduce the numbers of scavenging wildlife (such as carnivores and birds) attracted to the Project, and limit human-wildlife interactions.

- Education and enforcement of proper waste management practices to all workers and visitors to the site.
- Waste management awareness and incentive programs will be implemented.
- Waste will be monitored and the sources of misdirected waste will be identified and managed.
- Training will be provided to on-site personnel about wildlife awareness and safety including the dangers of improper food waste disposal and feeding wildlife.
- Providing designated indoor areas for lunch and coffee breaks for staff working outdoors.
- Separation of food waste and non-food waste through the use of designated garbage cans.
- Food waste and other attractants will be incinerated frequently and regularly to reduce holding time and odours.
- Waste facilities and incinerators will be fenced or enclosed.

- Food waste and non-toxic combustible waste will be burned in oil-fired incinerators, according to the Waste Incineration Guidelines (Environment Canada 2010, internet site).
- Hazardous material will be shipped out for recycling or disposal at an appropriate facility.
- The landfill will be inspected and covered frequently.
- Waste products that cannot be incinerated or landfilled will be collected, sorted, and placed in designated areas within the Waste Management Area until they can be shipped off-site.
- Ongoing monitoring and review of the efficiency of the waste management program and improvement through adaptive management.

7.I.2.3.3 Actively Deterring Wildlife

The goal of wildlife deterrent action is to respond to situations using humane methods that keep both humans and wildlife safe. All deterrent actions start with the least intrusive method, and then increase in intensity. Each deterrent action will stop as soon as the animal moves away from the potentially hazardous site or activity or no longer poses a threat to humans. Deterrents may be used to remove wildlife from roads, airstrip, and potentially hazardous sites and activities. The intensity of the deterrent practice should increase only if previous steps are unsuccessful, and if warranted by the risk to staff or wildlife.

Wildlife deterrent actions will be performed only by designated individuals (such as the environmental monitors or security staff). Designated individuals will be required to hold a valid Canadian Possession-Acquisition Firearms License. Training for these individuals will include the following information:

- basic wildlife ecology and behaviour;
- prevention of wildlife-human encounters;
- contingencies for wildlife-human encounters;
- proper use of deterrents (such as bear bangers and firearms); and
- documenting and reporting any deterrent actions undertaken.

For deterrent actions to be successful there must be:

- knowledgeable, trained personnel who will select deterrent actions based on each situation;
- consistent application of deterrents;

- evaluation of the success of each deterrent action;
- documenting and reporting of deterrent actions to inform other staff, communities and regulatory agencies.
- effective implementation of the Waste Management Plan, particularly as it relates to the disposal of food waste; and
- absence of food, shelter or other rewards for wildlife within the Project site.

7.I.2.3.4 Caribou Protection

It is anticipated that caribou will interact with the Project. Baseline studies predict that the most common seasons for caribou to encounter the Project are during the post-calving migration and rut, approximately from August through to November. Occasionally, actions may be required to move caribou away from areas where they may be at risk. The appropriate level of action for a situation is one that removes the risk with the least disturbance to the caribou. The decision to use deterrent actions for caribou should consider the number of animals, and the potential for risk to caribou and human safety. The following policies, practices, and procedures are specifically related to caribou protection.

- All incidents involving interactions, deterrents or injury of caribou will be documented and evaluated.
- All sightings of caribou will be reported to environmental staff on-site.
- If caribou are crossing Project roads, traffic will stop and wait for them to cross (i.e., caribou have the right-of-way).
- Caribou will only be herded away from roads or the airstrip in specific circumstances, such as when there are incoming flights or an emergency.
- Blasting will be temporarily suspended if caribou are within the danger zone.

Electric fencing, flagging, and inukshuks have been moderately successful at deterring caribou from airstrips and other mine facilities. However, caribou have become entangled in electric fences. At the Ekati Diamond Mine, six caribou have been entangled in the electric fence surrounding the airstrip from 2001 through 2009 and four of these animals died (BHPB 2003, 2005, 2010). At the Diavik Diamond Mine, a caribou became entangled in an electric fence and was killed by a grizzly bear (DDMI 2006). Use of such forms of wildlife deterrent and control will only be implemented with the input from communities.

7.I.3 ON-SITE EDUCATION

To limit effects to wildlife, an education strategy will be implemented that consists of an orientation for site personnel and visitors. All site personnel will be expected to participate in orientation sessions and must be familiar with all operating procedures appropriate to their tasks and responsibilities before starting work.

Spill response team members will be trained and familiar with emergency and spill response resources, including their location and access, the Spill Contingency Plan, and appropriate emergency spill response methods. Team training will be conducted annually so that training remains current. All personnel and contractors at the Project site will be familiar with spill reporting requirements. All fuel handling employees and contractors will be fully trained in fuel transfer procedures, spill prevention and spill response.

Improvements to waste management at the existing mines has occurred through a number of notable changes in waste management practices, and time also been invested in on-going employee education on the hazards of feeding wildlife. Due to seasonal and year-to-year changes in scavengers such as gulls and fox, as well as staff turnover, a continuous program of employee education is required. There will be three stages to this program:

- During site orientation, all new employees and contractors are educated on the hazards of feeding wildlife and the disciplinary consequences of doing so.
- Signage and other reminders will be posted around camp.
- Site environmental technicians offer regular job-site presentations to mine employees, particularly if waste management issues arise.

7.I.4 ADAPTIVE MANAGEMENT

Wildlife monitoring by site environmental technicians will be used to determine the efficacy of the proposed mitigation and management plan. Regular surveys for wildlife presence around the Project site and constant communication with all staff will provide early-warning of wildlife presence on-site, and the opportunity to manage and mitigate situations as they develop to prevent incidents. This will include regular inspections of the landfill, waste storage and transfer areas, asking site staff about wildlife observations, and walking inspections of the Project site to record wildlife and wildlife sign. In this way, environmental staff on-site may correct problems as they arise. There will also be regular annual review and updates as required through the results of the Wildlife Effects Monitoring Program, and regular review and updates to the Operating Procedures, if necessary.

7.I.5 RELEVANT OPERATION PROCEDURES

Operating procedures for equipment operation and conducting regular tasks at the Project site will be developed as Project design proceeds. References to operating procedures relevant to wildlife mitigation and management will be listed in this section.

7.I.6 RELEVANT MANAGEMENT PLANS

The following management plans are also relevant to wildlife management at the Project site:

- Emergency Response and Contingency Plan;
- Hazardous Materials Management Plan; and
- Waste Management Plan.

7.I.7 REFERENCES

7.I.7.1 LITERATURE CITED

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7.I.7.2 INTERNET REFERENCES

Environment Canada. 2010. Technical Document for Batch Waste Incineration. http://dsp-psd.pwgsc.gc.ca/collections/collection_2010/ec/En14-17-1-2010-eng.pdf

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2010. Guidelines for Considering Wildlife at Risk in Environmental Impact Assessment in the Mackenzie Valley. May, 2010. Available at www.reviewboard.ca.

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7.I.8 ACRONYMS AND GLOSSARY

7.I.8.1 ACRONYMS

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
De Beers	De Beers Canada Inc.
ENR	Environment and Natural Resources
MVEIRB	Mackenzie Valley Environmental Impact Review Board
NWT	Northwest Territories
Project	Gahcho Kué Project
SARA	*Species At Risk Act*

7.I.8.2 UNITS OF MEASURE

km	kilometre
m	metre

APPENDIX 7.II

NOISE ASSESSMENT

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7.II.1 INTRODUCTION

7.II.1.1 CONTEXT

The environmental impact statement (EIS) for the Gahcho Kué Project (Project) has been prepared as part of an application by De Beers Canada Inc. (De Beers) to construct and operate a diamond mine at Kennady Lake in the Northwest Territories (NWT). The noise assessment considered the potential sound emissions and resulting ambient noise levels that would occur due to the construction and operation of the Project, including ancillary developments (e.g., Winter Access Road, airstrip).

The purpose of Appendix 7.II is to meet the *Terms of Reference for the Gahcho Kué Environmental Impact Statement* (Terms of Reference) released on October 5, 2007 by the Gahcho Kué Panel (2007). Section 3.1.3 in the Terms of Reference requires descriptions of the following:

- existing sources of noise in the Project area; and
- present noise in terms of frequency, duration, and decibel levels throughout the year.

The assessment presented in this appendix provides data and analyses that support Sections 7, 11, and 12. The following key line of inquiry and subjects of note have identified noise as an effect pathway:

- Key Line of Inquiry: Caribou (Section 7);
- Subject of Note: Traffic and Road Issues (Section 11.8);
- Subject of Note: Carnivore Mortality (Section 11.10);
- Subject of Note: Other Ungulates (Section 11.11);
- Subject of Note: Species at Risk and Birds (Section 11.12);
- Subject of Note: Impacts on Tourism Potential and Wilderness Character (Section 12.7.3); and
- Subject of Note: Proposed National Park (Section 12.7.4).

Summaries of the relevant noise effects to wildlife and people will be provided in the relevant key line of inquiry and subject of note in this EIS. The assessment of noise on the valued components (VCs) and the final determination of environmental consequence and significance on the VCs will be done in the relevant key line of inquiry and subject of note (listed above) with technical information taken from this appendix. Issues related to sensory disturbance and behaviour of VCs will be addressed within the appropriate subject of note in sections 11 and 12, and the effects of noise on caribou are assessed in the Key Line of Inquiry: Caribou (Section 7).

The determination of significance on VCs will not be done in this appendix. The results related to the general amount of change in the acoustic environment potentially caused by Project activities and the effects of noise on the occupants of the worker camp are included in this appendix.

7.II.1.2 PURPOSE AND SCOPE

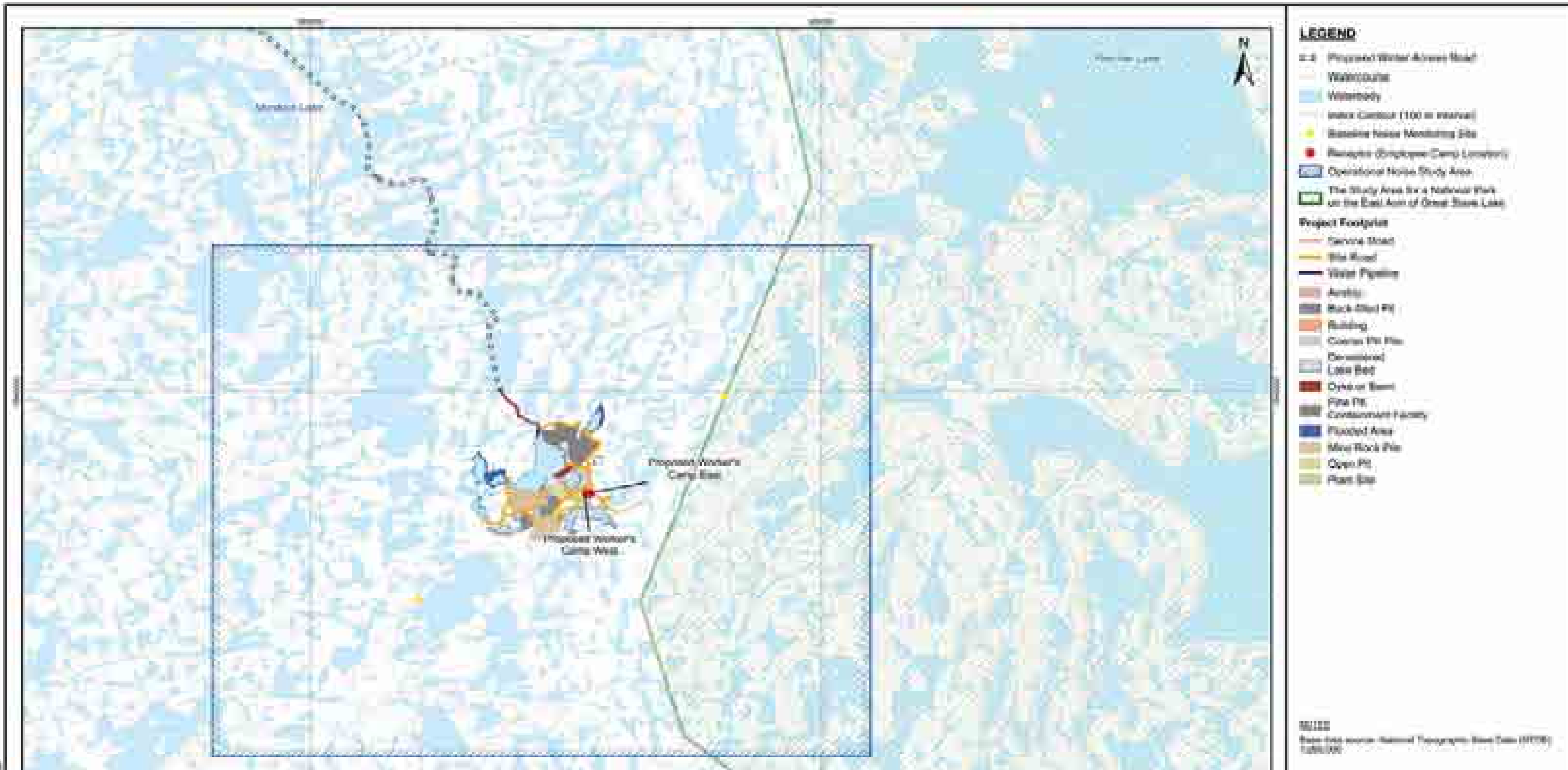
The noise assessment of the Project identifies the sound emissions associated with the Project activities and the potential effects on people and wildlife. Information is provided on existing noise levels in the area as well as the changes expected to result from the Project on a cumulative effects basis. The focus of the noise assessment is on determining changes to the existing ambient noise levels due to Project operations and comparing the results with noise regulations and guidelines from Alberta Energy Resources Conservation Board (ERCB) and World Health Organization (WHO), in the absence of NWT noise regulations.

7.II.1.3 STUDY AREAS

The noise assessment of the Project identified the following three rectangular study areas, two centred on the Project site and one centred on the Winter Access Road:

- Operational Study Area;
- Aircraft Study Area; and
- Winter Access Road Study Area.

These areas are the modelling domains for the noise predictions and were defined to ensure potential noise level changes from the Project and related infrastructure were properly assessed. Noise attenuates with distance and is expected to diminish to below background noise levels before reaching other human development noise sources (e.g. other mine sites). The study areas reflect this and are presented in Figure 7.II.1-1, Operational Noise Study Area, and Figure 7.II.1-2, Aircraft and Winter Access Road Noise Study Areas.



GAHCHO KUE PROJECT

Operational Noise Study Area

Figure 7.II.1-1

LEGEND
Proposed Winter Access Road
Tibbitt-to-Contwoyto Winter Road
Watercourse
Waterbody
Index Contour (100 m Interval)
Baseline Noise Monitoring Site
Receptor (Employee Camp Location)
Aircraft Study Area
Winter Access Road Study Area
The Study Area for a National Park on the East Arm of Great Slave Lake
Project Footprint
Service Road
Site Road
Water Pipeline
Airstrip
Back-filled Pit
Building
Coarse PK Pile
De-watered Lake Bed
Dyke or Berm
Fine PK Containment Facility
Flooded Area
Mine Rock Pile
Open Pit
Plant Site
Proposed Worker's Camp East
Proposed Worker's Camp West
GAHCHO KUE PROJECT
Aircraft and Winter Access Road Noise Study Areas
Figure 7.II.1-2

7.II.1.4 NOISE TERMINOLOGY

Because the assessment of outdoor acoustics is not widely understood, an introduction to the key concepts used in the assessment is provided to aid the reader. The key concepts include the following:

- “Sound” or “sound emissions” refers to the acoustic energy generated by natural or man-made sources, including the Project activities.
- “Noise” or “noise levels” refers to the levels that can be heard or measured at a receiver.
- A noise “receiver” is a location where measurements or predictions of noise levels are made.
- The “volume” of a sound or noise is expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a sound or noise that is twice as loud as another will only be 3 dB higher. A sound or noise with double the number of decibels is much more than twice as loud. A 3 dB change is also the average threshold at which the human ear can detect a change in volume.
- Sound emissions and noise levels also have a “frequency”. The human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear. Environmental noise levels are usually presented as “A weighted” decibels (or dBA), which is a weighting that incorporates the frequency response of the human ear.
- Outdoor noise is usually expressed as an “equivalent noise level” (L_{eq}), which is a logarithmic average of the measured or predicted noise levels over a given period of time. This type of average takes into account the natural variability of sound.
- Short-term noise events such as the passing of a vehicle or an aircraft are described as a maximum noise level (L_{max}) which usually implies the loudest noise level averaged over one minute.
- Short, impulsive noise events such as blasting are described using peak noise levels (L_{peak}) which is the highest instantaneous noise level generated.
- “Sound power level” (L_w) is the level of sound power, expressed in decibels relative to a stated reference value of 10 to 12 watts.

7.II.1.5 CONTENT

Appendix 7.II to Section 7 of the EIS presents the noise assessment for the Project. The headings that follow this section are arranged according to the sequence of steps in the assessment. This section is supported by one technical annex that provides additional details regarding the noise assessment. The following briefly describes the content under each heading of this appendix:

- **Existing Environment** defines the existing environment from a baseline noise survey conducted for the Project and considers future non-Project development in the area (Section 7.II.2).
- **Pathway Analysis** outlines the potential pathways that use information from the noise assessment, summarizes the environmental design features that will reduce noise, and lists the valid pathways (Section 7.II.3).
- **Noise Analysis Methods** outlines the approach and methods used for the prediction of noise from Project-related activities (Section 7.II.4).
- **Project Operations** defines the changes in continuous and short-term noise levels associated with the Project operations (Section 7.II.5).
- **Winter Access Road** presents the modelling results and defines the changes in continuous noise levels associated with the Winter Access Road (Section 7.II.6).
- **Air Traffic Noise** defines the changes in short-term noise levels associated with the airstrip (Section 7.II.7).
- **Blasting Activity** defines the changes in short-term noise levels associated with blasting (Section 7.II.8).
- **Residual Environmental Effects** provides a general assessment of changes in the acoustic environment (Section 7.II.9).
- **Monitoring and Follow-up** discusses any requirements for long-term follow-up or monitoring for noise (Section 7.II.10).
- **References** lists all documents and other material used in the preparation of this section (Section 7.II.11).
- **Glossary, Acronyms, and Units** explains the meaning of scientific, technical, or other uncommon terms used in this section. In addition, acronyms and abbreviated units are defined (Section 7.II.12).

Supporting information for the noise assessment is provided in Annex C (Noise Baseline).

7.II.2 EXISTING ENVIRONMENT

The existing noise levels represent an environmental baseline that describes the noise environment before the addition of noise from the Project. Typically the existing noise contains all of the naturally occurring sounds of the area and may also include noise from human activities typical of the area not related to the Project.

The Project is located in a remote (undeveloped) area where the existing noise will be comprised of the natural sounds of a wilderness area that generally lacks any human activity. The determination of the existing noise is consistent with the assessment approach adopted by ERCB Directive 038 (ERCB 2007) and the draft *National Guidelines for Environmental Assessment: Health Impacts of Noise from Health Canada* (Health Canada 2005).

7.II.2.1 METHODS

Existing conditions were established by monitoring ambient noise at the Project site. A continuous, 24 hour survey of baseline noise was completed at selected sites on June 25 to 29, 2010. Meteorological conditions were also monitored to record wind speed and precipitation concurrently with the noise measurements to determine the validity of the data. Noise measurements gathered could be invalidated when precipitation occurred, humidity exceeded 90 percent (%), or temperature exceeds manufacturer's tolerances (-10 degree Celsius [ºC] to +50ºC) for instrument operation.

This period of monitoring was considered sufficient to capture the characteristics of the existing noise level in the area. There was reasonable uniformity in ambient conditions from one day to the next when meteorological factors likely to affect noise levels were excluded; therefore, sufficient data to establish baseline conditions were collected. The full noise baseline assessment is provided in the Noise Baseline (Annex C).

7.II.2.2 EXISTING CONDITIONS

Baseline monitoring conducted at four locations near the Project site indicated that 24 hour L_{eq} noise levels ranged from 35 to 52 dBA (Annex C Noise Baseline). Slight variation in noise levels was noted between daytime (07:00 to 23:00) and nighttime (23:00 to 07:00) periods, which is consistent with the nature of noise in remote areas. The expected ambient noise levels in undeveloped areas range between 25 to 35 dBA (ERCB 2007). However, noise levels at R2, R3, and R4 locations elevated the measured noise levels due to comparatively higher wind. These were considered typical for summertime conditions in and around the Project area. Table 7.II.2-1 summarizes the existing noise levels. The results indicate the potential for high variability in noise levels with the influence of the natural environment.

Table 7.II.2-1 Summary of Existing Noise Levels, June 25 to 29, 2010

Monitoring Location	Description	Day L_{eq} (dBA)	Night L_{eq} (dBA)	24 Hour L_{eq} (dBA)
R1	proposed East Arm National Park boundary location	36.5	24.9	34.8
R2	proposed Winter Access Road 1.5 km criteria boundary location	43.9	36.3	42.4
R3	7.5 km southwest of exploration camp	48.3	44.9	47.4
R4	exploration camp	54.0	48.9	51.9

dBA = A-weighted decibel; L_{eq} = equivalent continuous sound and noise level.

The baseline measurements were conducted during summer months. Because of instrument limitations, winter condition monitoring could not be conducted. The noise levels measured during summer months are expected to be higher than during winter months due to the increased presence of natural sources such as vegetation (movement) and wildlife. Winter noise levels under similar wind conditions would likely be lower, and are expected to be in the 15 to 20 dBA range (Cacouna Energy 2005). Under higher wind conditions, the noise levels in winter would be similar to those during summer months.

7.II.2.3 LIKELY FUTURE CONDITIONS

In the absence of the Project, future noise levels in the study area are expected to remain the same as existing conditions. No other developments that would be substantial contributors of noise are planned within the study area at this time. The development of a national park extending northeast from the East Arm of Great Slave Lake may occur in the foreseeable future. The boundary of the area of interest is located east of the Project site (Figure 7.II.1-1). Although noise may affect the park if the two developments overlap in time, the park is not expected to be a contributor to cumulative noise effects during the operation of the Project. Therefore, no noise sources are expected to interact cumulatively with Project noise.

7.II.3 PATHWAY ANALYSIS

7.II.3.1 POTENTIAL PATHWAYS

Changes in noise levels themselves are not a primary environmental effect. However changes in noise levels have the potential to affect people and wildlife in the environment.

Activities at the Project site during construction and operation, as well as ancillary activities such as air and winter road traffic, are potential sources of sound. As sound travels through pathways (e.g., air), a change in noise levels may be detected by receivers in the surrounding environment (e.g., wildlife, people). This noise appendix considers the pathway from the sources of sound to the noise levels at varying distances from the sources. The effect on identified wildlife or human receivers (e.g., avoidance of, or attraction to, the site) will be assessed for all relevant VCs (e.g., caribou) in the relevant key line of inquiry (i.e., Section 7) and subjects of note.

Potential Project effects to noise occur during all Project phases, as summarized in Table 7.II.3-1.

Table 7.II.3-1 Potential Environmental Effects to the Acoustic Environment

Activities	Potential Environmental Effects
Construction Materials handling Power generation Ore processing	change in ambient (continuous) noise levels (L_{eq} [dBA])
Blasting Construction Aircraft Winter Access Road traffic	change in short-term noise events (L_{max} [dBA])

L_{eq} = equivalent continuous sound and noise level; L_{max} = maximum sound and noise level; dBA = A-weighted decibel.

7.II.3.2 ENVIRONMENTAL DESIGN FEATURES

During the development of the Project, features were incorporated into the design to reduce or eliminate potential impacts on the environment. These features are incorporated in the Project Description (Section 3). The environmental design features related to noise that reduce or eliminate potential impacts are listed in Table 7.II.3-2. This table also includes the potential environmental effect that has been reduced or eliminated, and a brief explanation of how this is achieved.

Table 7.II.3-2 Environmental Design Features that Reduce Effects Due to Noise

Potential Effect	Environmental Design Feature	Description of Reduction	Residual Effect
Increased noise	terrain changes (mine rock piles and pit depth)	noise is partly blocked by the height of a mine rock pile or by the slopes of the mine pit	noise is partly deflected or reduced due to physical impediment
Increased noise	buildings or other structures	noise is partly blocked by the structures	noise is partly deflected or reduced due to physical impediment
Increased noise	stationary equipment housed inside buildings	noise is contained inside buildings, reducing the amount released into the environment, provided doors are kept closed.	noise reaching the environment is reduced

7.II.3.3 PATHWAY VALIDATION

The analysis of noise in the environment contained in this appendix is a supporting study, providing part of the pathway information for the relevant key line of inquiry and subjects of note where noise has been identified as a valid pathway. Pathway validation discussions for the key line of inquiry and each subject of note listed in Section 7.II.1.1 are found in their respective EIS sections, as listed in Table 7.II.3-3.

Table 7.II.3-3 Noise Pathway Validation Reference List

Pathway	Environmental Impact Statement Section
Key Line of Inquiry: Caribou	7
Subject of Note: Traffic and Road Issues	11.8
Subject of Note: Carnivore Mortality	11.10
Subject of Note: Other Ungulates	11.11
Subject of Note: Species at Risk and Birds	11.12
Subject of Note: Impacts on Tourism Potential and Wilderness Character	12.7.3
Subject of Note: Proposed National Park	12.7.4

7.II.4 NOISE ANALYSIS METHODS

7.II.4.1 NOISE BENCHMARKS

To determine the effect of sounds emitted from the Project, the assessment focused on the incremental change in two key noise indicators:

- The average noise level L_{eq} outside for daytime (07:00 to 23:00) hours and during the nighttime (23:00 to 07:00).
- Maximum noise level from short-term events (L_{max}). This relates to the airstrip only.

Effects are addressed for areas of influence as well as specific receivers of noise.

There are currently no environmental noise regulations or guidelines for the NWT that would be directly applicable to noise impacts from the Project. Although there are several noise guidelines and regulations for community noise levels in jurisdictions across Canada, there are few that are applicable to developments in rural or remote areas. One exception to this is the ERCB Directive 038: Noise Control (ERCB 2007), which includes criteria to prevent uncontrolled noise generation in areas where there are no private dwellings within 1.5 kilometres (km) of a facility fenceline. Directive 038 requires that a target L_{eq} of 40 dBA (including a mandated ambient noise level of 35 dBA for the nighttime period) for continuous noise levels during nighttime hours should be met at a distance of 1.5 km from new facilities in these remote locations, thus allowing a 5 dB increase compared to existing sound levels. For daytime hours, the threshold is set 10 dB higher due to the higher acceptance of noise during daytime hours, and increased human activity. The ERCB criteria are the guidance used for assessment of impacts for the Project. The mandated ambient sound level of 35 dBA is lower than the ambient sound levels that were encountered during the baseline program. Thus, this criterion can be considered fairly conservative.

There are no guidelines or requirements regarding the effects of noise on wildlife.

The ERCB Directive 038 does not provide recommended noise levels for L_{max} levels from noise events, nor does it address living areas for Project personnel in the camp. To address these aspects of noise, WHO guidelines for noise levels to prevent sleep disturbance were used. The indoor L_{eq} limit to prevent sleep disturbance is 30 dBA (WHO 1999), and 45 dBA L_{eq} outside the opened bedroom window, assuming a sound attenuation of 15 dB (WHO 1999). These recommendations typically are applied to 3rd parties such as off-site dwellings. For workers camps (e.g., the accommodation complex), noise criteria other than occupational criteria are not readily available. Worker camps are excluded from ERCB Directive 038, Noise Control.

To conserve heart, northern building construction methods typically include heavily insulated buildings fitted with a minimum of double-glazed windows. This level of construction is expected to provide at least a 25 dB reduction of the exterior noise levels, assuming closed windows. For peak noises L_{max}, the WHO recommends a value in sleeping quarters of not more than 45 dBA. Following the same assumption regarding construction methods and closed windows, this results in an outdoor Leq noise limit near the accommodation complex of 55 dBA with an outdoor L_{max} during an event of 70 dBA during nighttime hours.

Table 7.II.4-1 summarizes the regulatory guidance that will be the benchmarks used to assess noise from the Project.

Should the change in the 24 hour L_{eq} be sufficiently large, there would be potential for noise levels to affect the receiving environment. Therefore predicted noise levels are also compared to the measured baseline value for an estimate of overall change.

Table 7.II.4-1 Noise Benchmarks for the Gahcho Kué Project

Noise Indicator	1.5 km from Project Footprint[(a)]	Limits for the Dormitory Area of the Site Camp[(b)]	
		Continuous Noises	Noise Events
L_{eq} [dBA]	40	55[(c)]	–
L_{max} [dBA]	–	–	70[(d)]

(a) Taken from the Alberta Energy Resources Conservation Board (ERCB) Directive 038: Noise Control (ERCB 2007). This is not a regulatory requirement as there are no noise regulations in the NWT although the Hope Bay Mine (Doris North) EIS (Miramar 2003) and Mackenzie Gas Project (MGP 2004) referenced this method.

(b) World Health Organization criteria to assess noise for occupants of the site camp are not a regulatory requirement as there are no noise regulations in the NWT and are for discussion of potential environmental effects. Any occupational hygiene or occupational health requirements regarding worker noise exposure will supersede these limits.

(c) This limit is the equivalent outdoor noise level that will ensure a continuous indoor noise level of not more than 30 dBA in heavily insulated buildings fitted with a minimum of double-glazed windows that are kept closed.

(d) This limit is the peak noise L_{max} that will ensure a peak indoor noise level of not more than 45 dBA in heavily insulated buildings fitted with a minimum of double-glazed windows that are kept closed.

L_{eq} = equivalent continuous sound and noise level; L_{max} = maximum sound and noise level; dBA = A-weighted decibel; km = kilometre; – = not applicable.

Blasting noise and vibration require a different approach due to the impulse nature of this source. Blasting regulations exist in most countries to regulate and control blast energy to prevent structural damage at neighbouring properties.

There are no regulatory requirements for environmental noise and vibration from blasting in the NWT; therefore, the US and Canada limits were the benchmarks used as it is the most applicable for the Project. These regulations address both ground and airborne vibration. The benchmarks selected are under the assumptions that a routine ground vibration monitoring plan is in place.

Table 7.II.4-2 Ground and Air Vibration Guidelines for the Gahcho Kué Project

Vibration Type	Unit	Guideline[(a)]
Ground Vibration	Peak Particle Velocity (mm/s)	12.5
Air Vibration	Peak Pressure Level (dBL)	120

mm/s = millimetres per second; dBL = linear decibel.

To help provide context for the chosen benchmarks, Table 7.II.4-3 and Table7.II.4-4 show common ground and airborne (overpressure) vibration levels.

Table 7.II.4-3 Vibration Levels Generated by Everyday Activities

Vibration Level (mm/s)	Activity
0.8	walking
0.8	heel drops
7.1	jumping
12.7	door slams
22.4	pounding nails

Source: Dowding 1985

mm/s = millimetres per second.

Table 7.II.4-4 Typical Overpressure Criteria

Overpressure Level (dBL)	Damage Measure
180	some structural damage possible
171	general window breakage
151	occasional window breakage
140	long-term history of application as safe project specification
134	United States Bureau of Mines recommendations for large-scale surface mine blasting

Source: ISEE 1998

dBL = linear decibel.

7.II.4.2 ASSESSMENT SCENARIOS

The temporal boundaries considered for the Project assessment include the two-year construction period to begin in 2013 and the 13-year operation period, after which the mine will be closed. Some construction activity will continue into the operations period. The nature and variety of Project-related activity required that noise be predicted for the following scenarios:

- continuous noise (L_{eq}) from mining activity at various stages to determine the variation in spatial extent:
  - Year 1;
  - Year 5; and
  - Year 8.
- continuous noise (L_{eq}) from the Winter Access Road (during winter construction and operation only);
- noise events (L_{max}) from use of the airstrip (construction and operation); and
- noise events (L_{max}) from blasting.

A comparison of Project activities and the associated environmental noise levels during the construction and operation phases indicates that the operations will likely result in the greatest extent of changes in noise levels at the Project. This is similar to the on-site activities during construction and operation at other mine developments, where detailed analysis of noise from construction versus operations have occurred (Suncor 2006). This assessment assumes that on-site construction activity will create localized and temporary increases in noise level due to various equipment similar to other projects; these changes vary in location and duration but increases during construction will generally be less than increases during operations. Since a worst-case approach to assess the greatest noise impacts over the life of the Project was taken for the noise study, the prediction of noise for the Project site and blasting was conducted for the operations phase. Construction impacts for the Project site and blasting impacts will be less than impacts during operations.

To maintain a worst-case approach to the assessment, the analysis of activity indicates that construction activity results in the greater use of the Winter Access Road and the airstrip, and would therefore be the phase where the most noise is generated in these study areas. To assess the activity that would result in the greatest extent of change in noise levels, use of the Project infrastructure during the construction phase was also evaluated as a source of impacts. A complete list of assumptions incorporated into the noise model is recorded in Attachment 7.II.1.

7.II.4.3 MODELLING METHODS

The noise assessment completed for the Project included an evaluation of the noise effects related to the operation of the Project. The evaluation of the noise effects focused on evaluating the noise levels associated with the fully developed operations.

Predictions for continuous noise and airstrip noise events were modelled using a commercially available specialized software package named “CadnaA”, manufactured by DataAkustik GMBH of Germany. The software follows several international prediction standards. The standard for calculation of outdoor noise propagation that was selected to model the Project is ISO 9613 (1&2): *Attenuation of Sound during Propagation Outdoors* (ISO 1996). Model scenarios were established to calculate normal Project operations that could potentially affect noise levels. This standard predicts sound propagation under downwind conditions and mild inverse conditions. These conditions are favourable for sound propagation. The standard can thus be considered as fairly conservative.

The model was configured to include the sounds emitted from the crusher, mill, workshop, power plant, mine fleet, and auxiliary equipment. Sources located within buildings were modelled so that ‘building hum’ was included in the calculations. Other factors taken into account by the model are the source spectrums, terrain, ground absorption, and atmospheric effects. Additional noise will result from sounds generated by active mine zones and active corridors from each mining zone to the plant site. This approach provided a “realistic worst case” of noise level contributions from the Project.

The CadnaA program (DataAkustik 2003) is capable of estimating ground-based noise levels associated with aircraft. The airstrip at the Project will be evaluated using the maximum (L_{max}) noise levels.

The determination of noise events from blasting activity required the use of standard reference formulae, due to the impulsive nature of this type of noise. Specific methods regarding noise peaks and vibration calculations are described in detail in the following sections.

7.II.4.4 SCIENTIFIC UNCERTAINTY

The modelling of outdoor noise attenuation is conducted using standard algorithms and assumptions that tend to simplify the acoustic environment. Normal variation of noise sources is addressed in the modelling depending on the noise source being assessed and the level of detail required.

The quality and relevance of predictions from the noise model is dependant on the data inputs. Sound emissions and site data used for the assessment were established with a high level of professional care to ensure the simulations were representative of the site, yet maintained conservatism where Project detail was not available.

The CadnaA model used for the assessment (DataAkustik 2003) predicted noise levels in accordance with ISO 9613 (1&2): *Attenuation of Sound During Propagation Outdoors* (ISO 1996). The ISO 9613 standard mentions an accuracy of plus or minus (±) 3 dBA for distances up to 1 km. The accuracy will diminish with distance.

This assessment is conservative based on the selection methods used for the noise sources emissions and the assumption that all equipment is working continuously under the highest expected load (the calculations do not account for maintenance shutdowns, worker breaks, or variations in production rates).

7.II.5 PROJECT OPERATIONS

7.II.5.1 INTRODUCTION

This section of the noise assessment describes and quantifies the expected changes in noise levels resulting from the operation of the Project.

7.II.5.2 SOUND EMISSIONS

The primary sources of sound associated with the operation of the Project occur at the mine pit, mine rock piles, and ore processing plant. These sources include the mine fleet, ore crushing and processing areas, as well as the power generators. All primary sources from the Project site will be removed during site closure and no sources will be present during post-closure.

Table 7.II.5-1 presents the sound emissions associated with activities at the Project. These numbers were derived from Project description information, literature, and reference formulae.

Table 7.II.5-1 Summary of Sound Emissions for the Project

Source	Type of Source[a]	Sound Power (dBA)[b]
Plant Site		
Primary Crusher	point	117.8
Transfer Tower	point	115.8
Process Plant	area	122
Power Generator	point	127.4
Power Generator exhaust	point	132.6
Mine Site		
CAT777	line and area	109
Utility line with one grader and one dozer	line	117
RH340C hydraulic shovel	area	123
Drilling operation	area	125
RH90 hydraulic excavator	area	117
CAT994 front end loader	area	116
CAT793 at pit or plant area	area	123
Loaded CAT793 truck	line	118
Unloaded CAT793 truck	line	121
D6 dozer	area	108
CAT992 front end loader	area	113
CAT 330 excavator	area	112
D10 dozer	area	111
Site Roads		
Highway passenger bus	line	107
Highway light trucks	line	107

[a] The type of source indicates how the emission was represented in the model. Area sources spread the emission over the relevant site for the activity, line sources move the sources along a given trace (e.g., roads), and point sources are a designated stationary location.
[b] dBA = A-weighted decibels.

7.II.5.3 NOISE PREDICTIONS

A summary of the predicted noise levels at various distances from the Project is presented in Table 7.II.5-2. These results are for operations only and do not include ambient noise, or noise from the Winter Access Road, or aircraft. The highest nighttime L_{eq} noise levels at the edge of the 1.5 km assessment boundary in the southern area of the Project were predicted to be 44 dBA in Year 1 of operations. This maximum is 4 dB above the benchmark value of 40 dBA for remote areas; however, noise levels are below the guideline over 80% of the assessment boundary. Noise levels in the portion of the boundary that exceeds the benchmark, decrease to 40 dBA at just over 2.5 km away from the Project.

These benchmarks were developed to address the effects of noise on people and to prevent cumulative effects with multiple developments. The consequences of the projected exceedence of the benchmark for the key line of inquiry and subjects of note are addressed in the relevant EIS sections.

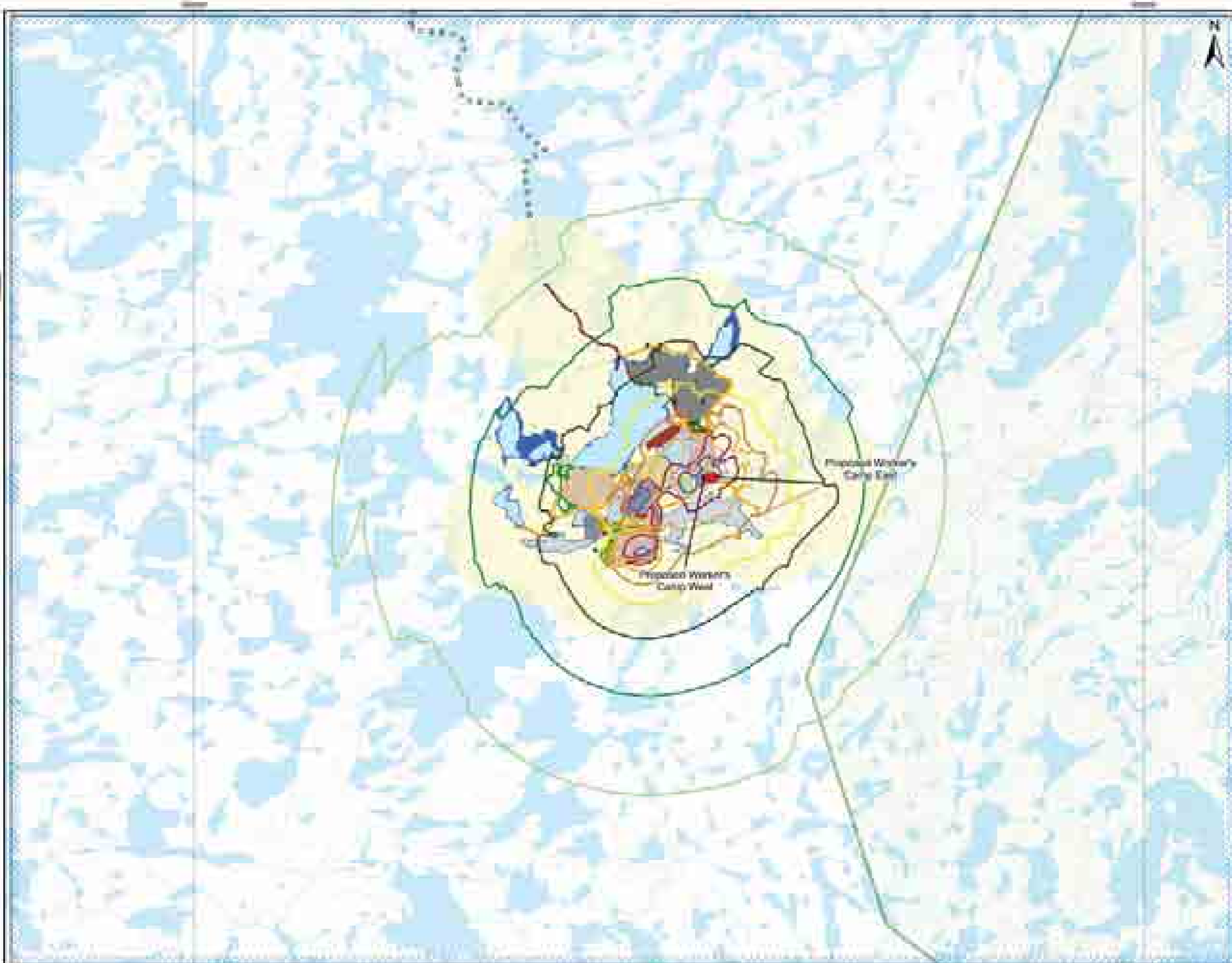
Noise levels at the same southern section of the 1.5 km boundary exceed the benchmark for all three operating years modelled, due primarily to proximity of the mine fleet and haul route to the Project disturbance boundary from which the assessment boundary is measured. Figures 7.II.5-1 to 7.II.5-6 present maps of the predicted continuous noise levels from the three operating years of the Project that were modelled, Years 1, 5, and 8.

Table 7.II.5-2 Predicted Noise Levels from Mine Operations

Location	Predicted L_{eq} Noise Levels (dBA)					
	Year 1		Year 5		Year 8	
	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)
Accommodations Complex (west side)	69	69	69	69	69	69
Accommodations Complex (east side)	58	58	58	58	58	58
Proposed East Arm National Park boundary location[(a)]	34	33	35	35	34	33
1.5 km boundary location[(a)]	43	42	44	44	41	41

(a) Location with highest predicted noise level.

L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibels; km = kilometre.



LEGEND

- Proposed Winter Access Road
- Watercourse
- Waterbody
- Index Contour (100 m interval)
- Receptor (Employee Camp Location)

Noise Contour (dBA)

- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 1.5 km Criteria Boundary
- Operational Noise Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

Project Footprint

- Service Road
- Site Road
- Water Pipeline
- Airstrip
- Back-filled Pit
- Building
- Coarse PK Pile
- De-watered Lake Bed
- Dyke or Berm
- Fine PK Containment Facility
- Flooded Area
- Mine Rock Pile
- Open Pit
- Plant Site

NOTES

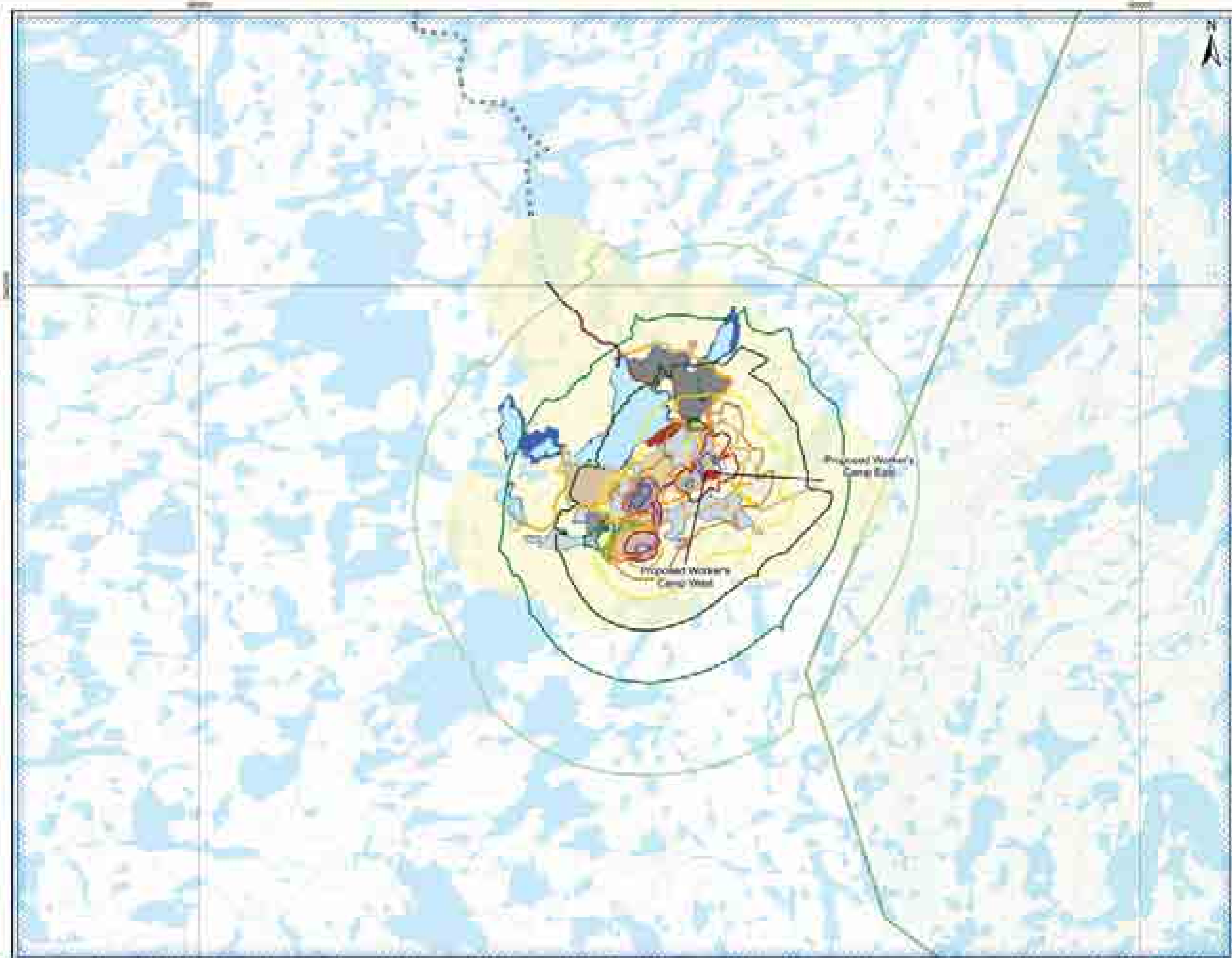
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUE PROJECT

Predicted Daytime Noise Levels During Operations, Year 1

DE BEERS

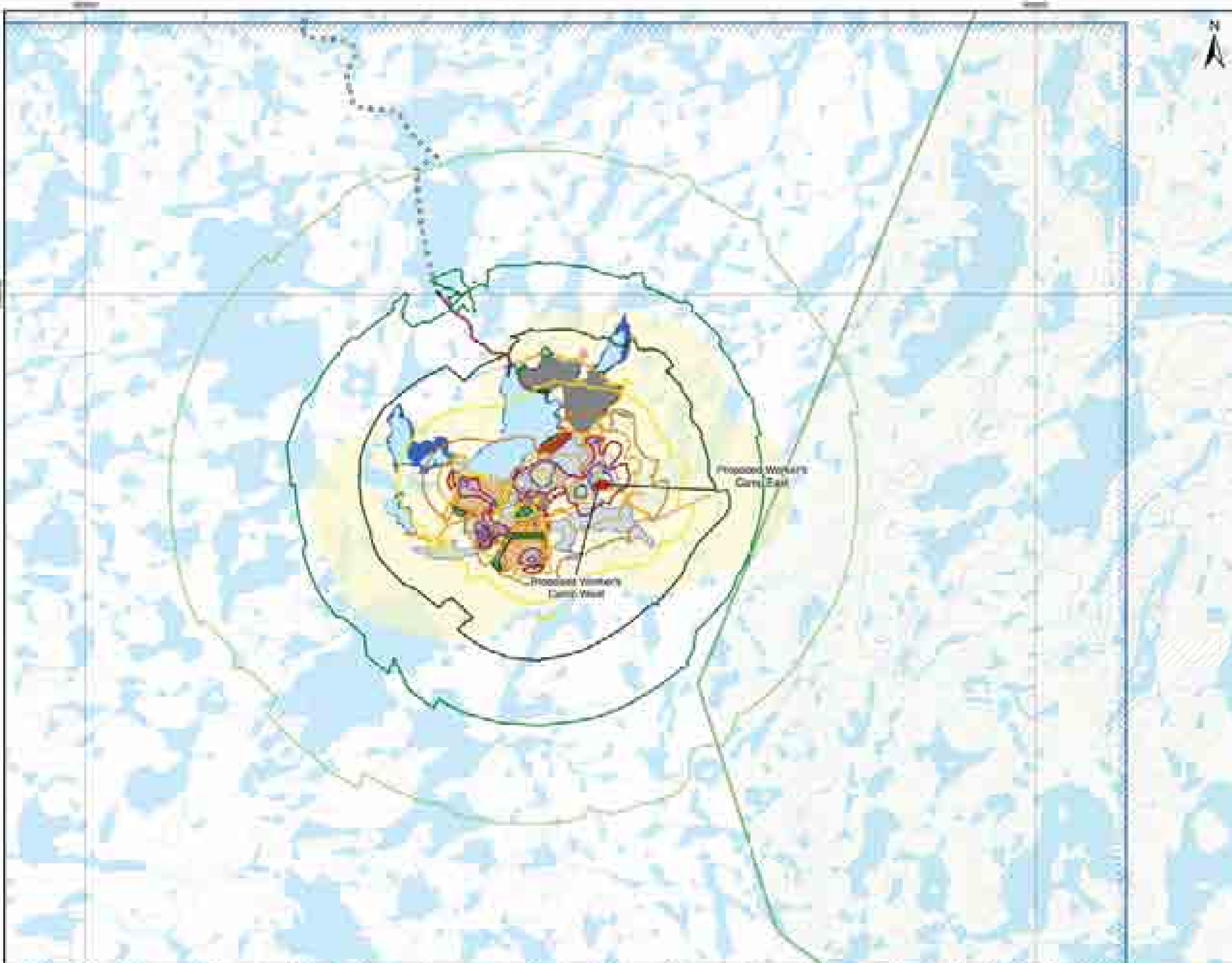
Figure 7.II.5-1



GAHCHO KUE PROJECT

Predicted Nighttime Noise Levels During Operations, Year 1

Figure 7.8.5-2

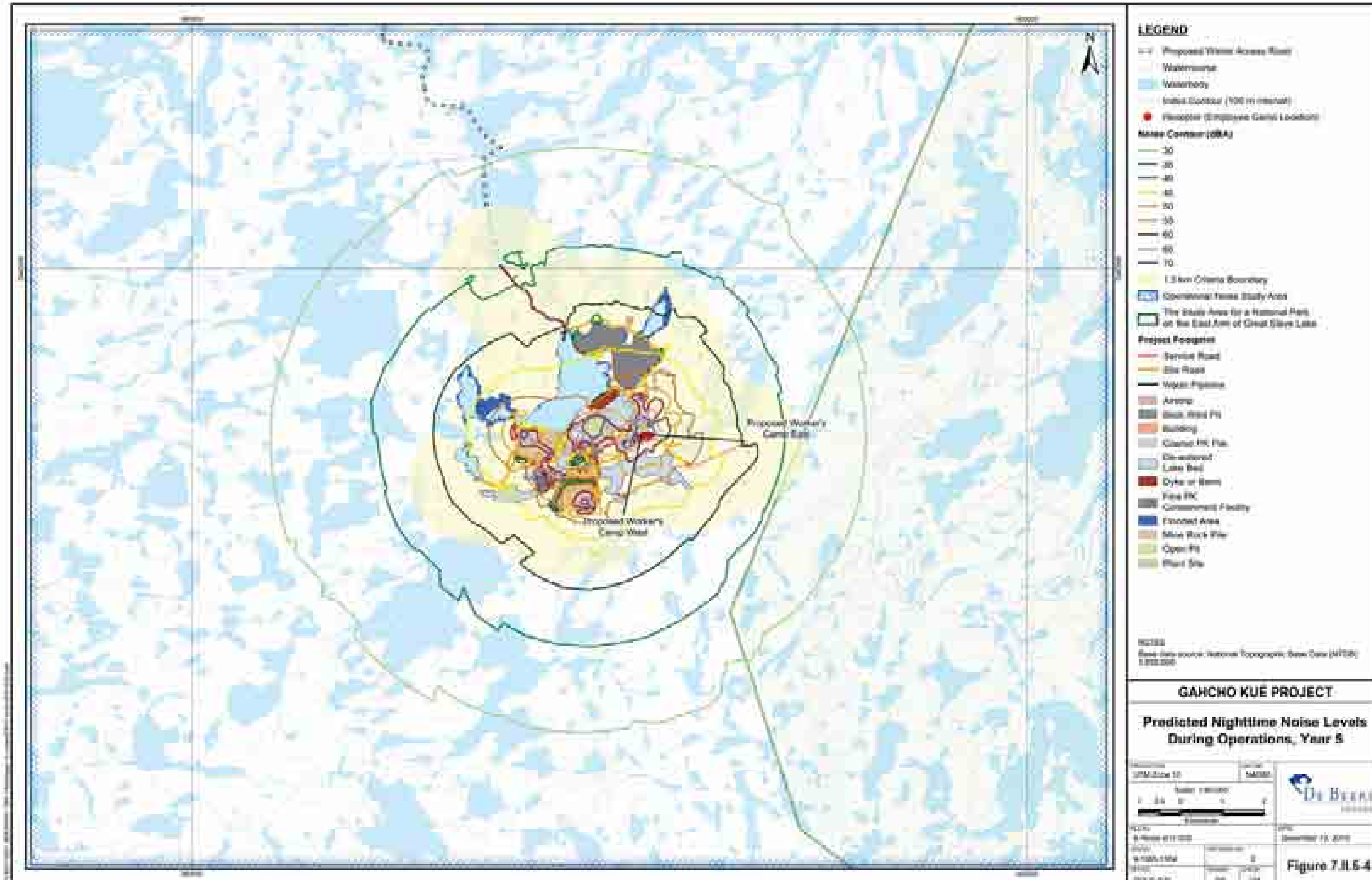


GAHCHO KUE PROJECT

Predicted Daytime Noise Levels During Operations, Year 5

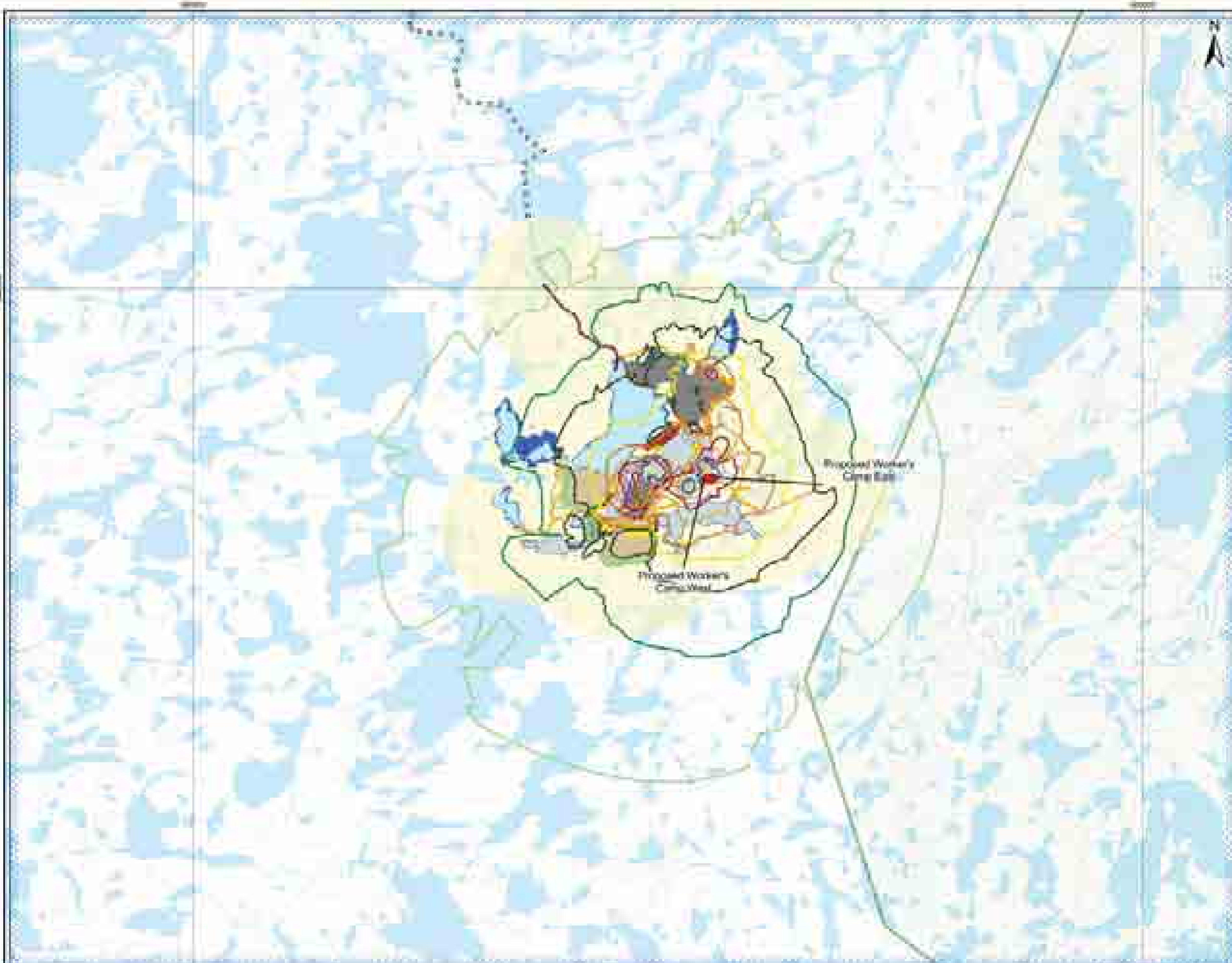
UTM Zone 12

Figure 7.II.5-3



Predicted Nighttime Noise Levels During Operations, Year 5

Figure 7.II.5-4



LEGEND

- Proposed Winter Access Road
- Watercourse
- Waterbody
- Index Contour (100 m interval)
- Receptor (Employee Camp Location)

Noise Contour (dBA)

- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 1.5 km Criteria Boundary
- Operational Noise Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

Project Footprint

- Service Road
- Site Road
- Water Pipeline
- Airstrip
- Back Filled Pit
- Building
- Coarse PK Pile
- De-watered Lake Bed
- Dyke or Berm
- Fine PK Containment Facility
- Flooded Area
- Mine Rock Pile
- Open Pit
- Plant Site

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUE PROJECT

Predicted Daytime Noise Levels During Operations, Year 8

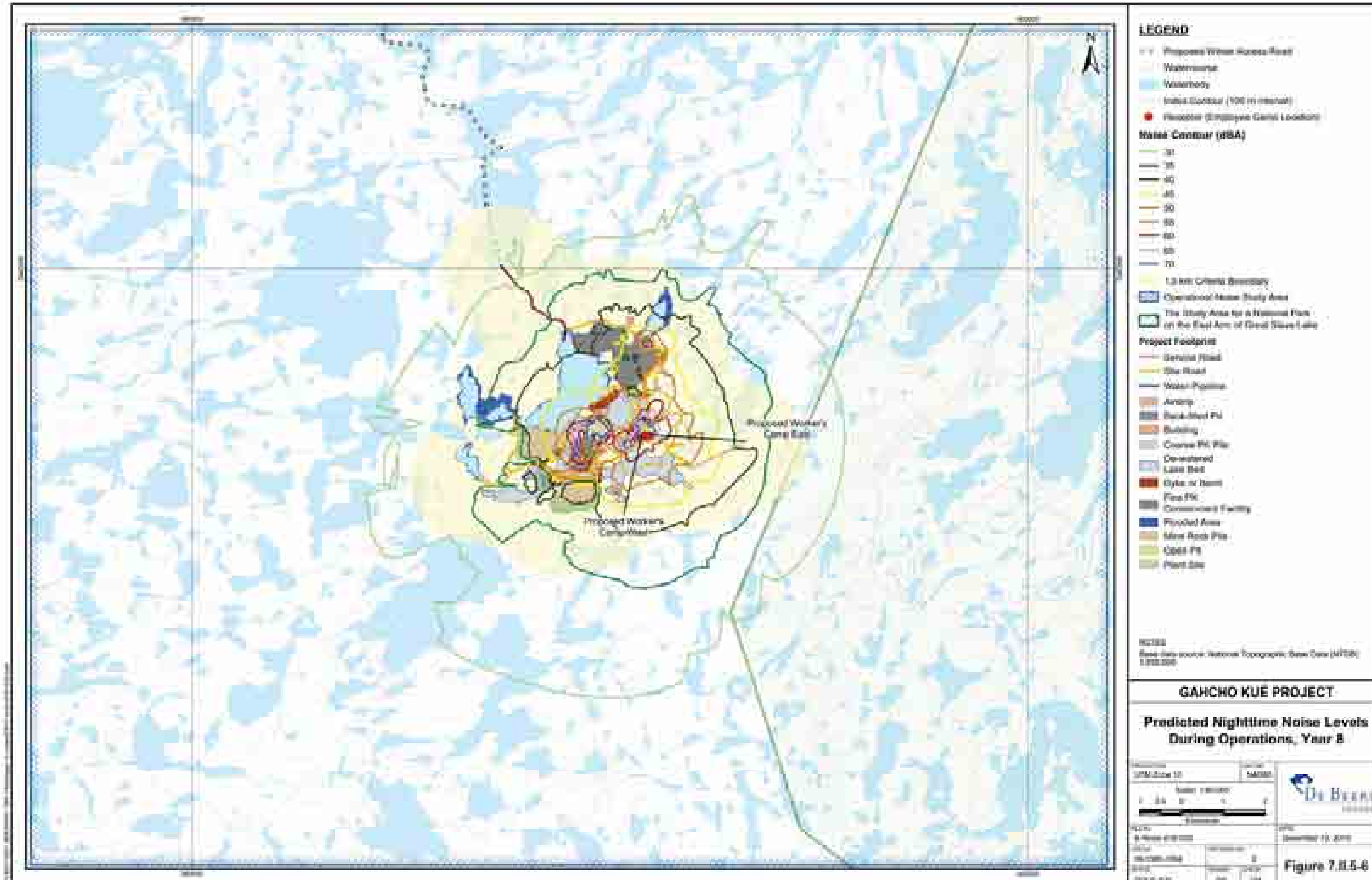
UTM Zone 12

Kilometres

DE BEERS

December 13, 2010

Figure 7.II.5-5



Predicted Nighttime Noise Levels During Operations, Year 8

Figure 7.8.5-6

The L_{eq} noise levels near the accommodations complex on-site are predicted to range between 58 and 69 dBA; these levels are up to 14 dB above the selected Project benchmark of 55 dBA (Section 7.II.4.1). Noise levels on the east and west sides of the complex were predicted separately because noise levels are influenced by buildings and other barriers that screen the location from noise sources.

An examination of possible mitigation measures will occur in the advance design stages of the mine.

The noise predictions indicate contribution from the Project alone. Expected noise levels cumulative with an existing baseline of 35 dBA are provided in Table 7.II.5-3.

Table 7.II.5-3 Predicted Cumulative Noise Levels from Mine Operations

Location	Predicted Cumulative L_{eq} Noise Levels[a] (dBA)					
	Year 1		Year 5		Year 8	
	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)	Daytime (07:00 to 23:00)	Nighttime (23:00 to 07:00)
Accommodations Complex (west side)	69	69	69	69	69	69
Accommodations Complex (east side)	58	58	58	58	58	58
Proposed East Arm National Park boundary location	38	37	38	38	37	37
1.5 km boundary location	44	43	44	44	42	42

(a) Results are the logarithmic addition of the average baseline of 35 dBA and the values from Table 7.II.5-1.

L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibels; km = kilometre.

7.II.6 WINTER ACCESS ROAD

7.II.6.1 INTRODUCTION

The Project will be accessed annually for delivery of major construction and operations goods and materials via a Winter Access Road, which will typically be in operation from late January or early February through March and, under favourable conditions, into early April. This might result in noticeable noise at key receivers of noise near the Project during the winter season. An assessment of noise caused by trucks was conducted for the Winter Access Road to ensure all major sources of sound emissions from the Project were assessed.

7.II.6.2 SOUND EMISSIONS

The noise assessment completed for the Winter Access Road includes an evaluation of the noise effects related to the operation of the Winter Access Road for the period from late January until early April if conditions are favourable. The evaluation of the noise impacts focused on evaluating the noise levels associated with the fully developed road operations.

During the two-year construction period, there are up to a maximum of 2000 trucks per year arriving at the Project site for offloading. As each arrival would indicate a departure from the Project site, up to 4,000 highway-type transport trucks are on the Winter Access Road per year. During operations, approximately 2,400 trucks will arrive at and leave the site using the Winter Access Road per year.

7.II.6.3 NOISE PREDICTIONS

A summary of the predicted noise levels at various distances from the Project is presented in Table 7.II.6-1. This table includes noise from winter road traffic only. The maximum nighttime L_{eq} noise levels at the edge of the 1.5 km buffer zone were predicted to be 23.5 dBA from the Project only (not including ambient sounds).

Table 7.II.6-1 Predicted Noise Levels at Various Distances from the Winter Access Road

Location	Predicted L_{eq} Noise Levels (dBA)	
	Construction	Operations
Accommodations Complex (west side)	16	14
Accommodations Complex (east side)	15	13
Proposed East Arm National Park boundary location[(a)]	5	3
1.5 km boundary location[(a)]	23	23

(a) Location with highest predicted noise level along the winter access road route.
L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibels; km = kilometre.

The noise predictions indicate contribution from the Winter Access Road alone. Expected noise levels cumulative with an existing baseline of 35 dBA are provided in Table 7.II.6-2.

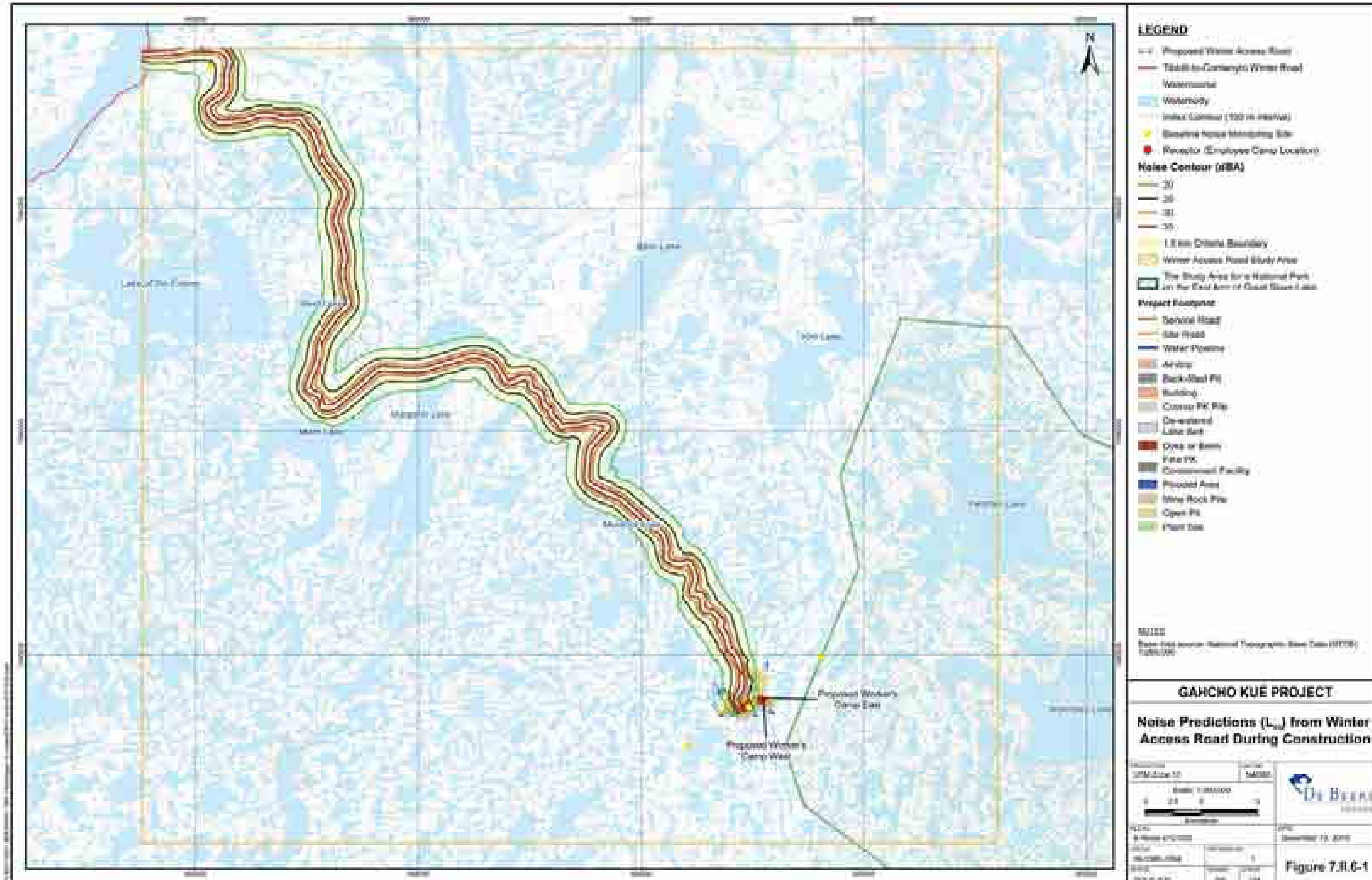
Table 7.II.6-2 Predicted Cumulative Noise Levels from the Winter Access Road

Location	Predicted Cumulative Leq Noise Levels[(a)] (dBA)	
	Construction	Operation
Accommodations Complex (west side)	35	35
Accommodations Complex (east side)	35	35
Proposed East Arm National Park boundary location[(a)]	35	35
1.5 km boundary location[(a)]	35	35

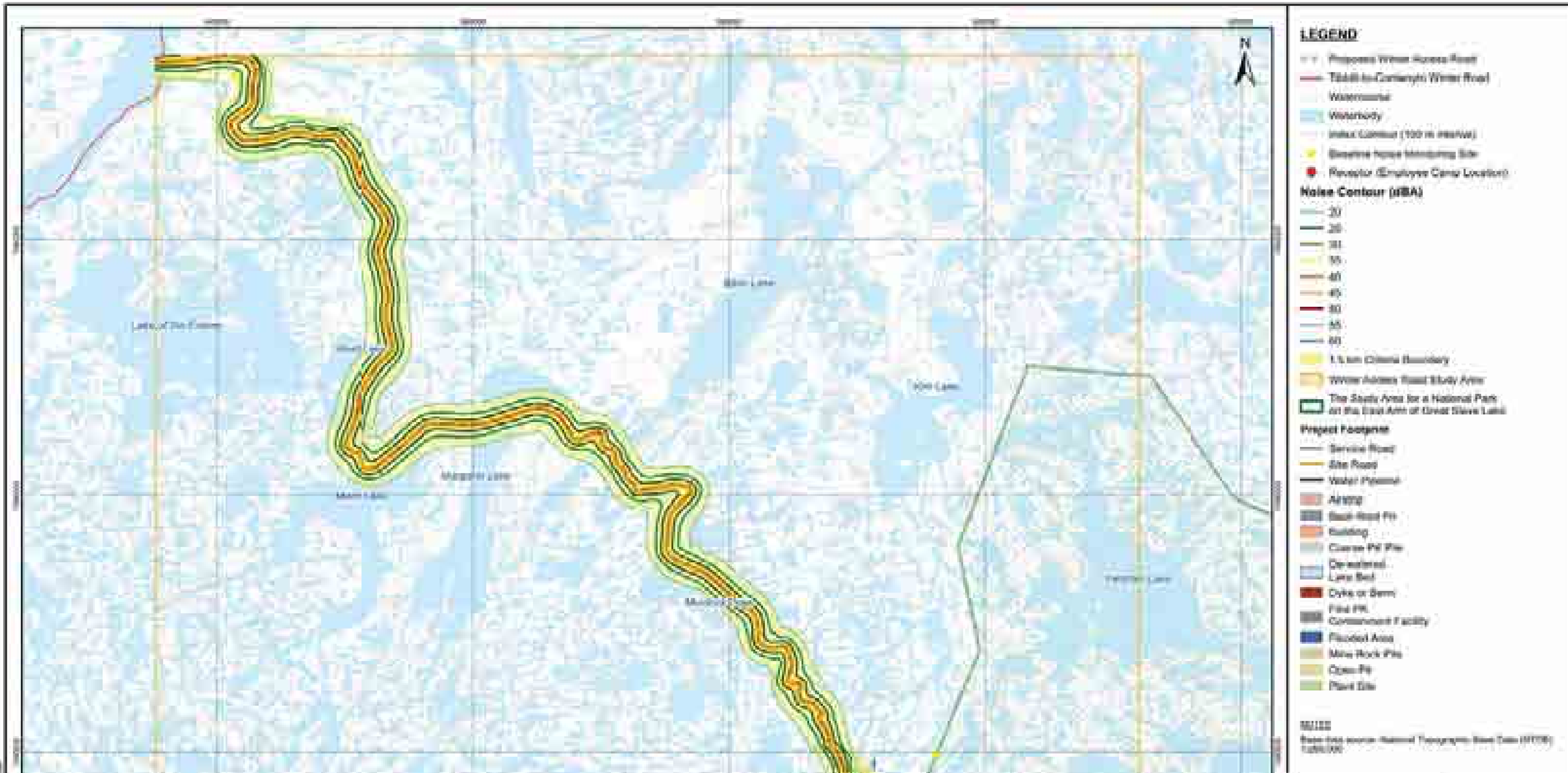
(a) Results are the logarithmic addition of the average baseline of 35 dBA and the values from Table 7.II.6-1.
L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibels; km = kilometre.

The predicted cumulative noise levels L_{eq} are 35 dBA, indicating no significant contribution from the winter road to the overall sound level L_{eq}. This value is well below the threshold of 40 dBA during nighttime hours.

Noise maps of the equivalent (L_{eq}) noise levels expected during the arrival and departure of trucks for the construction and operations periods show where noise effects occur (Figures 7.II.6-1 and 7.II.6-2).



N
Proposed Worker's Camp East
Proposed Worker's Camp West
LEGEND
Proposed Winter Access Road
Tibbitt-to-Contwoyto Winter Road
Watercourse
Waterbody
Index Contour (100 m interval)
Baseline Noise Monitoring Site
Receptor (Employee Camp Location)
Noise Contour (dBA)
20
1.5 km Criteria Boundary
Winter Access Road Study Area
The Study Area for a National Park on the East Arm of Great Slave Lake
Project Footprint
Service Road
Site Road
Water Pipeline
Airstrip
Back-filled Pit
Building
Coarse PK Pile
De-watered Lake Bed
Dyke or Berm
Fine PK Containment Facility
Flooded Area
Mine Rock Pile
Open Pit
Plant Site
GAHCHO KUE PROJECT
Noise Predictions (L) from Winter Access Road During Construction
DE BEERS
Figure 7.II.6-1



GAHCHO KUE PROJECT

Noise Predictions (L_{eq}) from Winter Access Road During Operations

Figure 7.II.6-2

7.II.7 AIR TRAFFIC NOISE

7.II.7.1 INTRODUCTION

De Beers proposes to use an airstrip for transporting workforce to and from the Project on a regular basis. This might result in noticeable short-term noise events at key receivers of noise near the Project. The assessment of noise from the airstrip focused on predicting the loudest expected noise levels during aircraft approach and departure from the Project airstrip.

7.II.7.2 SOUND EMISSIONS

Two types of aircraft will likely be used for the construction and operation of the Project: the Hercules C-130 may be used to fly in materials and supplies and a Dash-8 will be used to transport workers. Sources and Project design parameters used in the modelled air traffic assessment for the Project are detailed in Table 7.II.7-1.

A maximum of one round-trip flights per day are expected during Project construction and during normal operations. Each round-trip flight involves one take-off and one landing during daytime hours only.

Table 7.II.7-1 Noise Sources and Model Assumptions for Air Traffic

Design Parameter Used	Aircraft Model	
	Hercules C-130	De Havilland Dash 8
Length of flight route	20 km	20 km
Length of runway	1,600 m	800 m
Flight path orientation	65°/245°	65°/245°
Number of flights per day	1	1
Flight operation time	7.00 a.m. to 7.00 p.m.	7.00 a.m. to 7.00 p.m.
Runway surface	gravel	gravel

km = kilometre; m = metre; ° = degree.

7.II.7.3 NOISE PREDICTIONS

Air traffic noise predictions showing the maximum (L_{max}) noise levels expected from west-southwest and east-northeast arrivals and departures are detailed in Table 7.II.7-2.

Table 7.II.7-2 Noise Event Predictions L_{max} Air Traffic

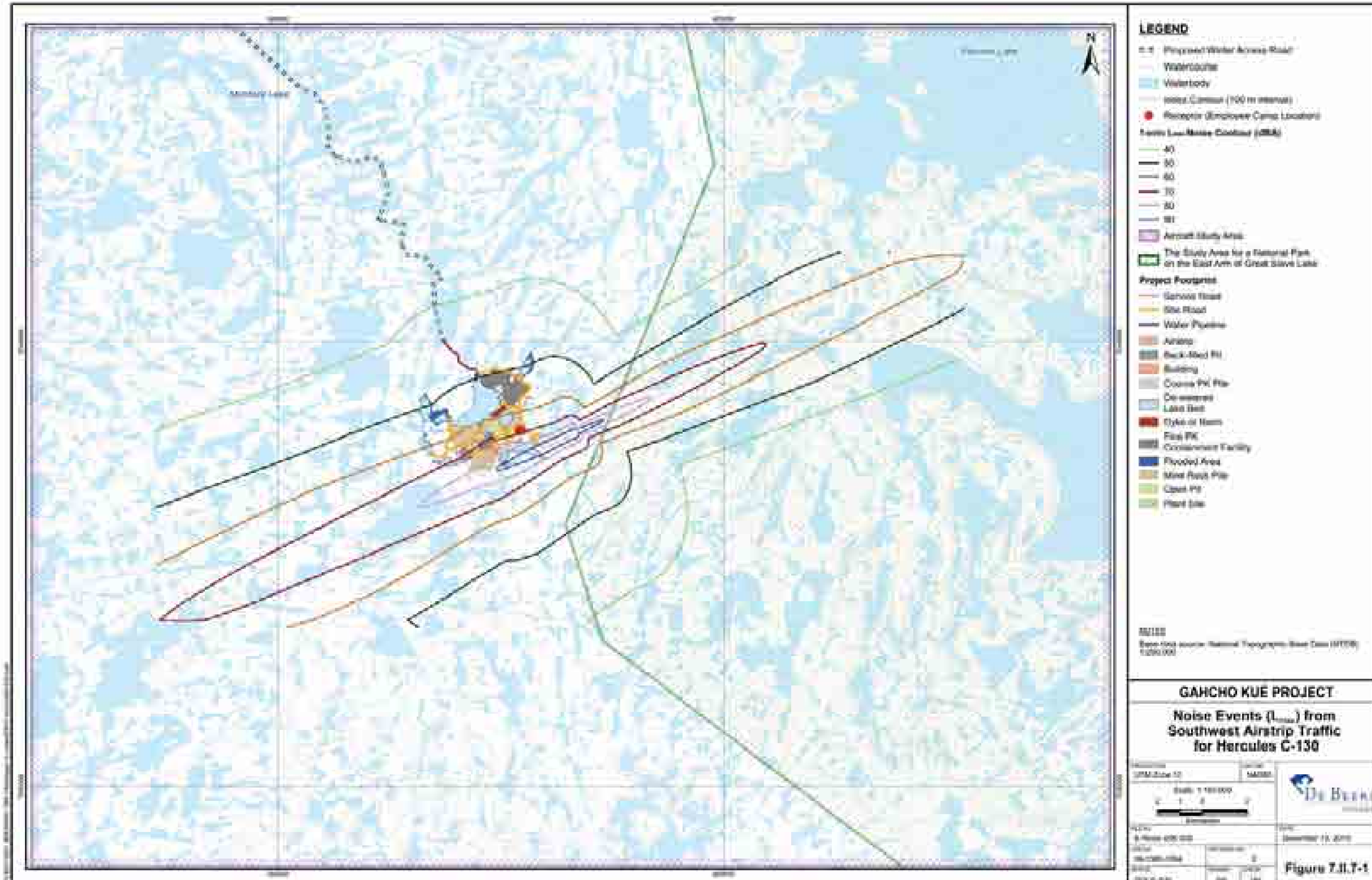
	L_{max} Air Traffic (dBA)			
Aircraft Type	**Lockheed C-130E**		**De Havilland Dash 8**	
Location	**West – Southwest[a]**	**East - Northeast**	**West - Southwest[a]**	**East - Northeast**
Accommodations Complex (west side)	68	61	61	55
Accommodations Complex (east side)	69	62	61	55
East Arm National Park Boundary Location[b]	88	90	88	83
1.5 km Boundary Location[b]	91	92	91	85

[a] Location with highest predicted noise level.

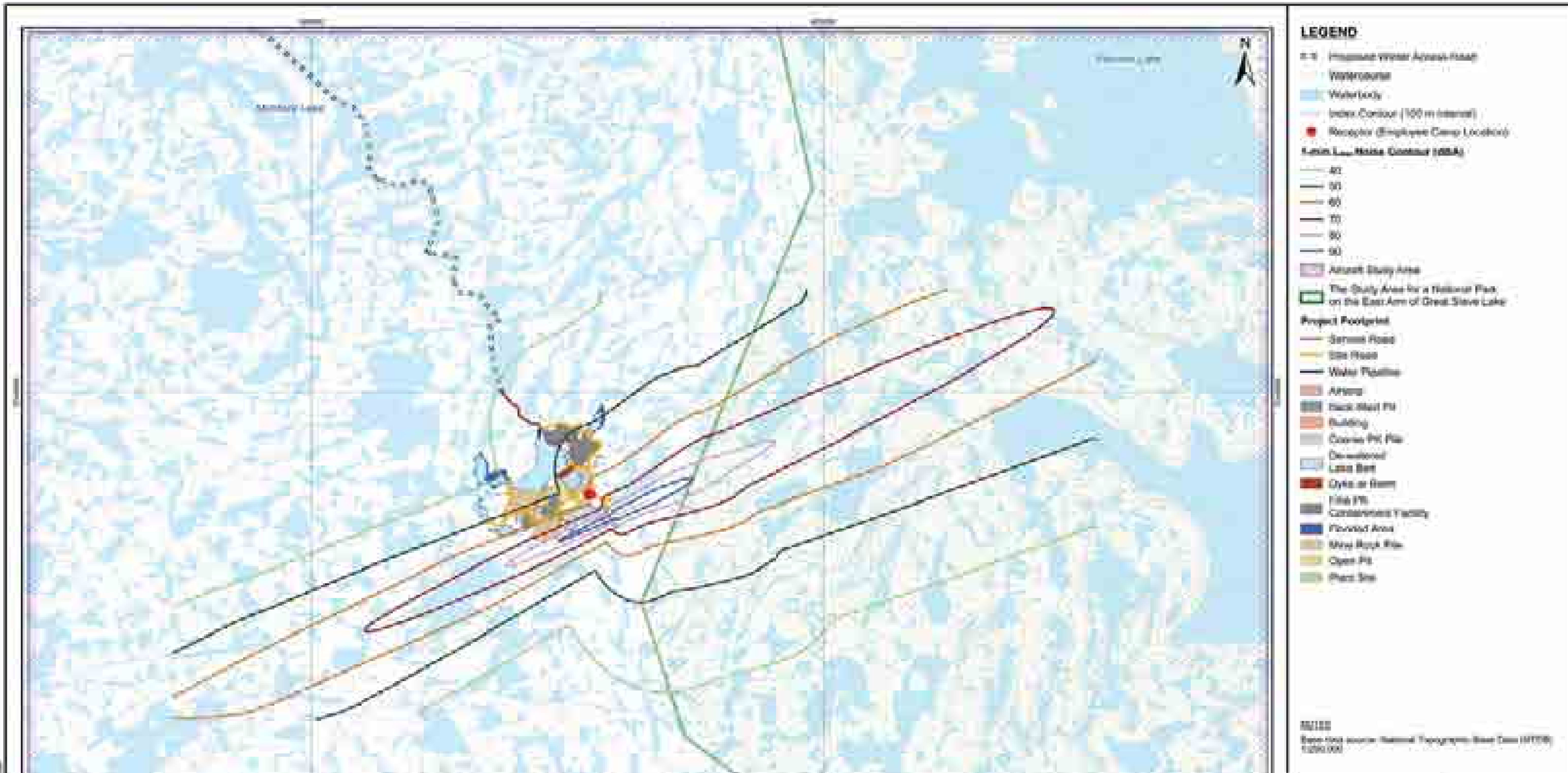
[b] Due to model threshold limitations, noise level increments greater than 0 but less than 30 dBA are not defined. This value indicates that noise levels are predicted, but they are less than 30 dBA.

L_{max} = maximum sound and noise level; dBA = A-weighted decibels; km = kilometre.

Noise maps of the maximum (L_{max}) noise events expected during air traffic arrival and departure show where noise effects occur (Figures 7.II.7-1 to 7.II.7 4). Flights to the site are expected to occur 200 to 700 times a year during construction and 100 to 250 times a year during operations during daytime hours only. Noise impacts from air traffic will be intermittent and infrequent compared to the noise levels generated through Project operations.



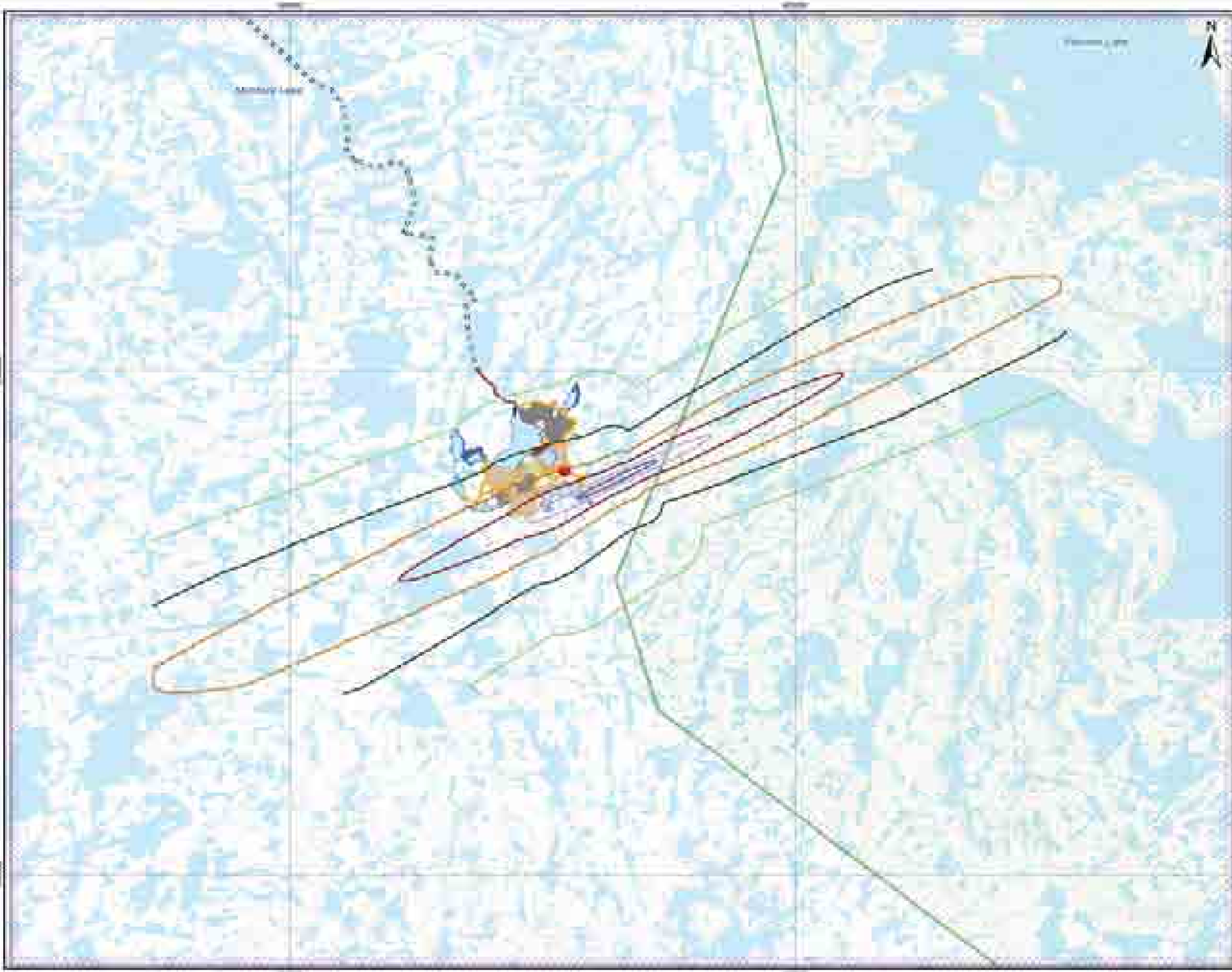
LEGEND
Watercourse
Waterbody
Receptor (Employee Camp Location)
40
50
60
70
80
Aircraft Study Area
The Study Area for a National Park on the East Arm of Great Slave Lake
Project Footprint
Site Road
Water Pipeline
Airstrip
Building
Coarse PK Pile
De-watered Lake Bed
Dyke or Berm
Fine PK Containment Facility
Flooded Area
Mine Rock Pile
Open Pit
Plant Site
GAHCHO KUE PROJECT
Noise Events (L_{max}) from Southwest Airstrip Traffic for Hercules C-130
Figure 7.II.7-1



GAHCHO KUE PROJECT

Noise Events (L_{max}) from Northeast Airstrip Traffic for Hercules C-130

Figure 7.II.7-2



LEGEND

- Proposed Winter Access Road
- Watercourse
- Waterbody
- Index Contour (100 m interval)
- Receptor (Employee Camp Location)

1-min L_{max} Noise Contour (dBA)

- 40
- 50
- 60
- 70
- 80
- 90
- Aircraft Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

Project Footprint

- Service Road
- Site Road
- Water Pipeline
- Airstrip
- Back-filled Pit
- Building
- Coarse PK Pile
- De-watered Lake Bed
- Dyke or Berm
- Fine PK Containment Facility
- Flooded Area
- Mine Rock Pile
- Open Pit
- Plant Site

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUE PROJECT

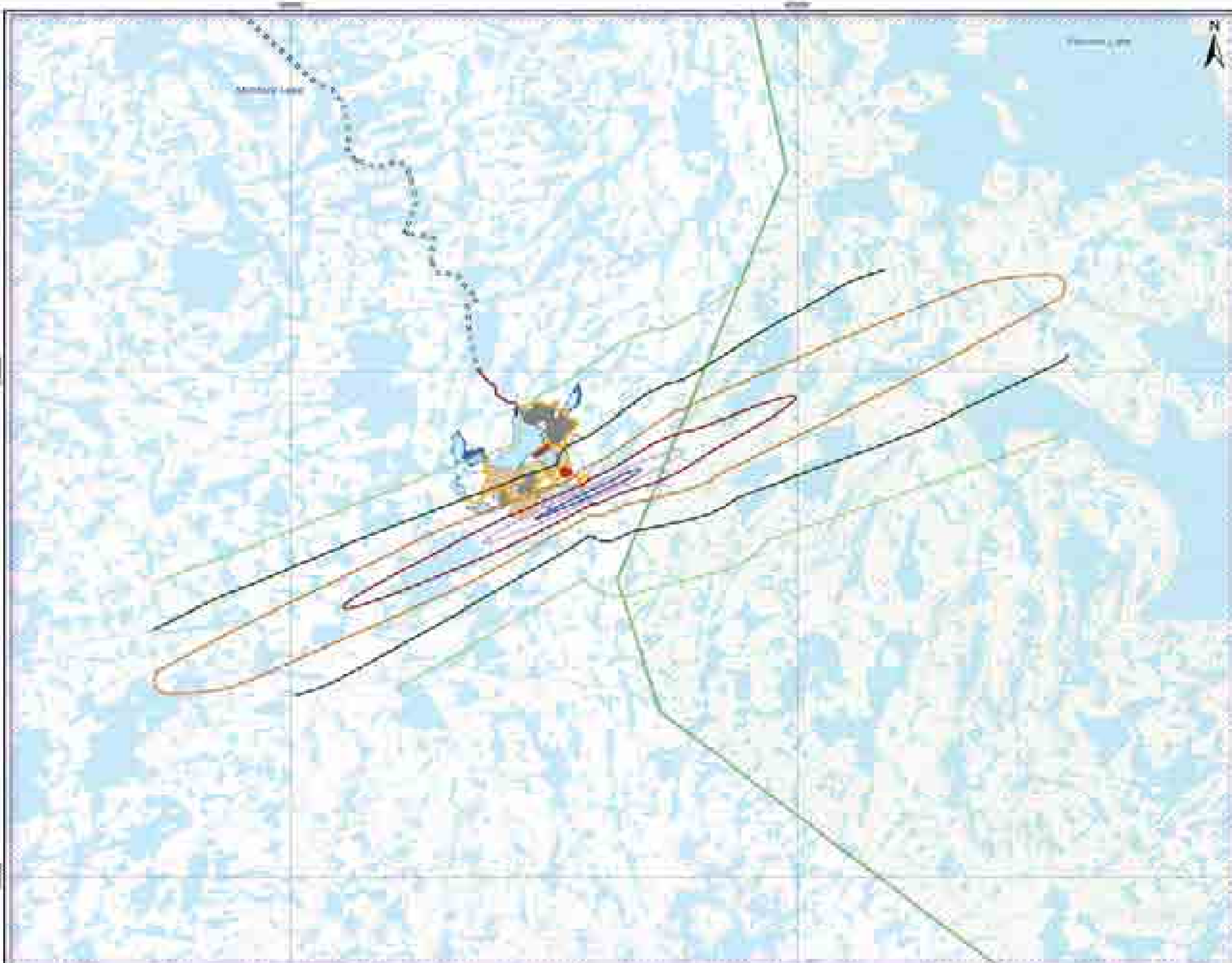
Noise Events (L_{max}) from Southwest Airstrip Traffic for Dash-8

UTM Zone 12

Scale: 1:150,000

Kilometres

Figure 7.II.7-3



LEGEND

- Proposed Winter Access Road
- Watercourse
- Waterbody
- Index Contour (100 m interval)
- Receptor (Employee Camp Location)

1-min L_{eq} Noise Contour (dBA)

- 40
- 50
- 60
- 70
- 80
- 90
- Aircraft Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

Project Footprint

- Service Road
- Site Road
- Water Pipeline
- Airstrip
- Back-filled Pit
- Building
- Coarse PK Pile
- De-watered Lake Bed
- Dyke or Berm
- Fine PK Containment Facility
- Flooded Area
- Mine Rock Pile
- Open Pit
- Plant Site

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUE PROJECT

Noise Events (L_{max}) from Northeast Airstrip Traffic for Dash-8

UTM Zone 12

DE BEERS

Figure 7.II.7-4

7.II.8 BLASTING ACTIVITY

7.II.8.1 ASSESSMENT METHODS

Blasting activities are identified as the source for both ground-borne and airborne vibration. The level of vibration experienced by receptors will be directly related to the amount of charge (explosive material) used for a blast.

Blast design and explosives quantities are not fully defined in the Project Description (Section 3). Therefore, the assessment approach was to determine the worst-case charge quantities. The analysis determines hypothetical worst-case blasting charge quantities that would result in vibration and airborne noise levels equal to or greater than the benchmark at various distances. These hypothetical blasting charge quantities were then compared to the estimated charge quantities for the mine blasting program. The comparison was conducted to determine whether estimated blasting charges used would result in vibration levels below benchmark levels.

Ground vibration was calculated to determine the peak particle velocity in mm/s due to the blast. The rate at which ground vibrations decay or attenuate from a blast site can be expressed by the scaled distance, which is defined as:

- scaled distance (SD) = $D/\sqrt{W}$
  - where D = distance (m) between the blast and receptor
  - W = maximum weight of explosive (kilogram) detonated per delay period

The prediction of maximum ground vibrations can be calculated based on the following equation (ISEE 1998):

- $PPV = 1{,}725(SD)^{-1.6}$
  - where PPV = peak particle velocity (mm/s)
  - SD = scaled distance (metre per kilogram [m/kg]0.5)

For airborne noise, the L_{peak} values were calculated to determine the instantaneous maximum noise level during a blast event. Airborne vibration levels were predicted using a linear attenuation model.

Airborne vibrations attenuate from a blast site at a slower rate than ground vibrations. The distribution of air vibration energy from a blast is also strongly influenced by the prevailing weather conditions during the blast. Other factors influencing air vibration distribution from a blast include:

- the length of collar and type of stemming material;
- differences in types of explosive material; and
- variations in burden distance.

The rate at which air vibrations decay or attenuate from a blast site can be expressed by the scaled distance, which is defined as:

- scaled distance (SD) = D/ $_3\sqrt{}$W
  - where D = distance (m) between the blast and receptor
  - W = maximum weight of explosive (kilogram) detonated per delay period

Prediction of maximum air vibrations was based on the following equation (ISEE 1998) which assumes average burial of the explosive:

- $P = 20\log_{10}[(SD)^{-1.1}] + 170.75$
  - where P = peak air pressure (dBL)
  - SD = scaled distance (feet per pound $[ft/lb]^{0.33}$)

No other noise sources were included in the L_{peak} calculation. Analysis of residual impacts in terms of a change to baseline levels is not applicable to vibration. This is because baseline conditions for existing vibrations cannot be established since baseline ambient vibration levels are normally near zero.

7.II.8.2 GROUND VIBRATION EMISSIONS AND ASSUMPTIONS

Blast-induced ground vibrations, both surface (as airborne noise) and body (underground) waves, naturally attenuate with increased distance from the blast site. This is due to material damping and geometric spreading. Body waves attenuate more rapidly than the surface waves. This results in the surface waves being more dominant at greater distances. The vibration intensity perceived or measured at the closest off-site points of reception around the Project site would be dominated by surface waves or the blasting noise (L_{peak}).

The intensity of ground vibrations, which is an elastic effect measured in units of peak particle velocity, is defined as the speed of excitation of particles within the ground resulting from vibratory motion.

Project details used in the calculation of blasting noise and vibration are provided in Table 7.II.8-1.

Table 7.II.8-1 Typical Blast Design Details Proposed for the Project

Material	Parameter	Dimension
Mine rock	drill hole pattern	6.25 by 6.25 m, 4.25 by 4.25 m
	drill hole diameter	165 to 250 mm
	average holes per blast[(a)]	50
	maximum explosive weight per hole	750 kg[(b)]
	hole depth (sub-drill depth)	13.5 m
	maximum holes per delay	1

(a) Based on assumed explosive densities of 0.9 grams per cubic centimetre (g/cm^3) for ammonium nitrate fuel oil and 1.1 g/cm^3 for emulsion.

(b) Based on the Ekati Mine (Tannant and Peterson 2001).

kg = kilogram; m = metre; mm = millimetres.

The rate at which ground vibrations attenuate from a blast site is dependent on several variables, including:

- characteristics of the blast (e.g., delay timing and type of explosive);
- topography of the site; and
- characteristics of the bedrock and/or soil materials.

As mining operations have not yet started, there is no site-specific ground vibration monitoring data from the Project site. The magnitude of blast vibrations from the open-pit blasting operations at the Project receptors already identified were predicted using generalized attenuation equations available in published literature. The intensity of ground vibrations from blasting operations are primarily a function of the maximum explosive weight detonated (set off) per delay period and the distance between the blast and the receptor.

The scaled distance equivalent for a peak ground vibration limit of 12.5 mm/s would be 21.7 kilogram (kg) of explosive per delay for each 1 m distance from the blast. Since the blast design and charge weights are expected to vary during normal operations, maximum explosive weights per delay period can be calculated for varying distances from the blast using the scaled distance and are provided in Table 7.II.8 2. As this is a generalized equation based on the results from numerous mining and construction applications, attenuation characteristics for the Project will be better defined once blasting begins.

Table 7.II.8-2 Maximum Charge for Ground Vibration Guidelines to be met by Differing Receptor Distance

Distance between Blast and Receptor (m)	Maximum Calculated Explosive Weight/Delay (kg) to meet 12.5 mm/s
500	529
600	761
650	893
700	1,036
750	1,189
800[a]	1,353
850	1,528
900	1,713

[a] Distance for closest identified receptor (between worker camp and Tuzo Pit).

Kg = kilogram; m = metre; mm/s = millimetre per second.

7.II.8.3 AIRBORNE VIBRATION EMISSIONS AND MODEL ASSUMPTIONS

The planned blasting charge described in Table 7.II.8-1 will result in airborne vibration. The L_{peak} airborne vibration levels are measured in linear decibels (dBL) which attenuate with distance from the blasting site, similar to airborne noise.

The scaled distance equivalent for the more stringent L_{peak} air pressure benchmark of 120 linear decibels would be the cubed root of 202.68 ft/lb (87.7 metres per kilogram [m/kg]). Since the blast design and charge weights are expected to vary during normal operations, maximum charge weights per delay can then be calculated for varying distances from the blast site and are provided in Table 7.II.8 3. This calculation is similar to the calculations for peak ground vibration levels discussed previously.

Table 7.II.8-3 Maximum Charge for Airborne Vibration Benchmark to be met by Receptor Distance

Distance Between Blast and Receptor[(a)] (m)	Maximum Calculated Explosive Weight/Delay (kg) for 120 dBL
500	241
600	416
650	529
700	661
750	813
800[(b)]	986
850	1,183
900	1,404

(a) Represents worst-case scenario.

(b) Distance for identified closest receptor (between worker camp and Tuzo pit).

dBL = linear decibels; kg = kilogram; m = metre.

7.II.8.4 BLASTING RESULTS SUMMARY

As shown in Tables 7.II.8-2 and 7.II.8-3, the distance to the closest identified receptor (between the accommodation complex and Tuzo Pit) is approximately 800 m. Based on a distance of 800 m, the calculated maximum explosive loads for limiting peak ground vibration and overpressure levels to 12.5 mm/s and 120 dBL would be 1,353 kg and 986 kg respectively. Based on estimates of about 750 kg per delay period, the peak ground vibration and airborne noise levels will meet benchmarks at the nearest sensitive receptor (accommodations complex) and therefore all other receptors.

It is apparent from both tables that, at equivalent distances, the airborne vibration limit of 120 dBL becomes the more restrictive parameter when determining maximum explosive loads for the mine’s production blasts.

7.II.9 RESIDUAL ENVIRONMENTAL EFFECTS

7.II.9.1 GENERAL EFFECTS

The predicted noise levels from the various Project activities are compared with the relevant benchmarks in Table 7.II.9-1. The results show that, while noise will be generated by the Project, the expected levels at identified noise receptors are within most of the relevant benchmarks established for remote areas. These benchmarks are guidelines selected for the Project, and do not indicate a regulatory requirement, as there are no environmental noise regulations in the NWT. In addition, the benchmarks are from guidance focused on human effects only. Wildlife impacts are discussed in the relevant key line of inquiry and subjects of note sections.

Table 7.II.9-1 Summary of Noise Effects from the Project

Receptor	Mine Operations[c] L_{eq} (dBA)		Winter Road L_{eq} (dBA)		Airstrip L_{max} (dBA)	
	Prediction	Benchmarks	Prediction	Benchmarks	Prediction	Noise Event Benchmarks
Accommodations Complex (west side)	69	55[a]	35	55[a]	68	70[a]
Accommodations Complex (east side)	58	55[a]	35	55[a]	69	70[a]
East Arm National Park Boundary Location[d]	38	40[b]	35	40[b]	90	-
1.5 km Boundary Location[d]	44	40[b]	35	40[b]	92	-

(a) WHO 1999.
(b) ERCB 2007.
(c) Highest cumulative noise levels calculated at each receptor.
(d) Location with highest predicted noise level along the length of the boundary.
L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibel; L_{max} = maximum sound and noise level;
km = kilometre; ≥ = greater than or equal to; - = not applicable.

The analysis of blasting activity indicates the maximum explosive loads for limiting peak ground vibration and overpressure levels to 12.5 mm/s and 120 dBL at the nearest receptor (accommodations complex) are 1,353 kg and 986 kg, respectively. Since the Project estimates about 750 kg per delay period, the distances calculated at which the benchmark peak ground vibration and overpressure levels of 12.5 mm/s and 120 dBL would be met are 596 and 730 m, respectively. However, some ground and airborne vibration motion will be perceived at the accommodations complex (800 m).

The above summary of results indicates that the Project meets most of the relevant benchmarks for remote areas and for the accommodations complex, with the exception of the 40 dBA benchmark being exceed in a 2.0 km long stretch at the southern area of the 1.5 km boundary. In this southern area, the noise level exceeds the 40 dBA limit for each operating year modelled due to the close proximity of the process plant and main haul road to the edge of the development area.

The geographic extents of the influence of noise from various Project activities are shown in Figures 7.II.5-1, 7.II.5-2, 7.II.5-3, 7.II.5-4, 7.II.5-5, 7.II.5-6, 7.II.6-1, 7.II.6-2, 7.II.7-1, 7.II.7-2, 7.II.7-3, and 7.II.7-4. Maximum distances for Project noise (noise from Project operations and winter road and airstrip use) to attenuate to background levels are summarized in Table 7.II.9-2. The distances indicate the area within which Project related noises may be found to be easily distinguishable by people from the natural environment. When Project noise predictions diminish to levels below background, they are not expected to be easily distinguishable by people from natural noises, although it is still possible depending on the character of the sound.

Table 7.II.9-2 Distance for Noise Attenuation to Background

Background Noise Level	Mine Operations (km)	Winter Road (km)	Airstrip (km)
Continuous (35 dBA)	3.5 [a]	–	–
Noise Event	–	3.0 [b]	5.5

[a] Based on the distance to the nearest noise sources.
[b] Based on maximum pass-by level.
km = kilometre; dBA = A-weighted decibel; – = not applicable.

Surface blasting noise is expected to extend for tens of kilometres; however, the ability for people to distinguish such a short event at distances over 10 km is expected to be low.

7.II.10 MONITORING AND FOLLOW-UP

The Project meets most of the relevant noise benchmarks for 3rd parties used in the assessment, with the exception of the 40 dBA limit at 1.5 km from the Project, which is exceeded for about 1.5 km along the south side of the Project site. The noise benchmark used in the EIS is an ERCB Directive 038: Noise Control (ERCB 2007). Since the benchmark used for the Project is an Alberta criteria, this is not a regulatory requirement in the NWT. There are no similar NWT criteria; therefore, there is no compliance issue. The predictions for the Project are considered conservative; as such, the predictions are intended to overestimate rather than underestimate the effect.

Follow-up noise monitoring will be done once the Project is in operation to verify the modelling and resulting disturbance area. Long-term monitoring is not contemplated.

The relevant benchmark for sleep disturbance from the project is exceeded for the workers camps with up to 14 dB. There are no regulatory requirements regarding these sound levels. Mitigation measures will be considered during the advanced design stages of the project.

7.II.11 REFERENCES

7.II.11.1 LITERATURE CITED

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7.II.11.2 INTERNET REFERENCES

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7.II.12 ACRONYMS AND GLOSSARY

7.II.12.1 ACRONYMS AND ABBREVIATIONS

Canada	Computer Aided Noise Attenuation
De Beers	De Beers Canada Inc.
EIS	environmental impact statement
ERCB	Alberta Energy Resources Conservation Board
NWT	Northwest Territories
PPV	peak particle velocity
Project	Gahcho Kué Project
SD	scaled distance
Terms of Reference	*Terms of Reference for the Gahcho Kué Environmental Impact Statement*
VC	valued component
W	maximum weight of explosive (kilogram) detonated per delay period
WHO	World Health Organization

7.II.12.2 UNITS OF MEASURE

%	percent
±	plus or minus
≥	greater than or equal to
°	degree
°C	degrees Celsius
dB	decibel
dBA	A-weighted decibel
dBL	linear decibel
ft/lb	feet per pound
g/cm^3	gram per cubic centimetre
kg	kilogram
km	kilometre
L_{eq}	equivalent continuous sound and noise level
L_{max}	maximum sound and noise level
L_{peak}	peak sound and noise level
L_W	sound power level
m	metre

m/kg	metre per kilogram
mm	millimetre
mm/s	millimetre per second

7.II.12.3 GLOSSARY

Ambient Noise	The pre-existing sound environment of a location, before the introduction of, or in absence of, noise from a specific source which also affects the sound environment of that location.
Atmospheric effects	Refers to how acoustic energy is absorbed by the atmosphere; the amount of absorption depends on the temperature and humidity of the atmosphere.
Attenuation	The process by which a compound is reduced in concentration over time, through adsorption, degradation, dilution and/or transformation.
A-weighted decibel	A unit of sound or noise that has been filtered so the result is similar to the frequency response of the human ear.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Benchmark	A standard or point of reference against which something is measured.
Carnivore	An animal that preys on other animals; especially any mammal of the Order Carnivora including wolves, bears and wolverine.
Cumulative Effects	The effects of one project with consideration of current conditions, other existing projects, other approved projects and typically, other planned projects.
Decibel	A unit that measures the volume of sound or noise expressed on a logarithmic scale.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental impact of a project.
Equivalent Continuous Noise Level (L_{eq})	The equivalent continuous noise level. This is a logarithmic average of the measured or predicted noise levels over a given period of time. This type of average takes into account the natural variability of sound.
Frequency	The number of cycles per second of a passing sound wave at a point. The human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear.
Geometric spreading	Refers to the spreading of sound energy as a result of the expansion of the wavefronts, and has a major effect in almost all sound propagation situations. Sound propagation losses due to spreading are normally expressed in terms of x dB per doubling of distance from the source.
Key Line of Inquiry	Areas of the greatest concern that require the most attention during the environmental impact review and the most rigorous analysis and detail in the Environmental Impact Statement. Their purpose is to ensure a comprehensive analysis of the issues that resulted in significant public concern about the proposed development.
Linear decibel	A linear measurement of sound intensity in watts per square metre.
Material damping	The dissipation of vibratory energy in solid media and structures with time or distance.
Maximum noise level (L_{max})	Short-term noise events such as the passing of a vehicle or an aircraft; usually implies the loudest noise level averaged over one minute.

Noise	The levels of sound that can be heard or measured at a receiver.
Overpressure	Increased atmospheric pressure (positive overpressure), followed by a wave of decreased atmospheric pressure (negative overpressure), produced around the origin of an explosive or violent detonation.
Peak Noise Levels (L_{peak})	Short, impulsive noise events such as blasting which is the highest instantaneous noise level generated.
Peak Particle Velocity	The particles or molecules of a medium are displaced from their random motion in the presence of a sound wave. The speed of the particle during displacement is called the particle velocity. The peak particle velocity is the maximum velocity during a sound vibration.
Receiver	A location where noise levels are measured or predicted.
Sensitive human receptor	Any location where humans are likely to be receiving noise (e.g. typically populated areas such as schools, hospitals, residential areas).
Sound	The acoustic energy generated by natural or human-made sources, including the project activities.
Sound power level Lw	The level of sound power, expressed in decibels relative to a stated reference value of 10^{-12} W.
Source Spectrum	The range of frequencies (measured or identified) within a sound emission.
Subject of Note	An issue that requires serious consideration and a substantive analysis, although it does not have the same priority as a key line of inquiry.
Terms of Reference	Written requirements governing environmental impact assessment implementation, consultations to be held, data to be produced and form/contents of the environmental impact assessment report.
Ungulate	A hoofed, grazing mammal (e.g., caribou, muskox, deer, moose).
Valued Component	Represent physical, biological, cultural, and economic properties of the social-ecological system that are considered to be important by society.
Volume	The loudness of a sound or noise expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a sound or noise that is twice as loud as another will only be three decibels (3 dB) higher. A sound or noise with double the number of decibels is much more than twice as loud. A change of three decibels is also the general threshold at which a person can notice a change in sound volume.

ATTACHMENT 7.II.1

ASSUMPTIONS INCORPORATED INTO THE NOISE MODEL

The following assumptions are incorporated into noise models:

1. Within the ore processing area:

   a. The conveyor and feeder at the primary crusher area are modelled as a transfer tower.

   b. All future and standby pumps are not included.

   c. The screen is modelled as motor noise source with 1,200 rpm, bouncing rock noise is not included.

   d. The conveyors are modelled as a motor source with 400 rpm at the height of 10 m.

   e. All pumps and compressors motors are 1,200 rpm.

   f. The crane in the area 3900 is not part of daily/normal operation.

   g. The primary crusher is not enclosed and only operating 12 hours a day between 7.00 am to 7.00 pm. The noise source is modelled at the height of 16.90 m.

   h. The diesel generator exhaust height is 2 m above the generator casing. The exhaust is fitted a silencer. The silencer ratings is listed as below:

Octave Band Center Frequency (Hz)	31.5	63	125	250	500	1,000	2,000	4,000	8,000
Dynamic Insertion Loss (dB)	15	18	35	32	30	20	20	20	20

   i. The maximum height of the ore stockpile is 15.0 m and Processed Kimberlite rejects stockpile is 18.0 m.

   j. The aggregate crusher plant is modelled in Year 1 operation (2015). The aggregate crusher plant is not considered in Year 5 (2019) and year 8 (2022).

   k. Equipment requiring less than 50 kW power is assumed not a major noise contributor and not included in the noise model.

2. Winter Access Road

   a. The maximum load per year for construction and operation period is modelled. The loads are distributed evenly over 24-hour period.

   b. Heavy trucks travelling at a speed of 30 km/hr are modelled. The trucks are modelled as a line source at the height of 1.5 m.

3. Airstrip operation

   a. Only two types of aircrafts are modelled:

      I. the “large propeller” aircraft is a Lockheed C130 Hercules; and

      II. the “small propeller” aircraft is a DeHavilland Dash 8.

   b. There is only one flight per day during the daytime period. There is no flight operating during the nighttime period.

4. Mine fleet

   a. The following operation year is modelled for noise assessment:

      I. Year 1 (2015) for most mine rock at South Mine Rock;

      II. Year 5 (2019) as all pit 5034, Hearne and Tuzo are at work; and

      III. Year 8, 2022 for the highest production rate.

   b. One unit of 16H grader and 834H rubber tracked dozer are used for haul road maintenance.

   c. Haul road maintenance (grader, dozer and water truck) operates 24-hour. The maintenance crew is assumed travelling at the speed of 15 km/hr.

   d. Drilling operations are modelled in Pit 5034 in Year 1, and Pit Tuzo in Year 5 and 8.

   e. The following table describes the equipment distributions in the noise modelling. The mobile fleet or moving sources are not listed in the table:

Year	Location/Area	Equipment	Number of Units
2015	Pit 5034	RH340B Shovel	2
		RH90C Excavator	1
		994F Front End Loader	1
		793D Haul Truck	3
	South Mine Rock Pile	D10 Track Dozer	2
		793D Haul Truck	2
	Area 4 Coarse Processed Kimberlite	D10 Track Dozer	1
		777F Haul Truck	1
	Primary Crusher	992K Front End Loader	1
		CAT330 Excavator	1
		D6 Dozer	1
		793D Haul Truck	1
	Processed Kimberlite Rejects Stockpile	992K Front End Loader	1
		CAT330 Excavator	1
		777F Haul Truck	1

Year	Location/Area	Equipment	Number of Units
2019	Pit Hearne	RH340B Shovel	1
		RH90C Excavator	1
		777F Haul Truck	1
	Pit Tuzo	RH340B Shovel	1
		994F Front End Loader	1
		793D Haul Truck	3
	Pit 5034	D10 Track Dozer	1
		793D Haul Truck	1
		777F Haul Truck	1
	West Mine Rock Pile	D10 Track Dozer	1
		793D Haul Truck	1
		777F Haul Truck	1
	South Mine Rock Pile	777F Haul Truck	1
	Area 4 Coarse Processed Kimberlite	D10 Track Dozer	1
		777F Haul Truck	1
		793D Haul Truck	1
	Primary Crusher	992K Front End Loader	1
		CAT330 Excavator	1
		D6 Dozer	1
		777F Haul Truck	1
		793D Haul Truck	1
	Processed Kimberlite Rejects Stockpile	992K Front End Loader	1
		CAT330 Excavator	1
		777F Haul Truck	1
		793D Haul Truck	
2022	Pit Tuzo	RH340B Shovel	2
		RH90C Excavator	1
		994F Front End Loader	1
		793D Haul Truck	3
	Pit 5034	D10 Track Dozer	2
		793D Haul Truck	2
	Area 1 and 2 Processed Kimberlite Facility	D10 Track Dozer	1
		777F Haul Truck	1
	Primary Crusher	992K Front End Loader	1
		CAT330 Excavator	1
		D6 Dozer	1
		777F Haul Truck	1
		793D Haul Truck	1
	Processed Kimberlite Rejects Stockpile	992K Front End Loader	1
		CAT330 Excavator	1
		777F Haul Truck	1

APPENDIX 7.III

ABSOLUTE VALUES FOR CHANGES IN LANDSCAPE METRICS IN THE STUDY AREAS FOR CARIBOU

Table 7.III-I Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) for the Bathurst Caribou Herd (Northern Migration)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	22,000	21,956	21,956	21,944	4,329	4,319	4,319	4,317	1,701	1,703	1,701	1,702
Non-vegetated	3,858,744	3,855,640	3,855,660	3,855,168	789	794	792	794	2,852	2,824	2,840	2,831
Forest	5,903,556	5,901,672	5,901,060	5,898,196	1,069	1,071	1,079	1,092	1,442	1,440	1,433	1,419
Heath rock	1,428,552	1,427,060	1,427,104	1,427,064	1,066	1,074	1,072	1,072	1,381	1,373	1,375	1,375
Heath tundra	6,682,876	6,677,160	6,676,856	6,673,636	834	838	842	848	1,610	1,606	1,601	1,593
Lichen veneer	452,268	451,924	451,944	451,944	142	142	142	142	3,396	3,396	3,396	3,396
Rock association	4,839,828	4,835,140	4,834,748	4,833,556	1,497	1,506	1,508	1,518	1,591	1,569	1,566	1,558
Sedge association	131,496	131,404	131,404	131,352	176	176	176	177	5,334	5,334	5,334	5,295
Low shrub	34,268	34,268	34,268	34,268	21	21	21	21	21,748	21,748	21,748	21,748
Riparian shrub	688,316	688,064	688,056	687,672	794	797	796	798	2,844	2,828	2,832	2,825
Old burn	273,568	273,248	273,232	272,788	209	210	210	211	5,947	5,913	5,913	5,883
Young burn	611,392	611,136	611,116	610,924	210	212	212	214	3,741	3,527	3,527	3,491

ha= hectares; m = metres

Table 7.III-2 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) for the Bathurst Caribou Herd (Summer)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	12,640	12,596	12,596	12,584	2,496	2,486	2,486	2,484	1,723	1,728	1,724	1,725
Non-vegetated	1,662,588	1,660,320	1,660,368	1,659,928	272	275	274	276	3,544	3,508	3,521	3,490
Forest	1,513,160	1,512,268	1,511,604	1,510,132	707	710	717	728	1,549	1,545	1,535	1,515
Heath rock	887,108	885,856	885,900	885,860	658	667	666	666	1,533	1,517	1,520	1,520
Heath tundra	5,241,388	5,235,988	5,235,684	5,232,464	496	501	504	510	1,187	1,183	1,179	1,169
Lichen veneer	96,632	96,544	96,544	96,544	60	60	60	60	3,487	3,487	3,487	3,487
Rock association	2,418,576	2,414,856	2,414,468	2,413,408	763	770	772	777	1,634	1,616	1,611	1,603
Sedge association	167,596	167,492	167,492	167,440	196	196	196	197	3,969	3,969	3,969	3,940
Low shrub	13,660	13,660	13,660	13,660	12	12	12	12	31,373	31,373	31,373	31,373
Riparian shrub	378,960	378,816	378,816	378,456	444	446	445	447	2,420	2,410	2,416	2,405
Old burn	7,300	7,248	7,244	7,244	6	6	6	6	75,269	75,269	75,269	75,269
Young burn	18,928	18,748	18,732	18,732	13	15	15	15	8,882	5,158	5,160	5,160

ha= hectares; m = metres

Table 7.III-3 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) for the Bathurst Caribou Herd (Autumn)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	17,160	17,116	17,116	17,104	3,408	3,398	3,398	3,396	1,768	1,771	1,769	1,769
Non-vegetated	3,038,316	3,034,940	3,034,964	3,034,472	673	680	677	679	2,812	2,775	2,794	2,784
Forest	5,649,708	5,646,024	5,645,328	5,642,576	952	957	965	978	1,308	1,302	1,295	1,281
Heath rock	735,036	733,896	733,920	733,880	594	601	600	600	1,589	1,573	1,576	1,576
Heath tundra	5,474,612	5,469,100	5,468,852	5,465,632	744	748	752	758	1,527	1,523	1,518	1,509
Lichen veneer	228,576	228,316	228,328	228,328	62	62	62	62	2,910	2,910	2,910	2,910
Rock association	2,926,068	2,920,048	2,919,728	2,918,536	1,123	1,137	1,142	1,152	1,723	1,687	1,679	1,667
Sedge association	218,944	218,856	218,860	218,808	255	255	255	256	3,986	3,986	3,986	3,964
Low shrub	3,976	3,976	3,976	3,976	9	9	9	9	35,337	35,337	35,337	35,337
Riparian shrub	932,628	932,116	932,116	931,732	873	876	875	877	2,267	2,254	2,257	2,252
Old burn	196,432	196,128	196,108	195,832	130	131	131	132	8,775	8,699	8,699	8,631
Young burn	354,328	353,932	353,916	353,724	174	177	177	179	3,681	3,343	3,343	3,303

ha= hectares; m = metres

Table 7.III-4 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) for the Bathurst Caribou Herd (Winter)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	19,848	19,832	19,832	19,828	3,850	3,848	3,848	3,847	1,682	1,684	1,684	1,684
Non-vegetated	4,515,576	4,503,268	4,503,252	4,500,276	1,087	1,111	1,111	1,121	2,604	2,549	2,549	2,514
Forest	11,514,780	11,495,896	11,495,320	11,491,496	1,009	1,026	1,031	1,042	1,148	1,134	1,131	1,121
Heath rock	109,504	109,424	109,424	109,424	134	134	134	134	3,401	3,401	3,401	3,401
Heath tundra	2,672,968	2,671,212	2,670,992	2,669,280	566	568	569	573	2,269	2,212	2,210	2,198
Lichen veneer	1,424	1,424	1,424	1,424	3	3	3	3	198,215	198,215	198,215	198,215
Rock association	2,155,668	2,150,652	2,150,312	2,149,372	1,034	1,050	1,054	1,063	2,127	2,062	2,054	2,039
Sedge association	92,288	92,204	92,204	92,204	119	119	119	119	6,685	6,685	6,685	6,685
Low shrub	1,308	1,308	1,308	1,308	4	4	4	4	112,775	112,775	112,775	112,775
Riparian shrub	1,869,408	1,868,428	1,868,428	1,867,368	1,342	1,347	1,347	1,350	2,067	2,052	2,052	2,048
Old burn	788,732	788,168	788,168	787,400	570	572	572	573	3,437	3,419	3,419	3,413
Young burn	1,643,596	1,642,332	1,642,332	1,641,020	453	455	455	458	3,699	3,659	3,659	3,636

ha= hectares; m = metres

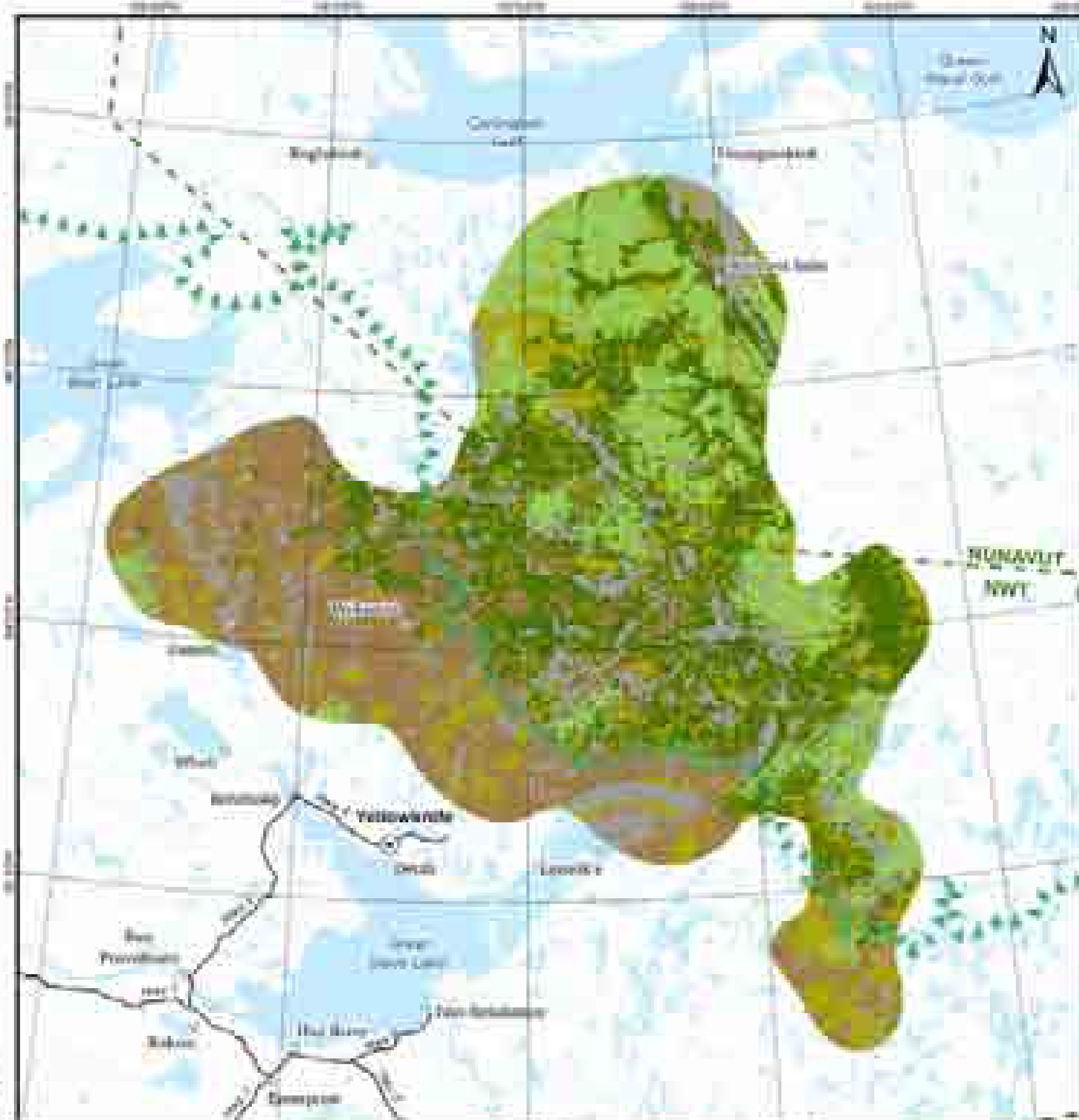
Table 7.III-5 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) for the Ahiak Caribou Herd (Winter)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	22,272.00	22,252.00	22,252.00	22,244.00	4,333.00	4,328.00	4,328.00	4,326.00	1,668.55	1,672.28	1,672.28	1,672.65
Non-vegetated	2,648,080.00	2,641,212.00	2,641,196.00	2,639,344.00	604.00	607.00	607.00	610.00	3,563.24	3,542.08	3,542.08	3,503.88
Forest	3,510,368.00	3,509,368.00	3,508,792.00	3,505,744.00	862.00	868.00	873.00	886.00	1,756.51	1,745.56	1,739.33	1,716.23
Heath rock	2,113,536.00	2,113,164.00	2,113,164.00	2,113,124.00	1,543.00	1,545.00	1,545.00	1,545.00	1,209.98	1,209.70	1,209.70	1,209.70
Heath tundra	6,372,196.00	6,369,420.00	6,369,200.00	6,366,264.00	768.00	770.00	771.00	778.00	1,672.50	1,670.34	1,669.57	1,658.15
Lichen veneer	766,024.00	766,024.00	766,024.00	766,024.00	243.00	243.00	243.00	243.00	2,874.54	2,874.54	2,874.54	2,874.54
Rock association	6,368,832.00	6,367,216.00	6,366,876.00	6,366,192.00	1,358.00	1,364.00	1,368.00	1,377.00	1,344.11	1,339.58	1,335.93	1,329.33
Sedge association	73,824.00	73,732.00	73,732.00	73,680.00	102.00	102.00	102.00	103.00	5,059.61	5,059.61	5,059.61	4,994.87
Low shrub	38,428.00	38,396.00	38,396.00	38,396.00	41.00	41.00	41.00	41.00	10,979.78	10,979.78	10,979.78	10,979.78
Riparian shrub	617,276.00	616,972.00	616,972.00	616,396.00	540.00	541.00	541.00	543.00	2,558.69	2,554.88	2,554.88	2,546.20
Old burn	295,016.00	294,904.00	294,904.00	294,224.00	234.00	234.00	234.00	235.00	4,599.71	4,599.71	4,599.71	4,578.96
Young burn	970,700.00	970,496.00	970,496.00	969,556.00	182.00	184.00	184.00	186.00	3,661.54	3,414.88	3,414.88	3,378.82

ha= hectares; m = metres

APPENDIX 7.IV

RESOURCE SELECTION FUNCTION MAPS FOR BATHURST AND AHIAK CARIBOU SEASONAL HOME RANGES DURING BASELINE, APPLICATION, AND FUTURE SCENARIOS



LEGEND

- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

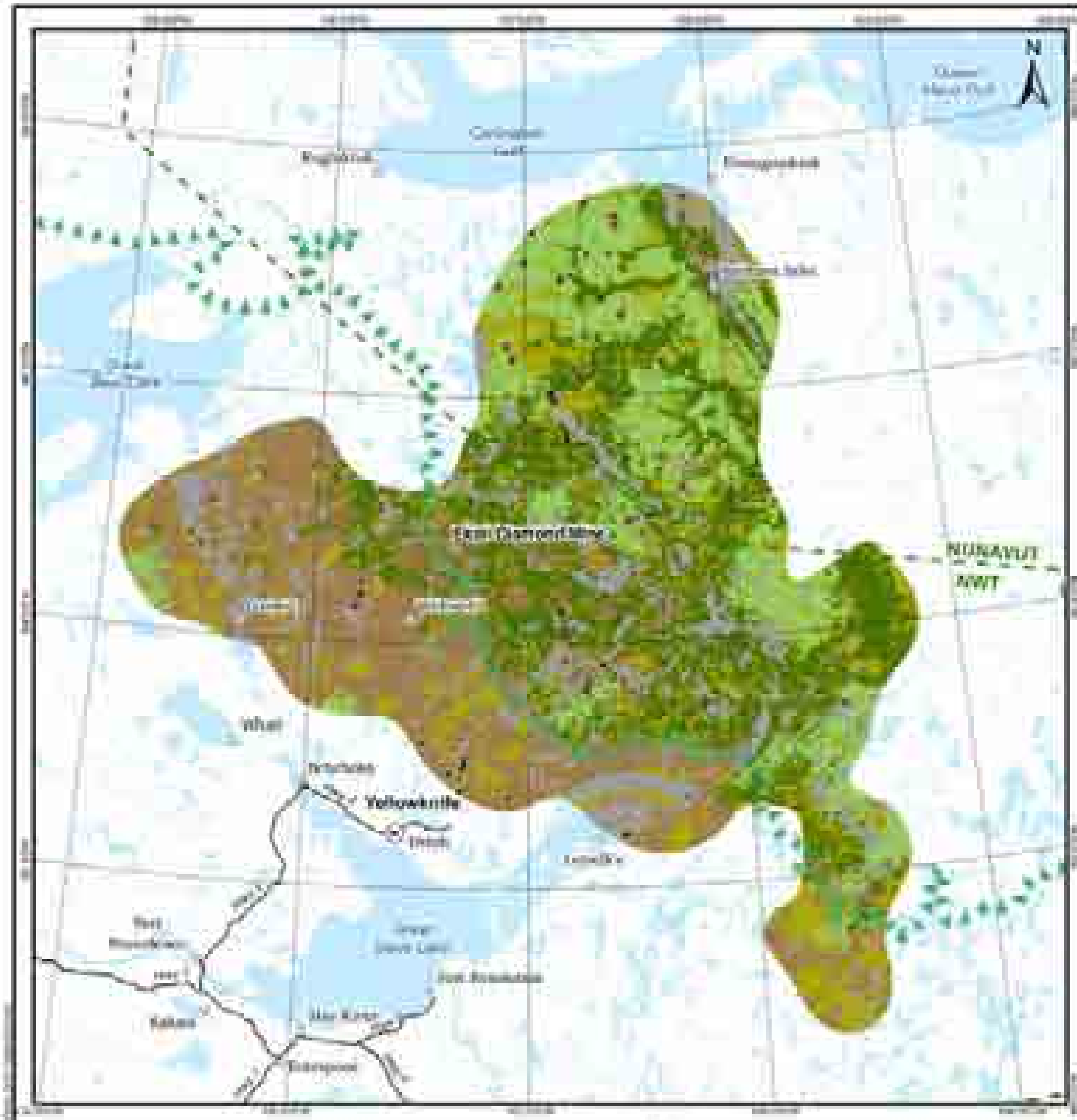
GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Spring: Reference Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE No	KLOI-07-008-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO.	2
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

De Beers

Figure 7.IV-1



LEGEND

- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

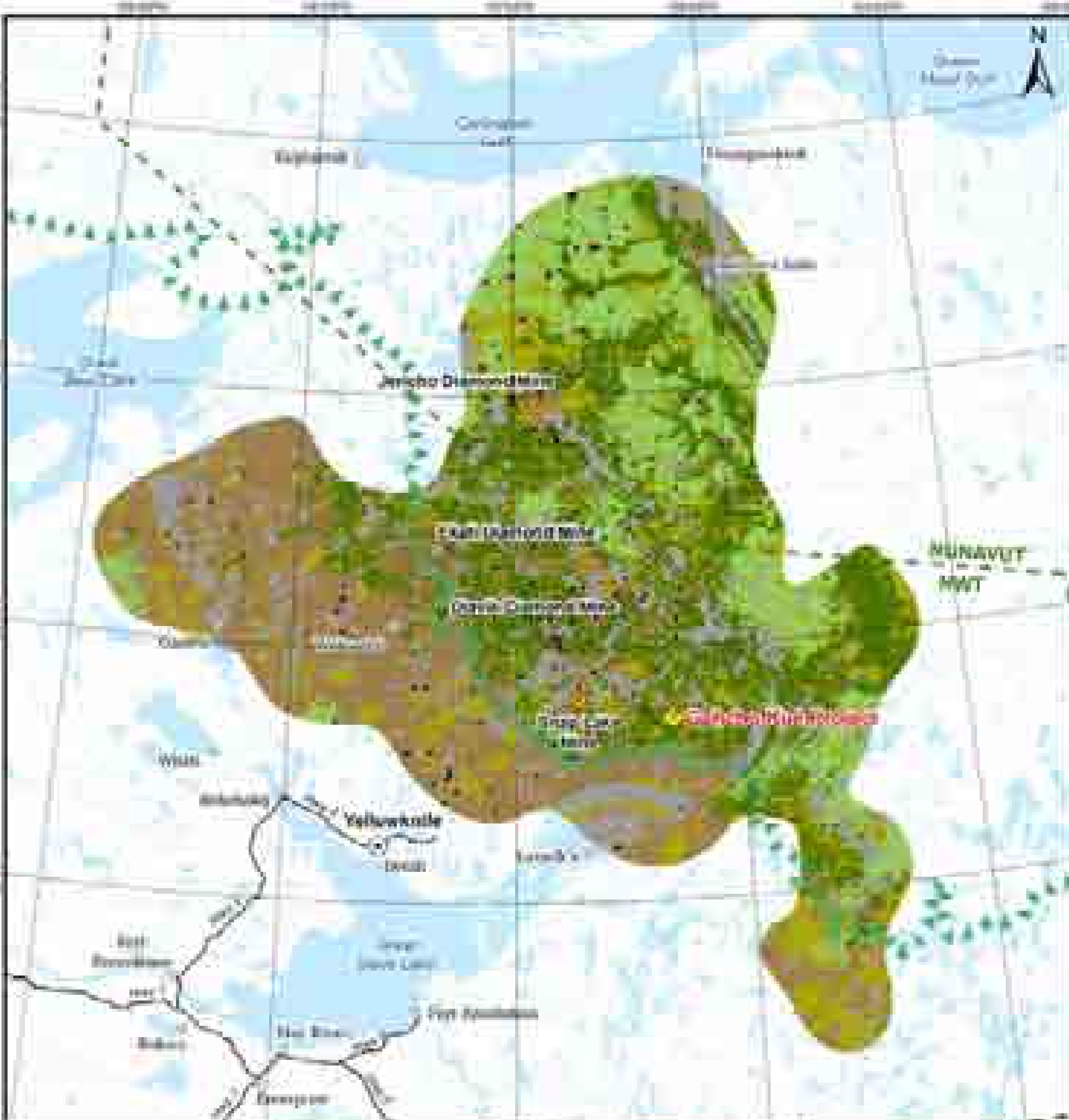
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Spring: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: KLOI-07-009-GIS	DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 5
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

Figure 7.IV-2



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

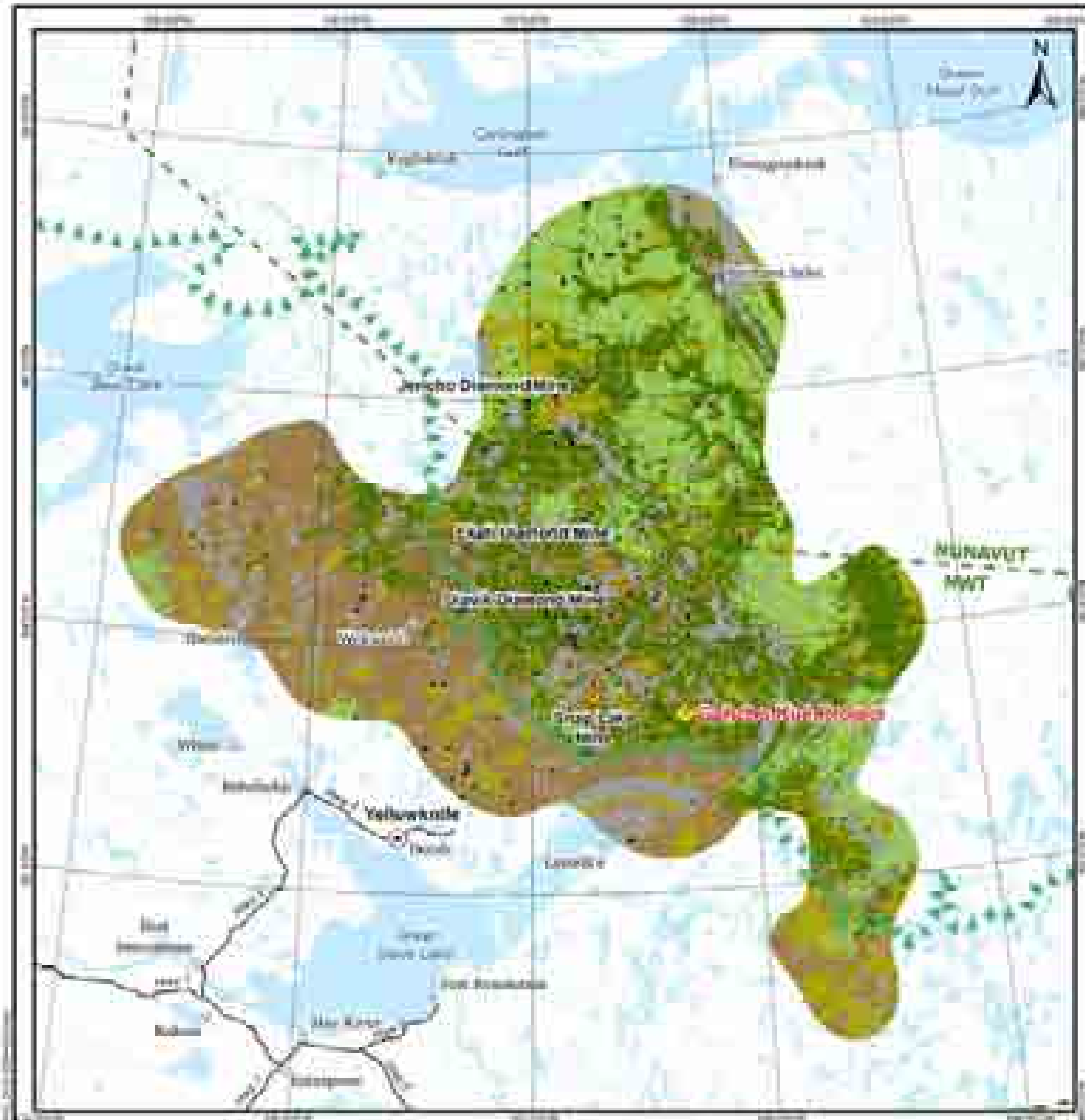
Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Spring: 2006 Baseline Conditions

PROJECTION: Canada Lambert Conformal Conic	DATUM: NAD83		
FILE No: KLOI-07-010-GIS		DATE: November 23, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 7.IV-3



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

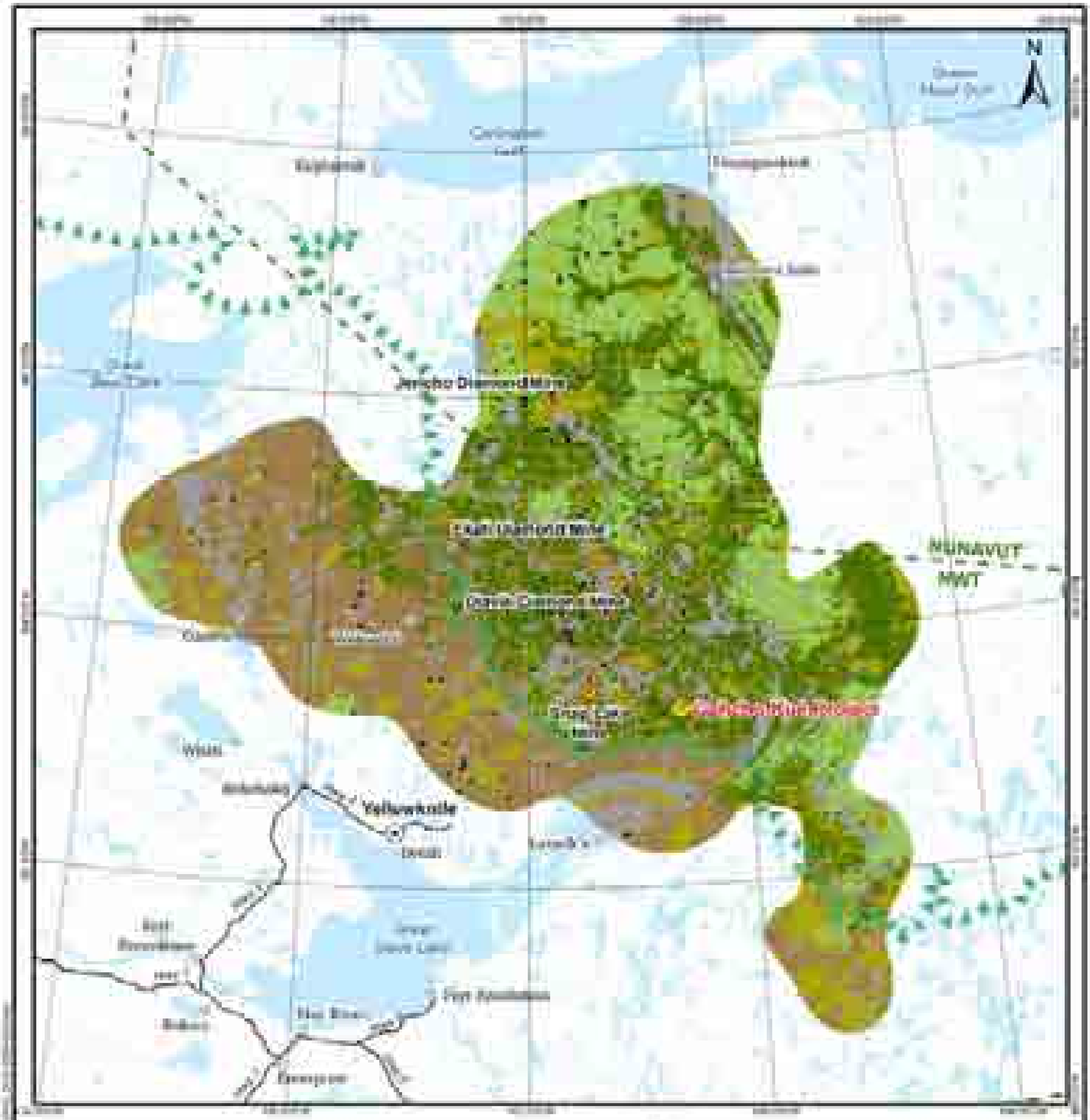
- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Spring: 2010 Baseline Conditions

PROJECTION: Canada Lambert Conf. Conic	DATUM: NAD83		
FILE No: KLOI-07-034-GIS			DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 4		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	**Figure 7.IV-4**

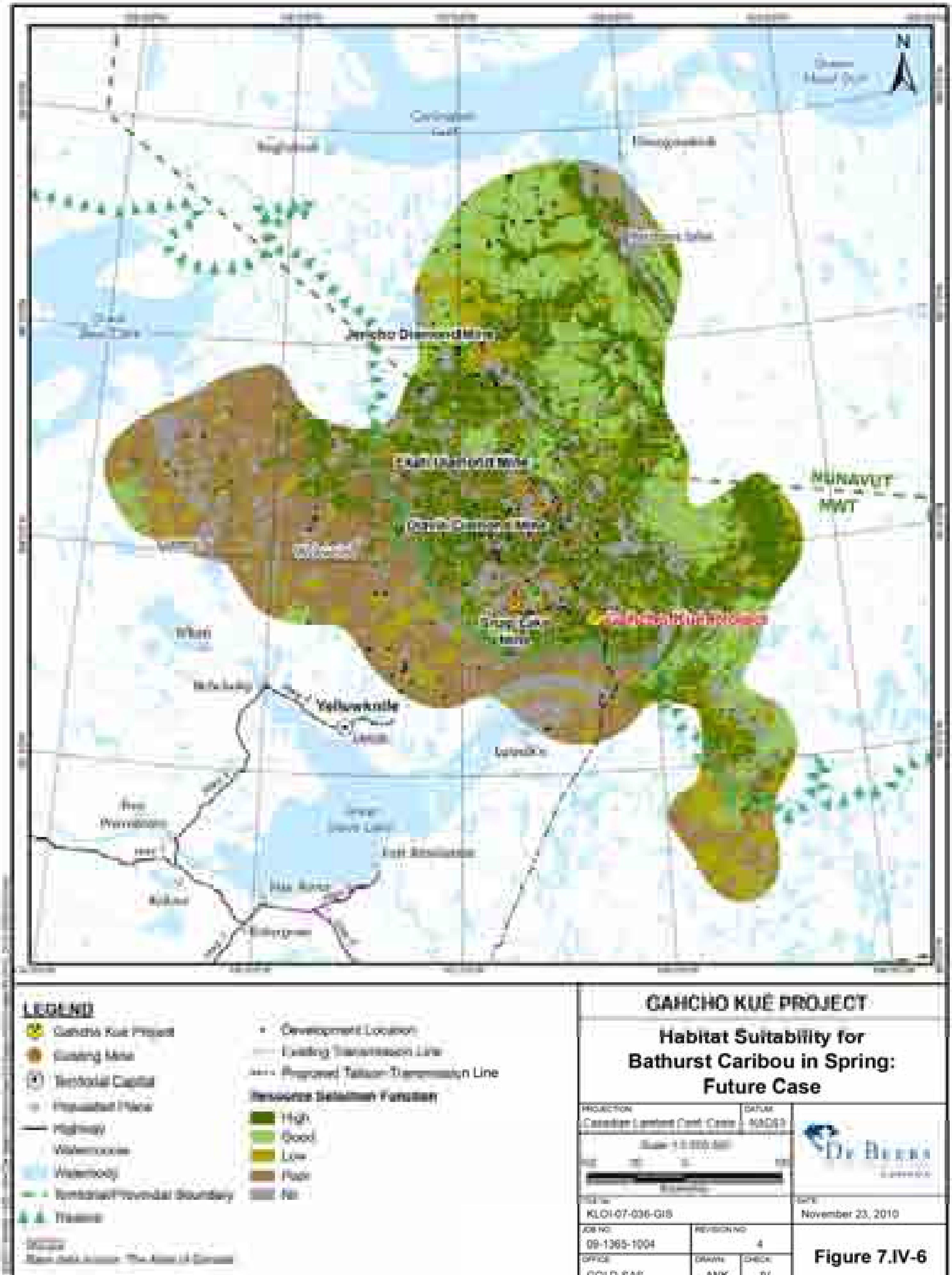


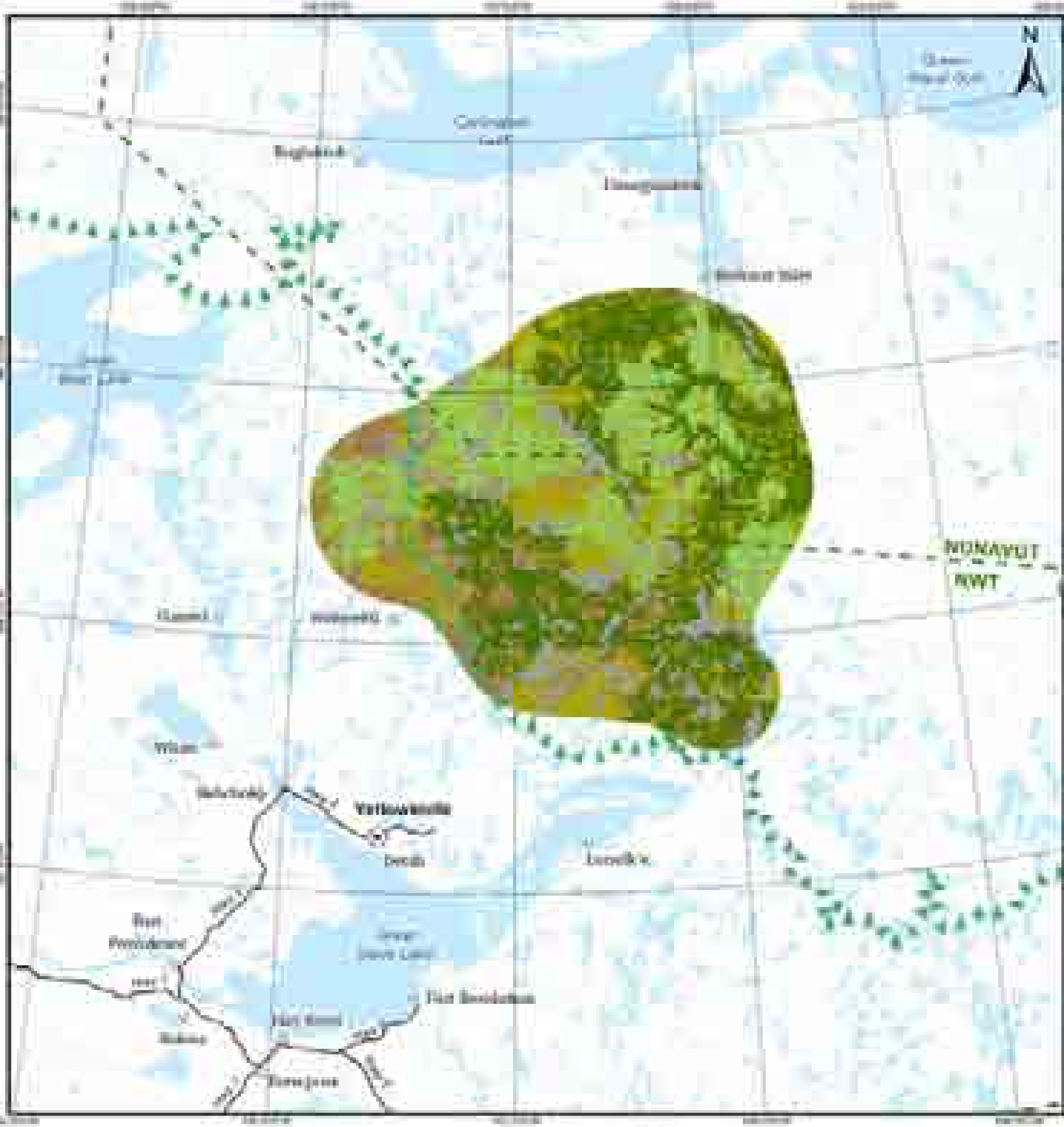
GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Spring: Application Case

FILE No. KLOI-07-035-GIS		DATE November 23, 2010
JOB NO. 09-1365-1004	REVISION NO. 3	
OFFICE GOLD-SAS	DRAWN ANK	CHECK JV

Figure 7.IV-5


N
Jericho Diamond Mine
Ekati Diamond Mine
Diavik Diamond Mine
Snap Lake Mine
NUNAVUT
NWT
Yellowknife
LEGEND
Gahcho Kue Project
Existing Mine
Territorial Capital
Populated Place
Highway
Watercourse
Waterbody
Territorial/Provincial Boundary
Treeline
Development Location
Existing Transmission Line
Proposed Taltson Transmission Line
Resource Selection Function
High
Good
Low
Poor
Nil
GAHCHO KUÉ PROJECT
Habitat Suitability for Bathurst Caribou in Spring: Future Case
PROJECTION
DATUM
NAD83
KLOI-07-036-GIS
DATE
November 23, 2010
JOB NO.
09-1365-1004
REVISION NO.
4
OFFICE
GOLD-SAS
DRAWN
ANK
CHECK
JV
Figure 7.IV-6



LEGEND

- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Post-Calving: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: KLOI-07-011-GIS	DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

Figure 7.IV-7

LEGEND

- Existing Mine
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Post-Calving: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
TITLE No: KLOI-07-012-GIS		DATE: November 23, 2010	
JOB NO: 09-1365-1004	REVISION NO: 5		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 7.IV-8

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Post-Calving: 2006 Baseline Conditions

PROJECTION	DATUM	DATE
Canadian Lambert Conf. Conic	NAD83	November 23, 2010

FILE No.	JOB NO.	REVISION NO.	OFFICE	DRAWN	CHECK
KLOI-07-013-GIS	09-1365-1004	4	GOLD-SAS	ANK	JV

Figure 7.IV-9

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

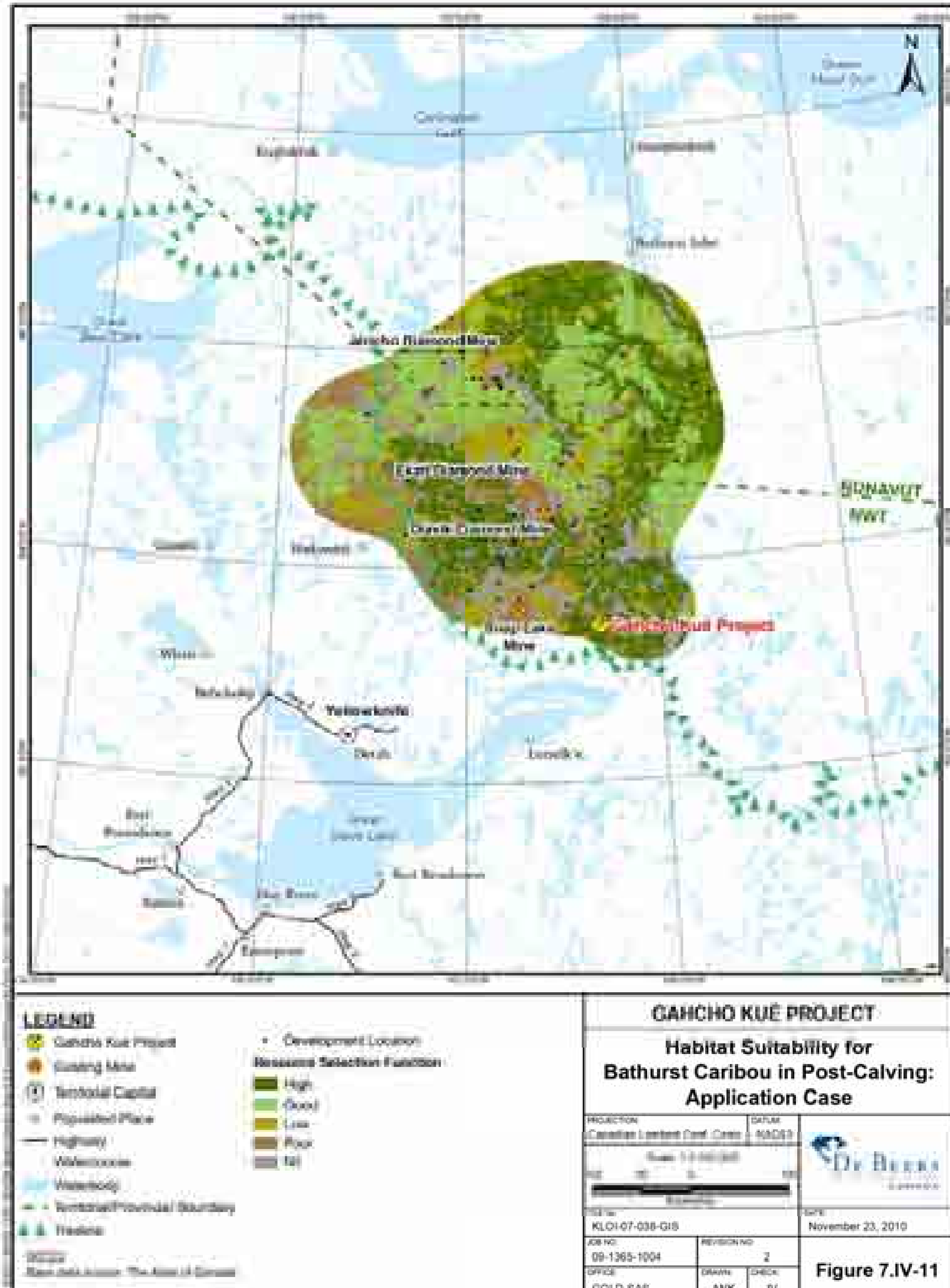
GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Post-Calving: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: KLOI-07-037-GIS	DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 3
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

De Beers

Figure 7.IV-10


N
Jericho Diamond Mine
Ekati Diamond Mine
Diavik Diamond Mine
Snap Lake
Mine
Gahcho Kué Project
Yellowknife
NUNAVUT
NWT
LEGEND
Gahcho Kué Project
Existing Mine
Territorial Capital
Populated Place
Highway
Watercourse
Waterbody
Territorial/Provincial Boundary
Treeline
Development Location
Resource Selection Function
High
Good
Low
Poor
Nil
GAHCHO KUÉ PROJECT
Habitat Suitability for Bathurst Caribou in Post-Calving: Application Case
PROJECTION
DATUM
KLOI-07-038-GIS
November 23, 2010
JOB NO.
09-1365-1004
REVISION NO.
2
OFFICE
GOLD-SAS
DRAWN
ANK
CHECK
JV
Figure 7.IV-11

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Existing Transmission Line
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

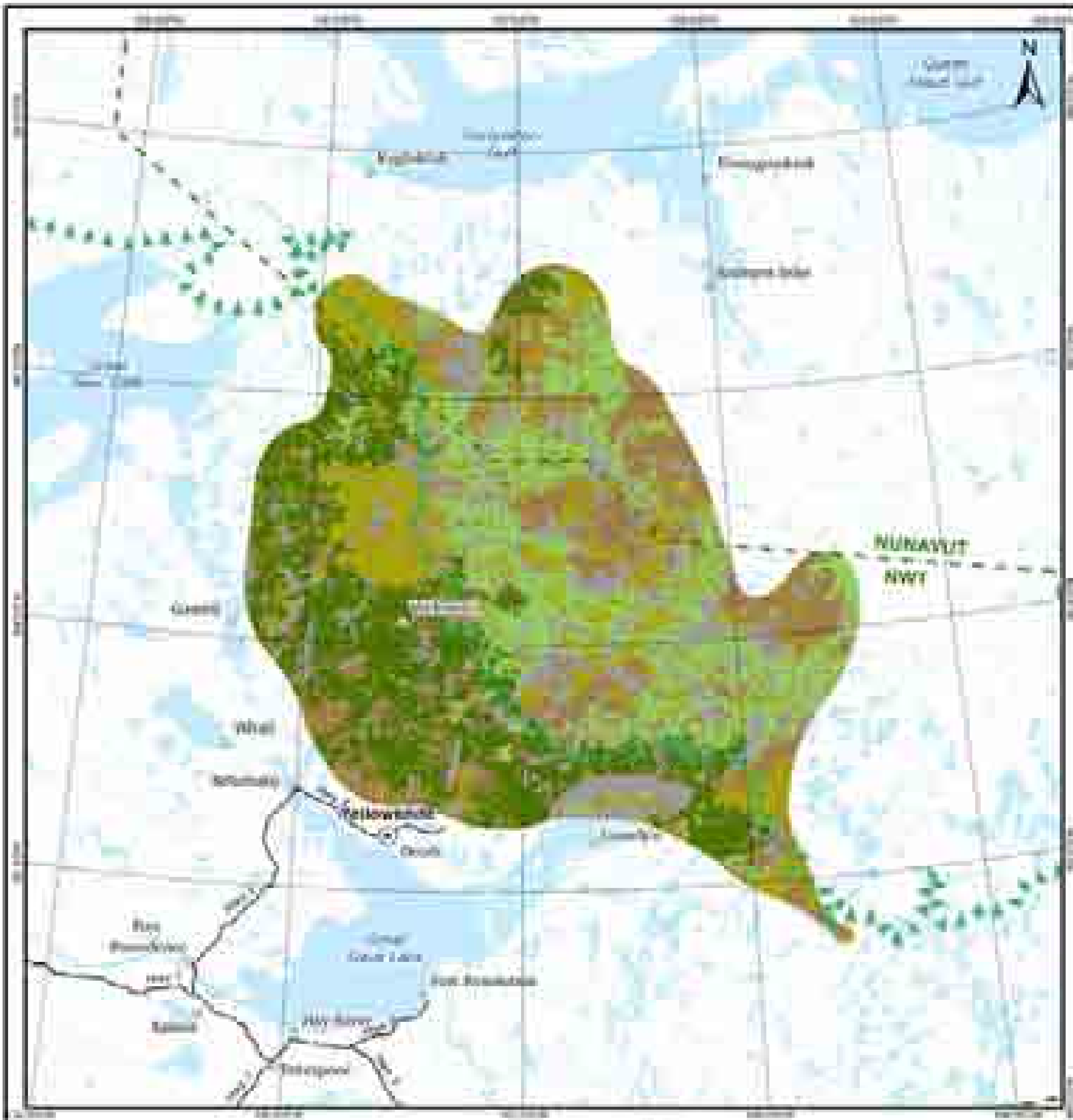
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Post-Calving: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No.: KLOI-07-039-GIS	DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 3
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

Figure 7.IV-12



LEGEND

- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: KLOI-07-005-GIS	DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

Figure 7.IV-13

Legend

- Existing Mine
- Seasonal Camp
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: 2000 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE No.	KLOI-07-006-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO.	4
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

De Beers

Figure 7.IV-14

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: 2006 Baseline Conditions

FILE No	KLOI-07-007-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO.	3
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-15

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

Source:
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: KLOI-07-031-GIS			DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 7.IV-16

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: Application Case

FILE No. KLOI-07-032-GIS		DATE November 23, 2010	
JOB NO. 09-1365-1004	REVISION NO. 2	**Figure 7.IV-17**	
OFFICE GOLD-SAS	DRAWN ANK	CHECK JV	

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Existing Transmission Line
- Proposed Taltson Transmission Line

Resource Selection Function

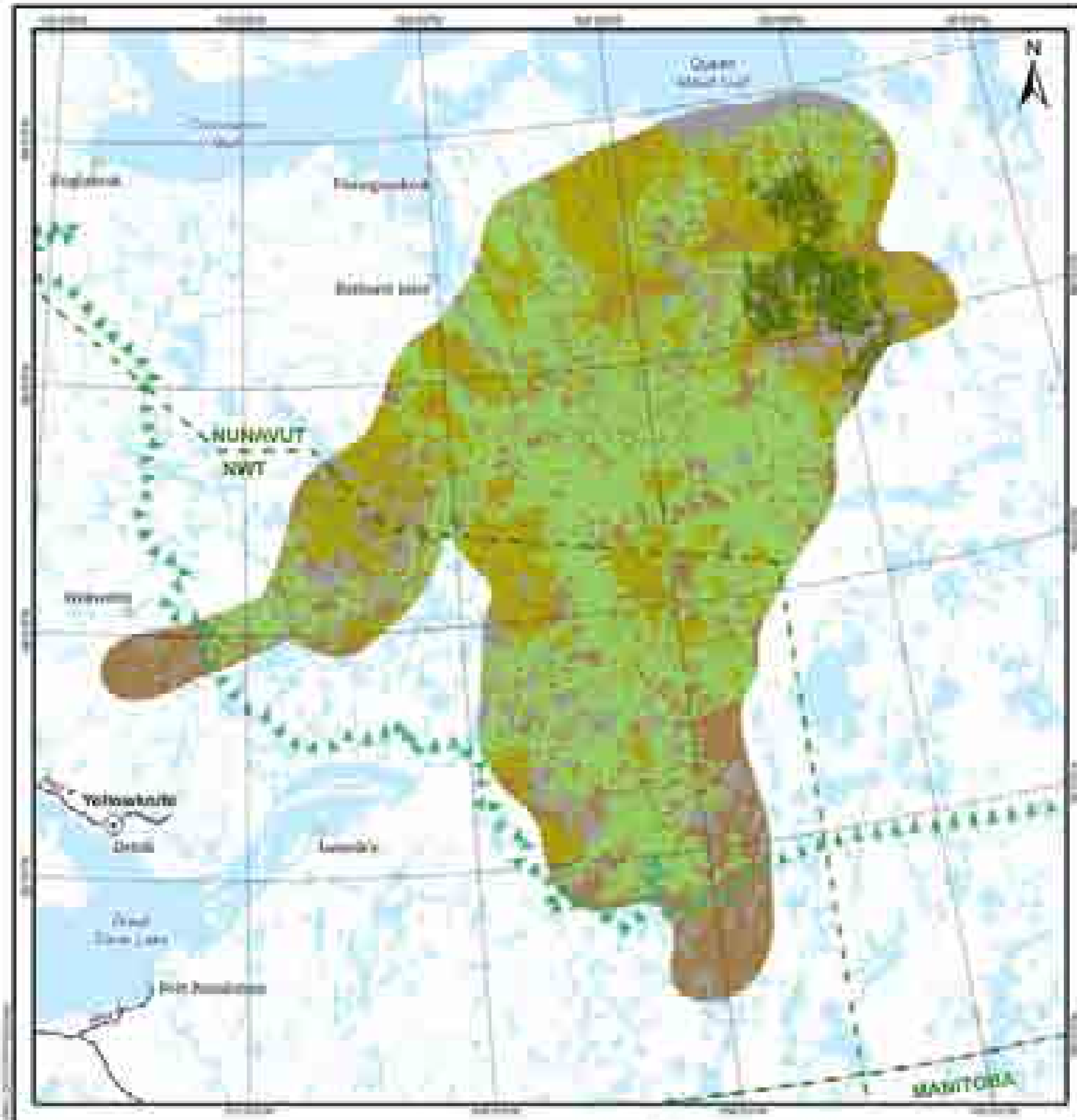
- High
- Good
- Low
- Poor
- Nil

GAHCHO KUÉ PROJECT

Habitat Suitability for Bathurst Caribou in Autumn: Future Case

PROJECTION	DATUM NAD83
FILE No. KLOI-07-033-GIS	DATE November 23, 2010
JOB NO. 09-1365-1004	REVISION NO. 3
OFFICE GOLD-SAS	DRAWN ANK / CHECK JV

Figure 7.IV-18



LEGEND

- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Spring: Reference Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
Scale	1:5,000,000
FILE No.	KLOI-07-017-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO.	3
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-19

LEGEND

- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Rare
- Nil

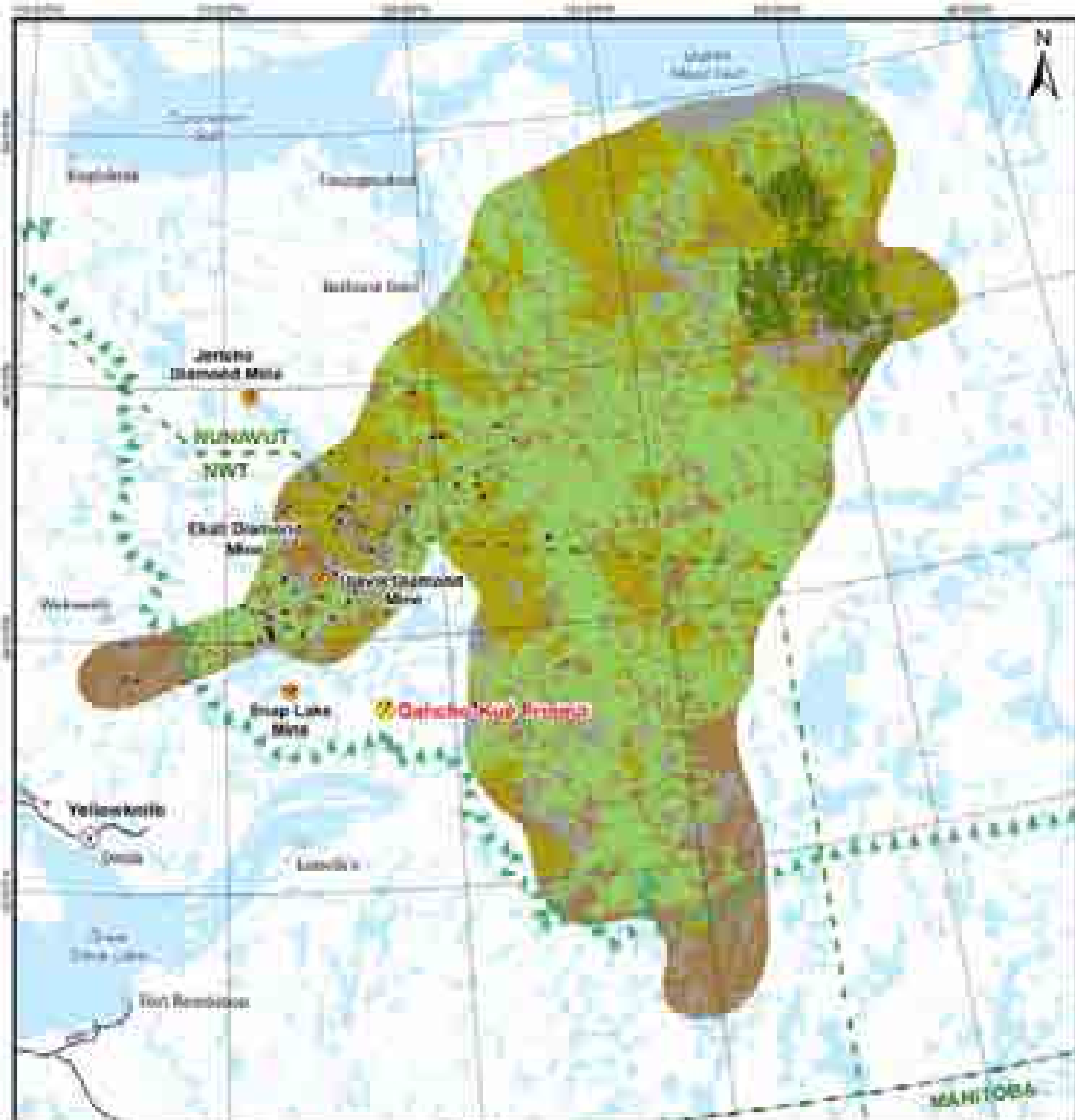
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Spring: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale 1:5,000,000	
FILE No: KLOI-07-018-GIS	DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 4
OFFICE: GOLD-SAS	DRAWN: ANK; CHECK: JV

Figure 7.IV-20



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

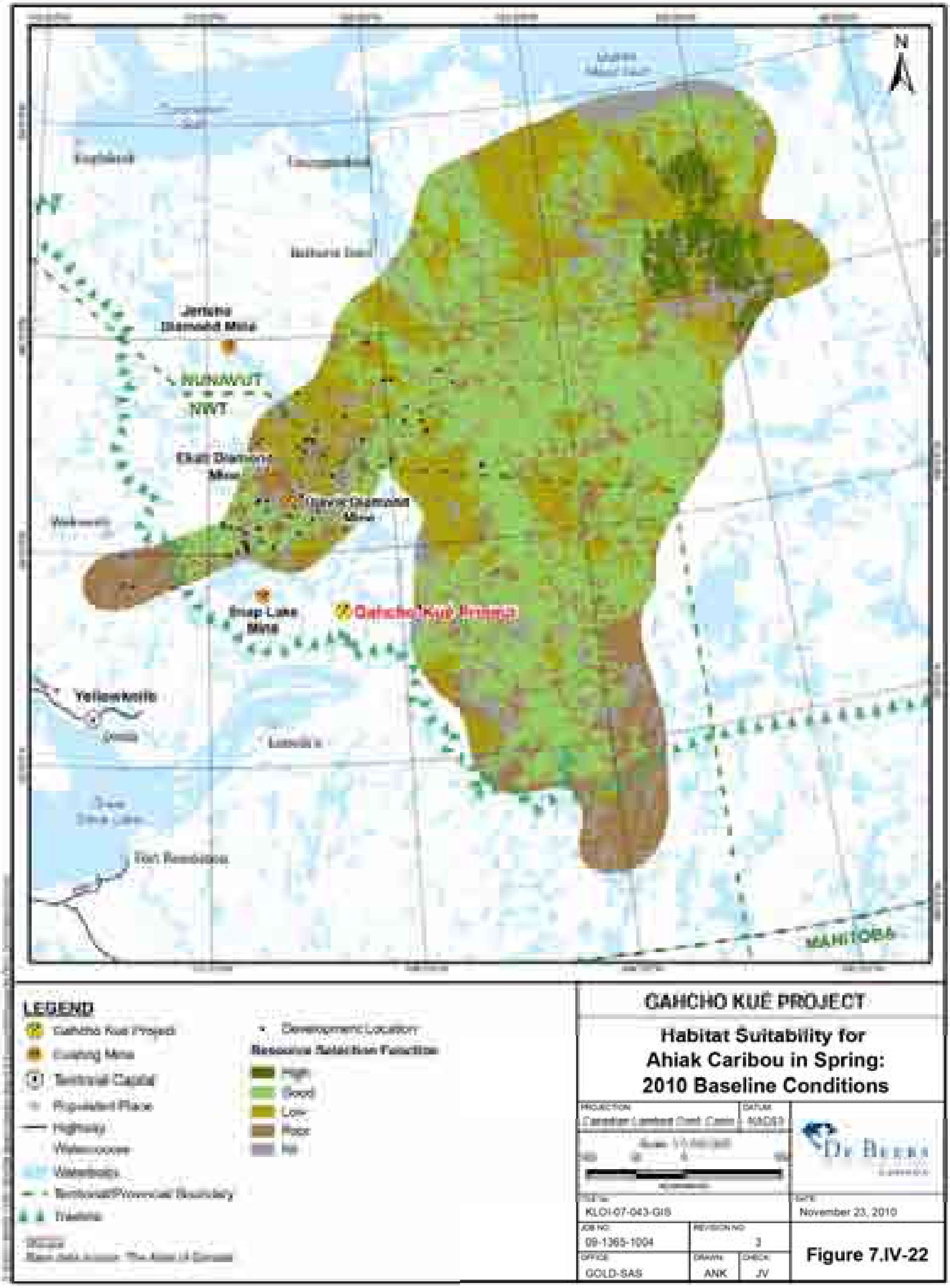
- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

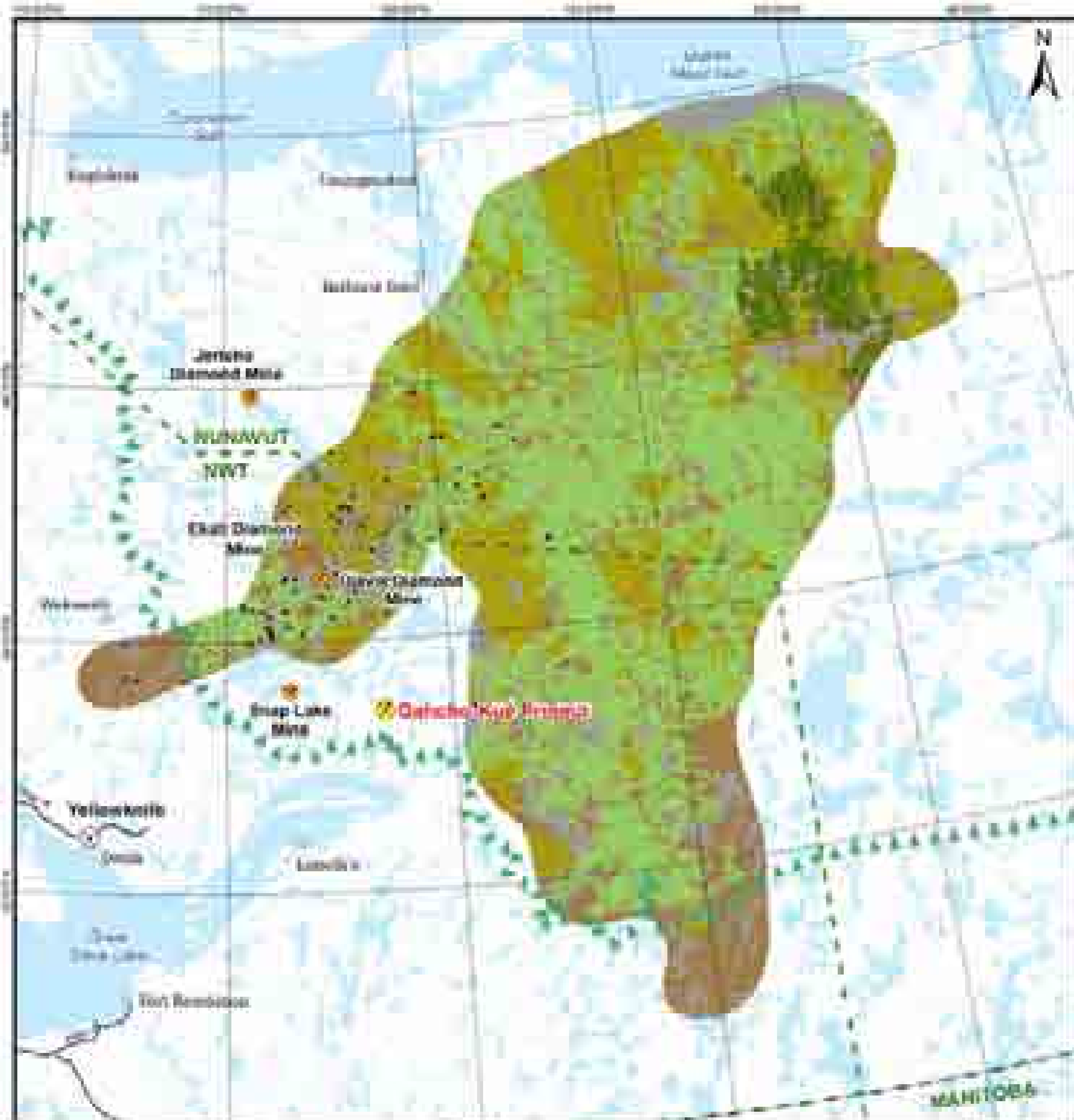
Habitat Suitability for Ahiak Caribou in Spring: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No.: KLOI-07-019-GIS		DATE: November 23, 2010	
JOB NO.: 09-1365-1004	REVISION NO.: 4		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	**Figure 7.IV-21**



Habitat Suitability for Ahiak Caribou in Spring: 2010 Baseline Conditions

Figure 7.IV-22



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

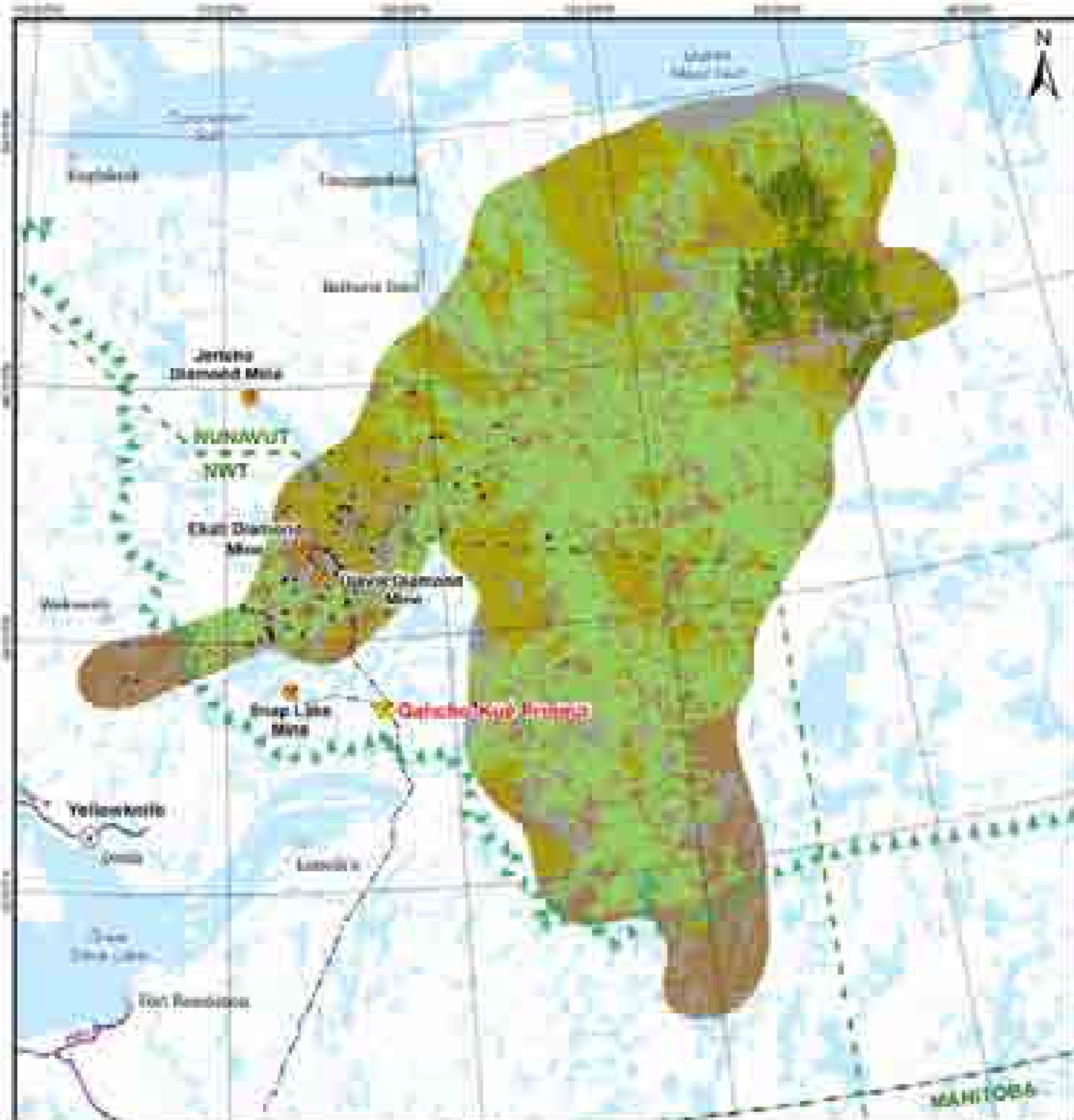
Source:
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Spring: Application Case

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE No.	KLOI-07-044-GIS
DATE	November 23, 2010
JOB No.	09-1365-1004
REVISION No.	2
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-23



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Existing Transmission Line
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

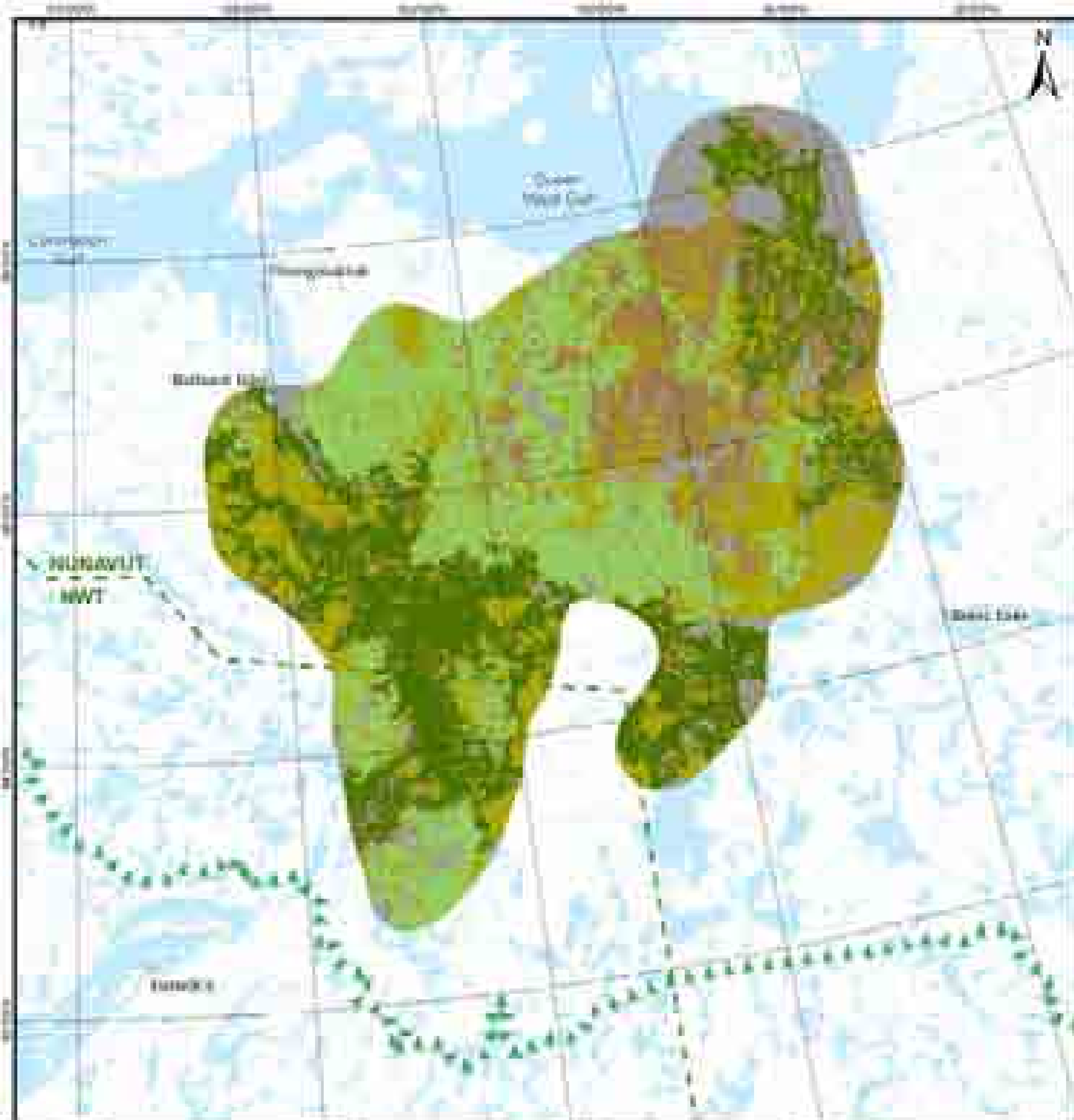
GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Spring: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No.: KLOI-07-045-GIS	DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 3
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

De Beers

Figure 7.IV-24



LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

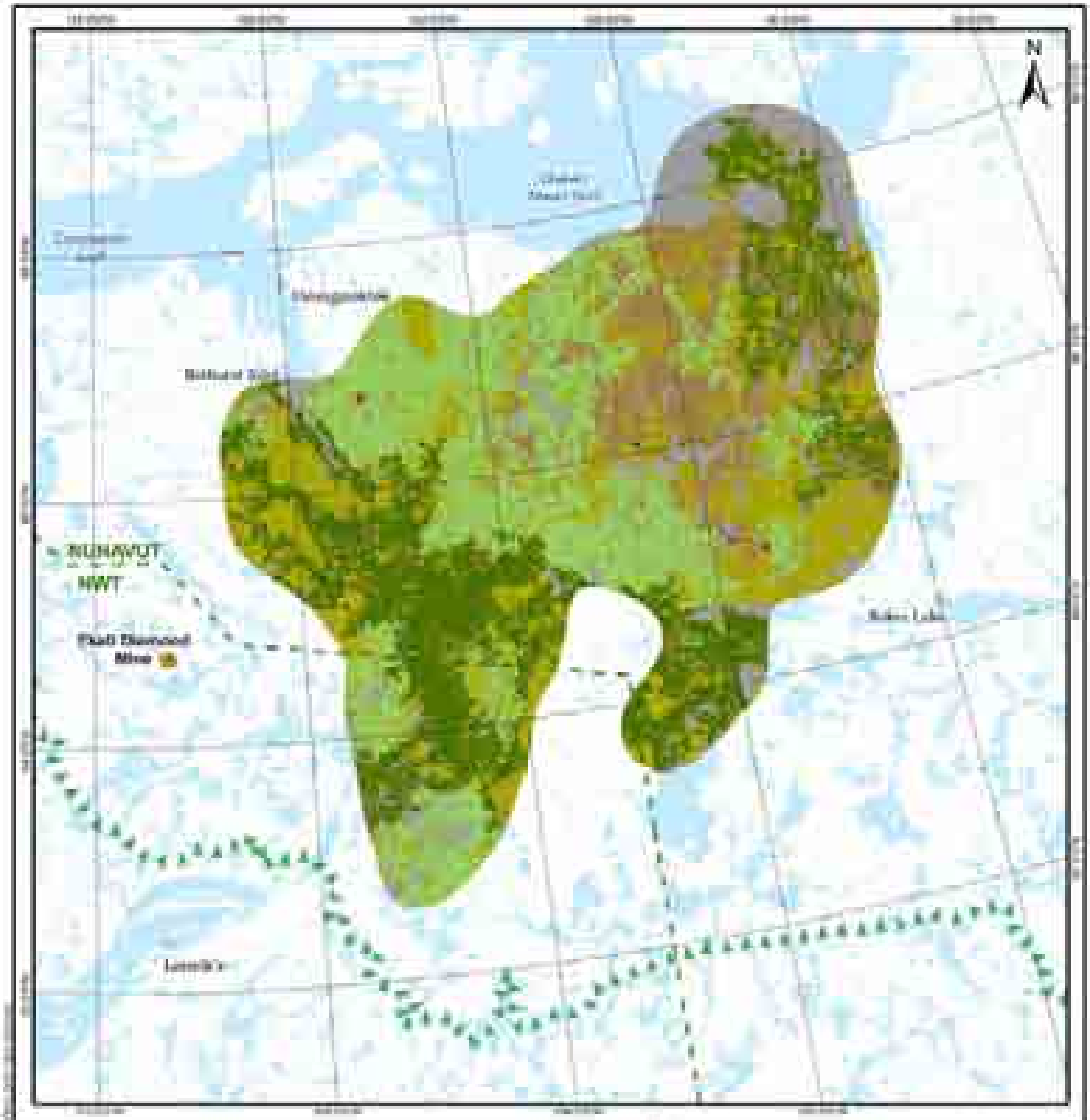
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
FILE No: KLOI-07-020-GIS		DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 3	
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV

Figure 7.IV-25



LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

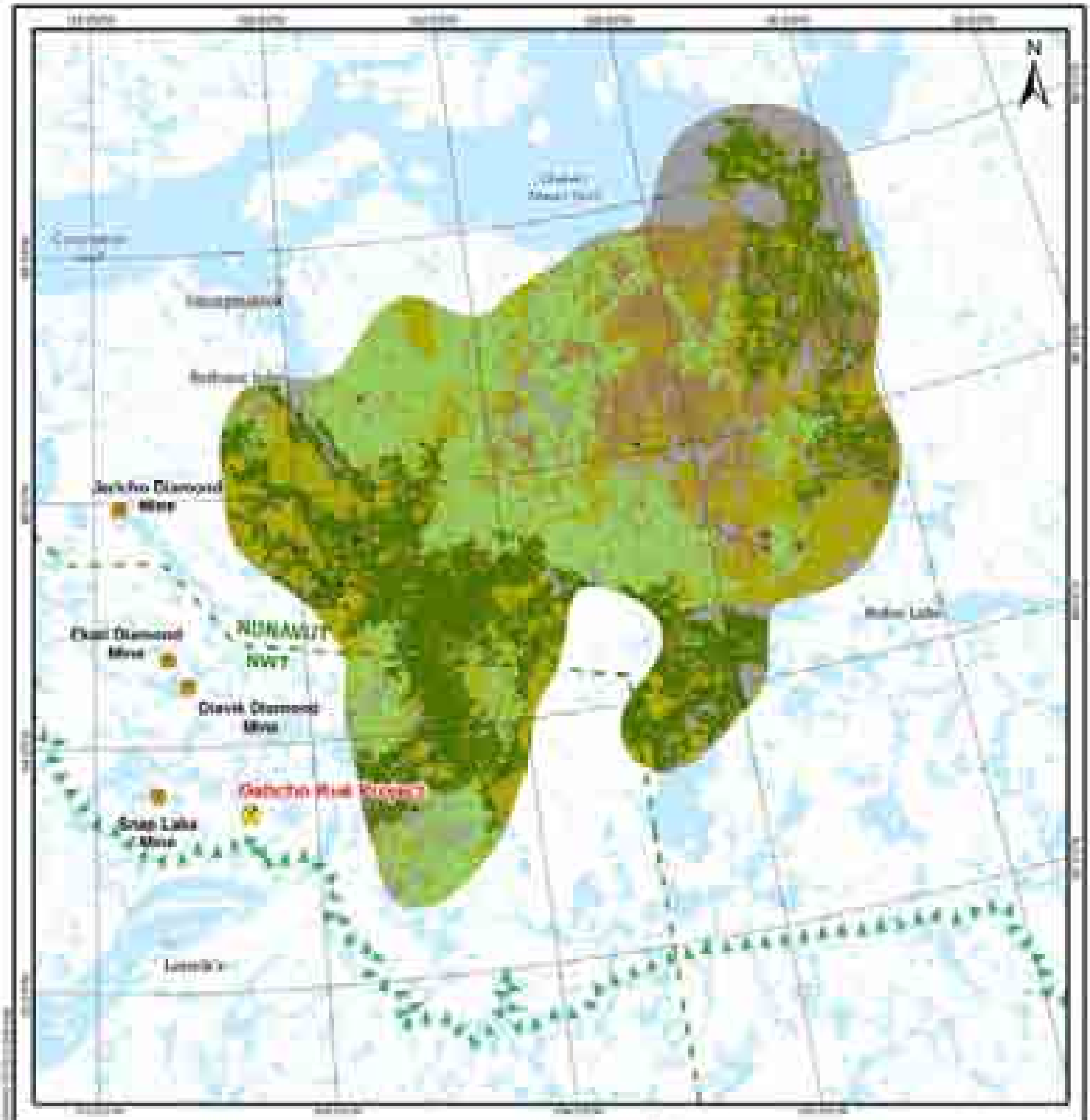
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: 2000 Baseline Conditions

PROJECTION	Canada Lambert Conic Conic
DATUM	NAD83
FILE No	KLOI-07-021-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO	5
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-26



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

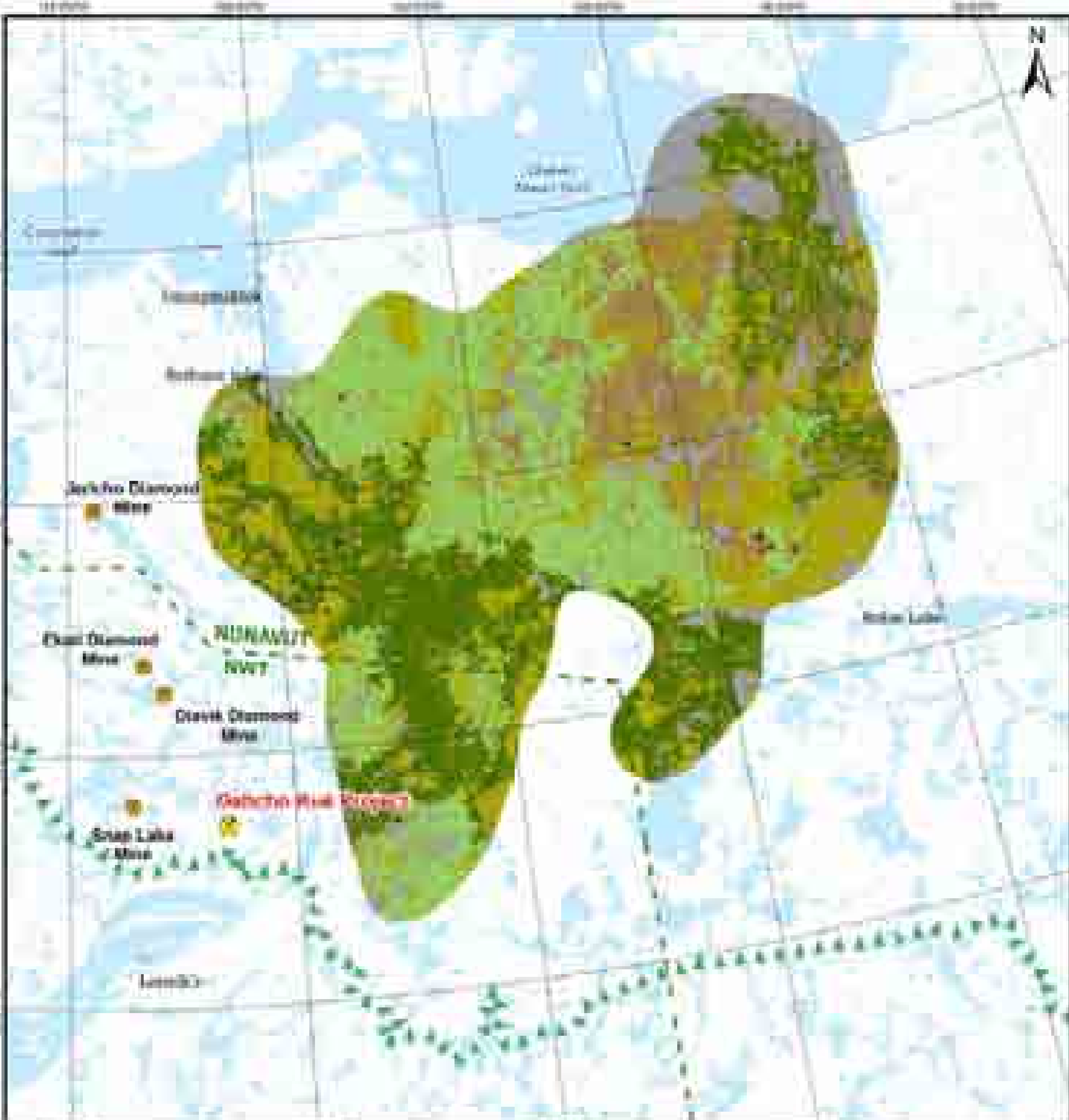
GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: KLOI-07-022-GIS	DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 4
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

De Beers

Figure 7.IV-27



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

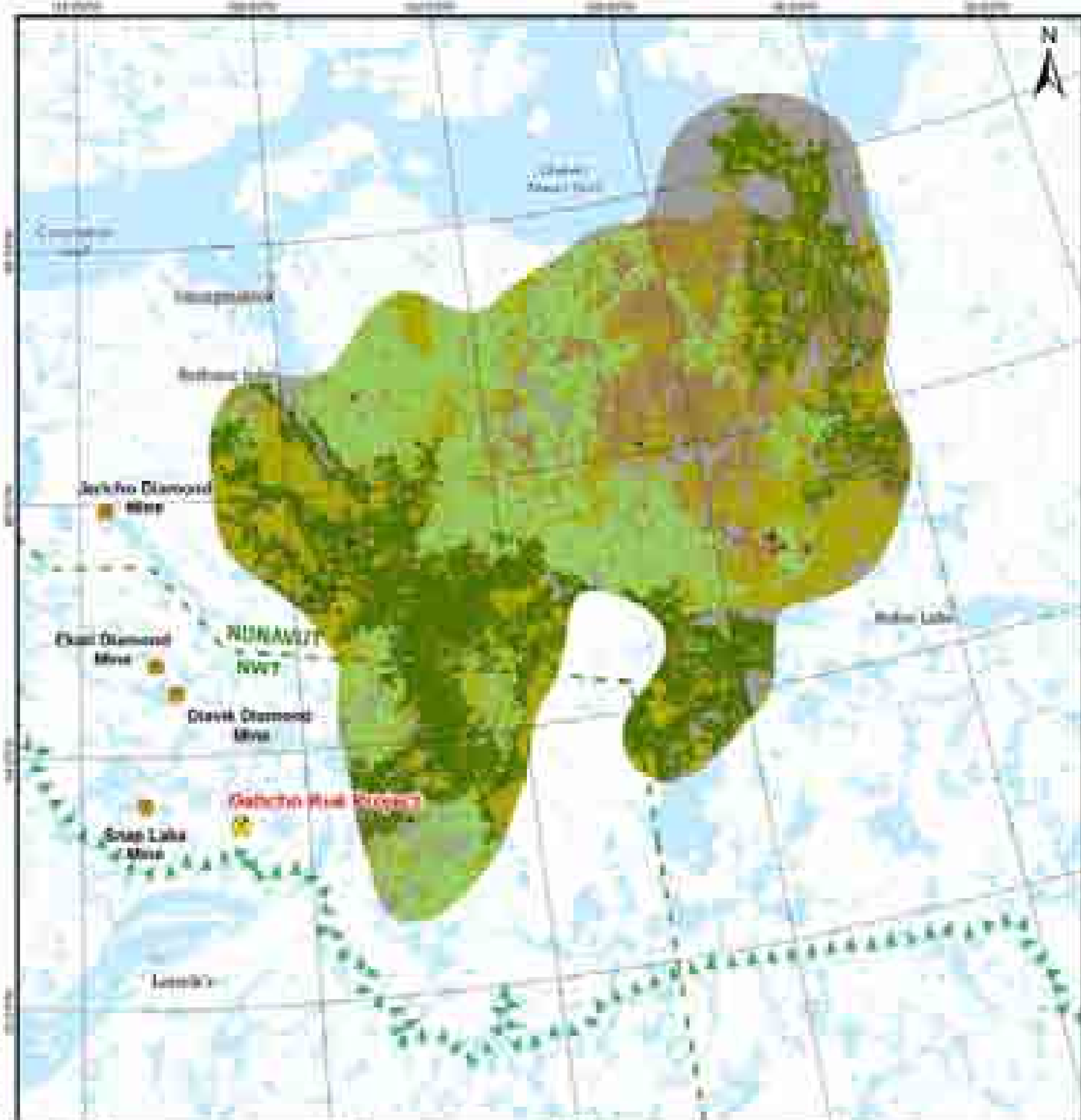
GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: 2010 Baseline Conditions

PROJECTION	DATUM NAD83
FILE No. KLOI-07-046-GIS	DATE November 23, 2010
JOB NO. 09-1365-1004	REVISION NO. 5
OFFICE GOLD-SAS	DRAWN ANK / CHECK JV

De Beers

Figure 7.IV-28



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

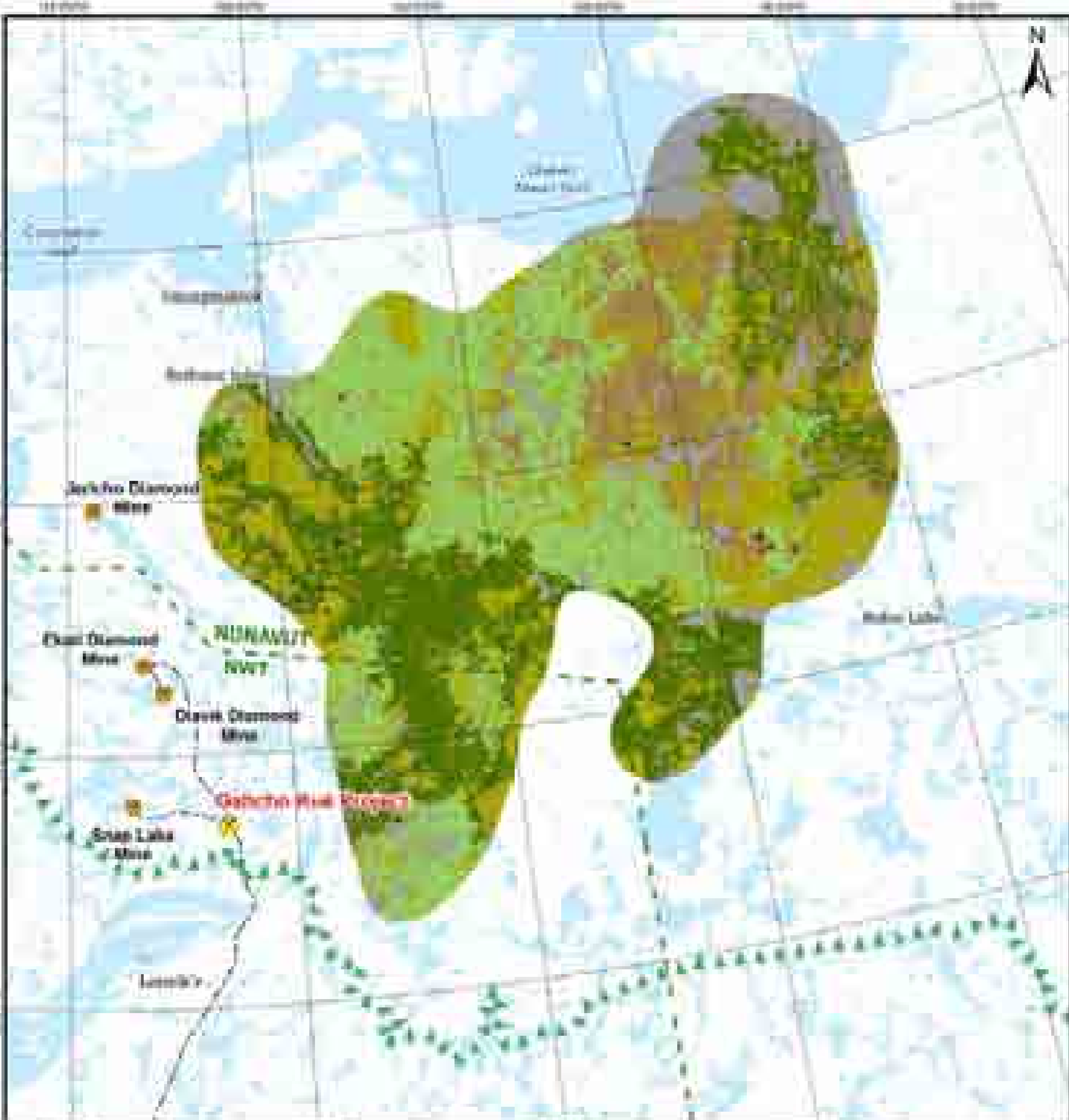
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: Application Case

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE No.	KLOI-07-047-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO.	4
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-29



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

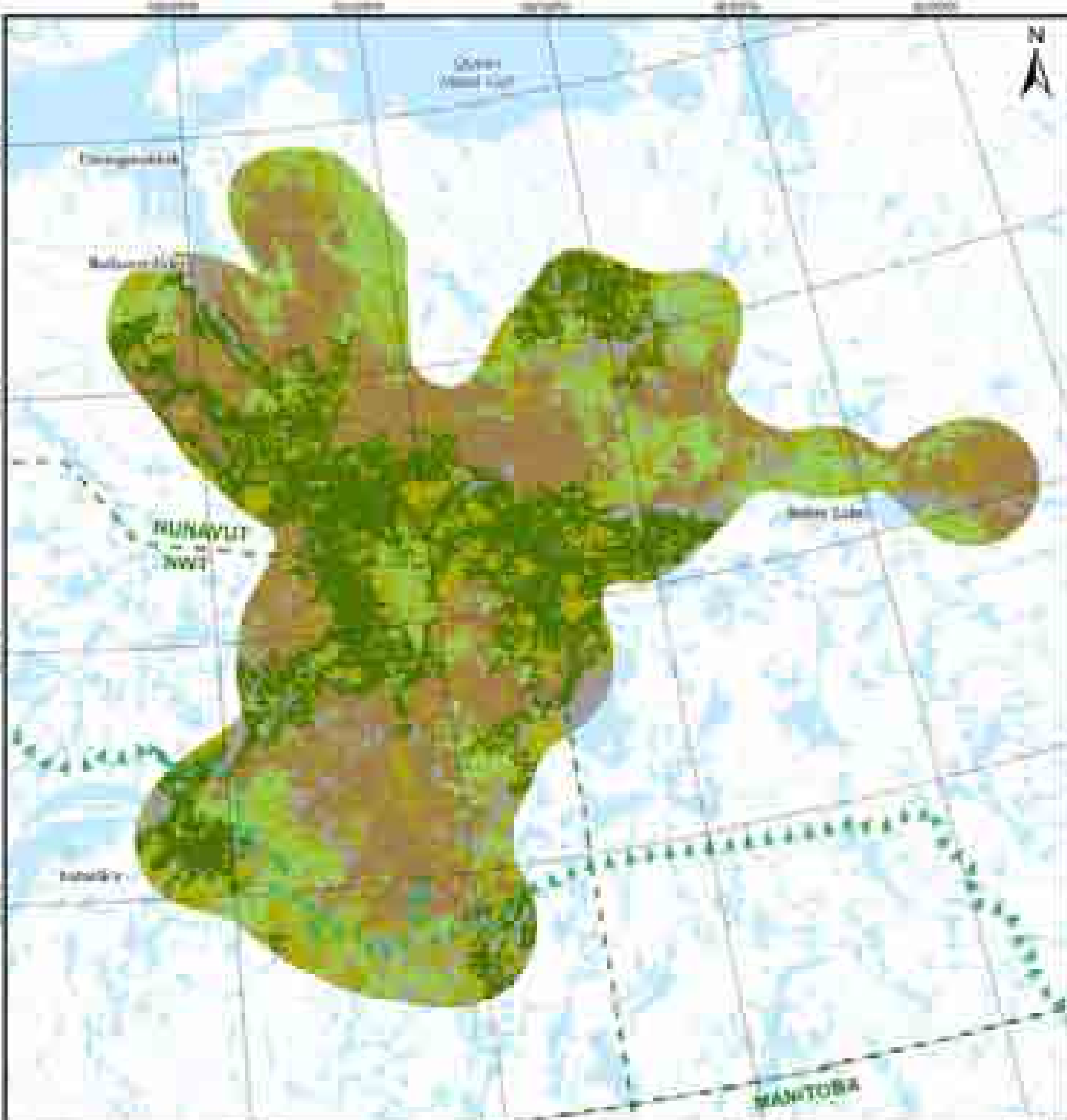
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Post-Calving: Future Case

PROJECTION: Canadian Lambert Conic Conic	DATUM: NAD83
FILE No: KLOI-07-048-GIS	DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 4
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

Figure 7.IV-30



LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

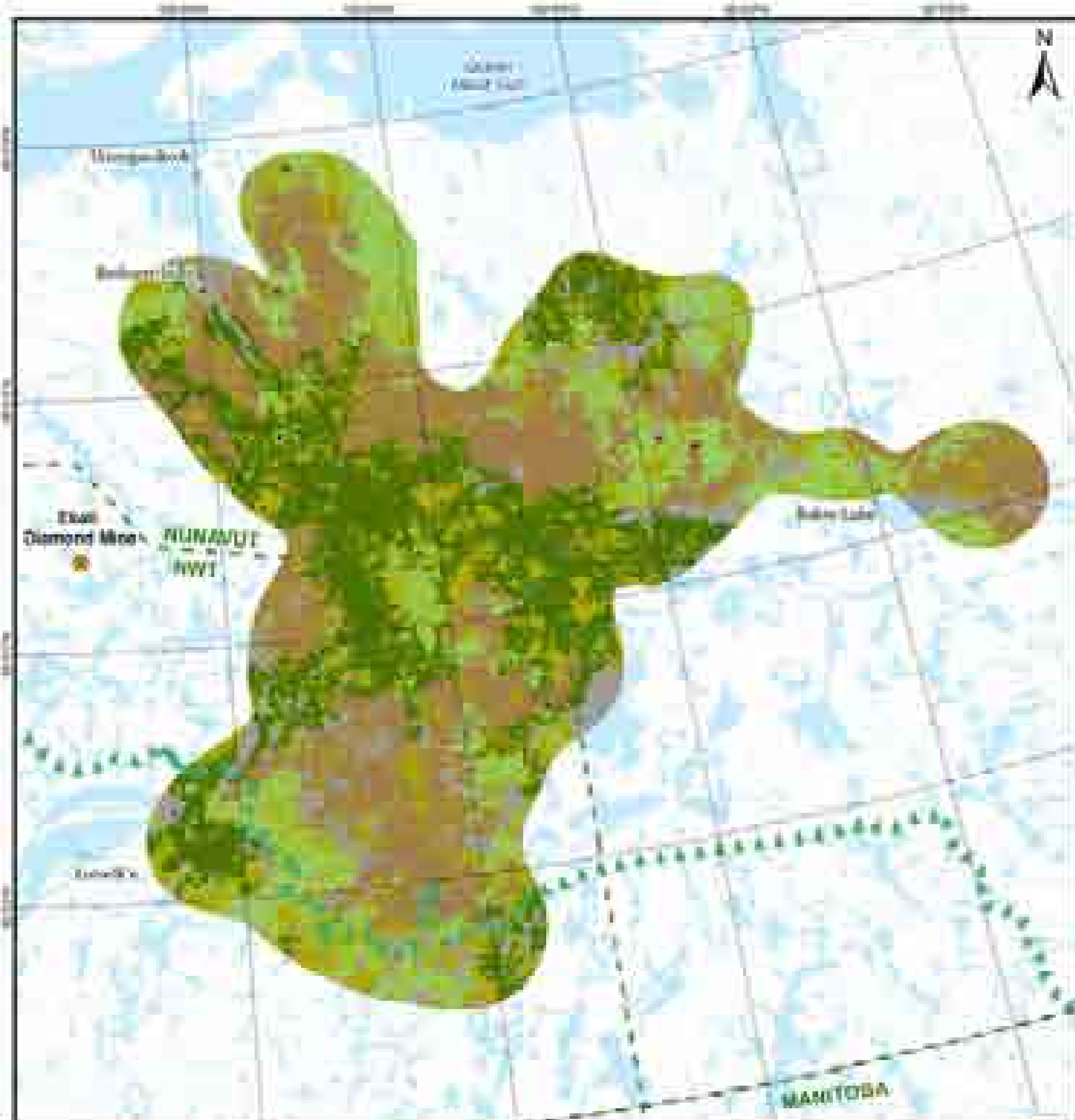
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for: Ahiak Caribou in Autumn: Reference Conditions

DATUM	NAD83
FILE No	KLOI-07-014-GIS
DATE	November 23, 2010
JOB NO.	09-1365-1004
REVISION NO	3
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 7.IV-31



LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

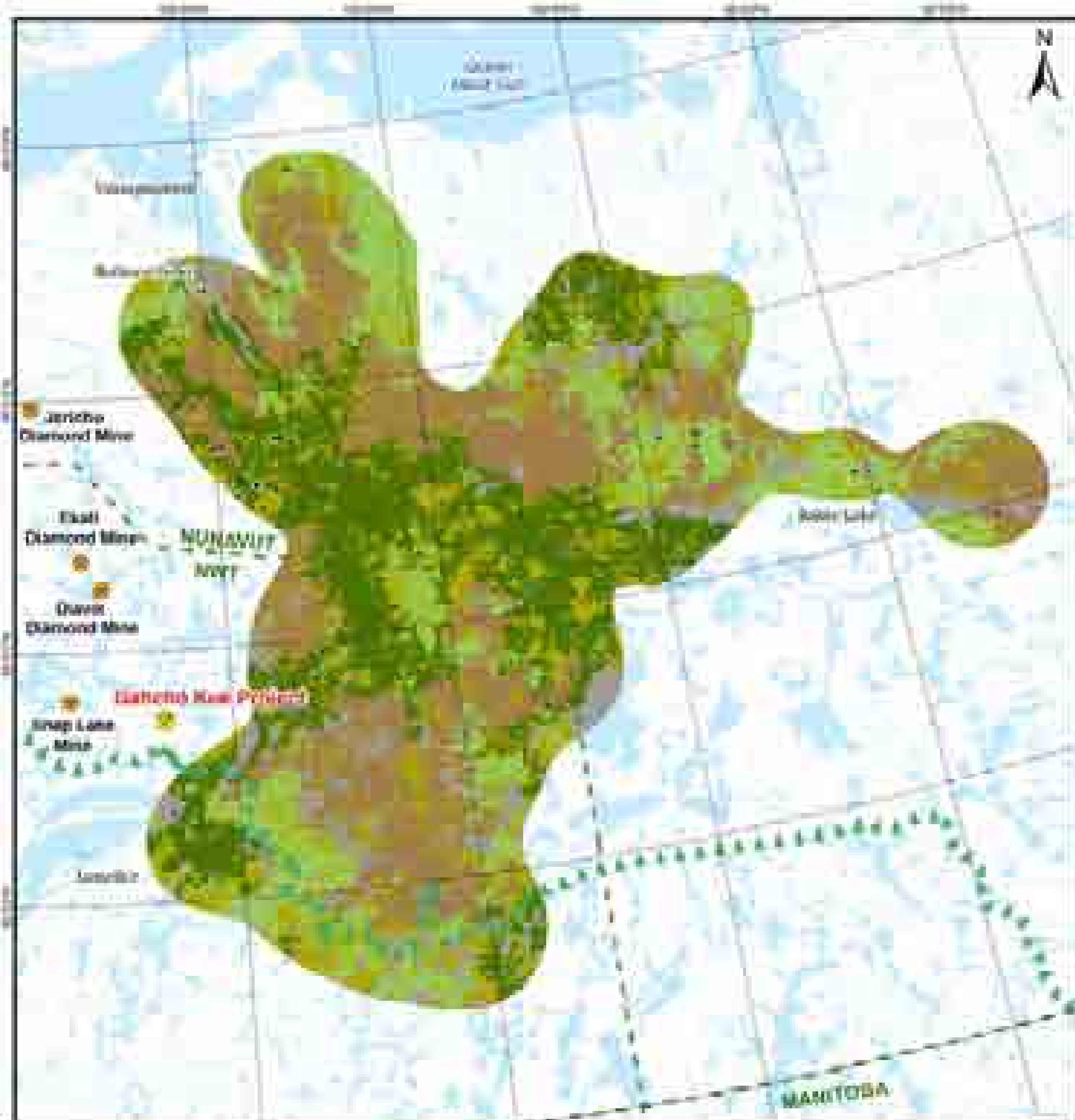
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Autumn: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: KLOI-07-015-GIS			DATE: November 23, 2010
JOB NO: 09-1365-1004	REVISION NO: 4		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 7.IV-32



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Autumn: 2006 Baseline Conditions

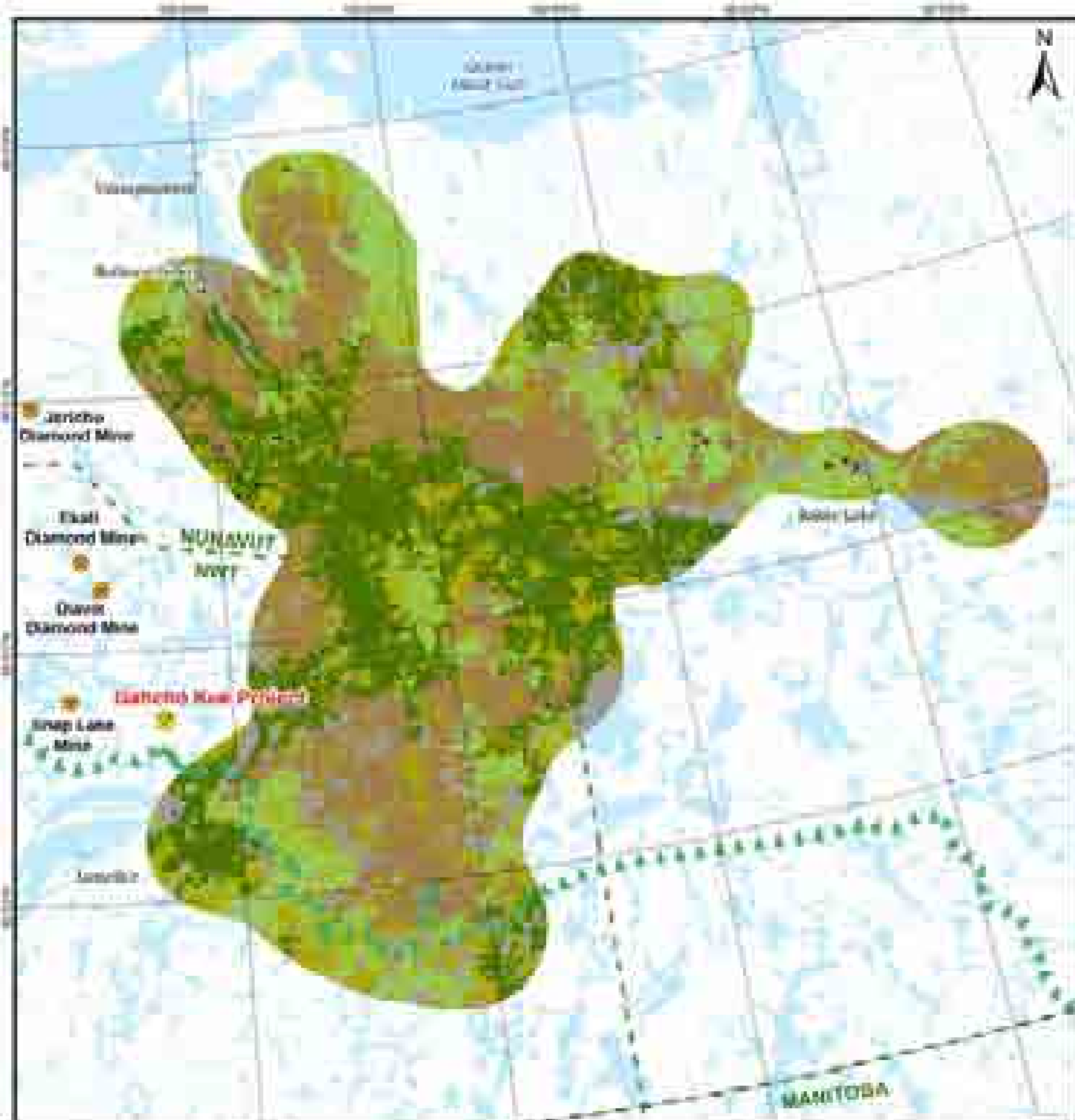
PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

FILE No.	DATE
KLOI-07-016-GIS	November 23, 2010

JOB NO.	REVISION NO.
09-1365-1004	5

OFFICE	DRAWN	CHECK
GOLD-SAS	ANK	JV

Figure 7.IV-33



LEGEND
- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function
- High
- Good
- Low
- Poor
- Nil

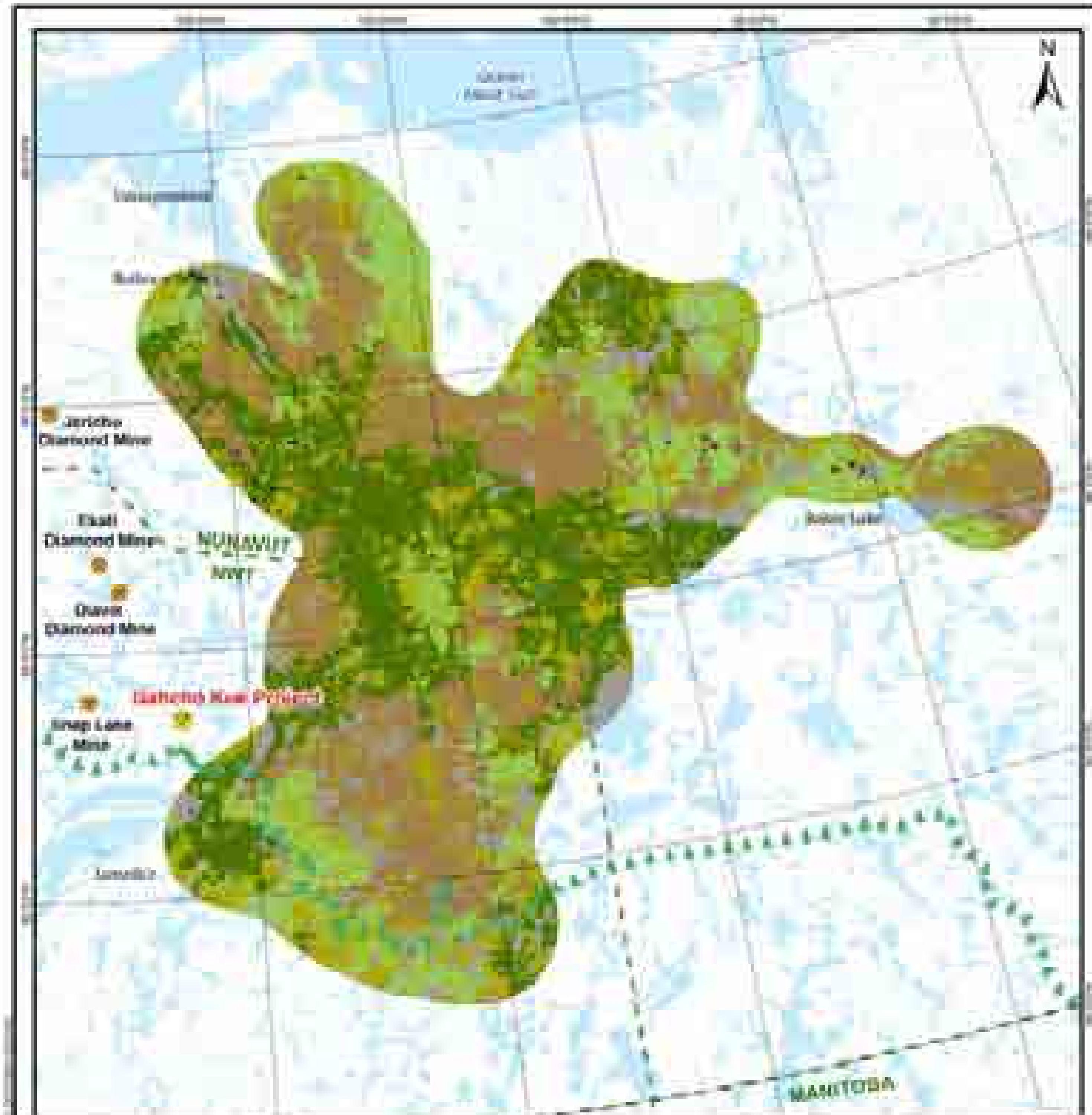
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Autumn: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: KLOI-07-040-GIS		DATE: November 23, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

Figure 7.IV-34



LEGEND

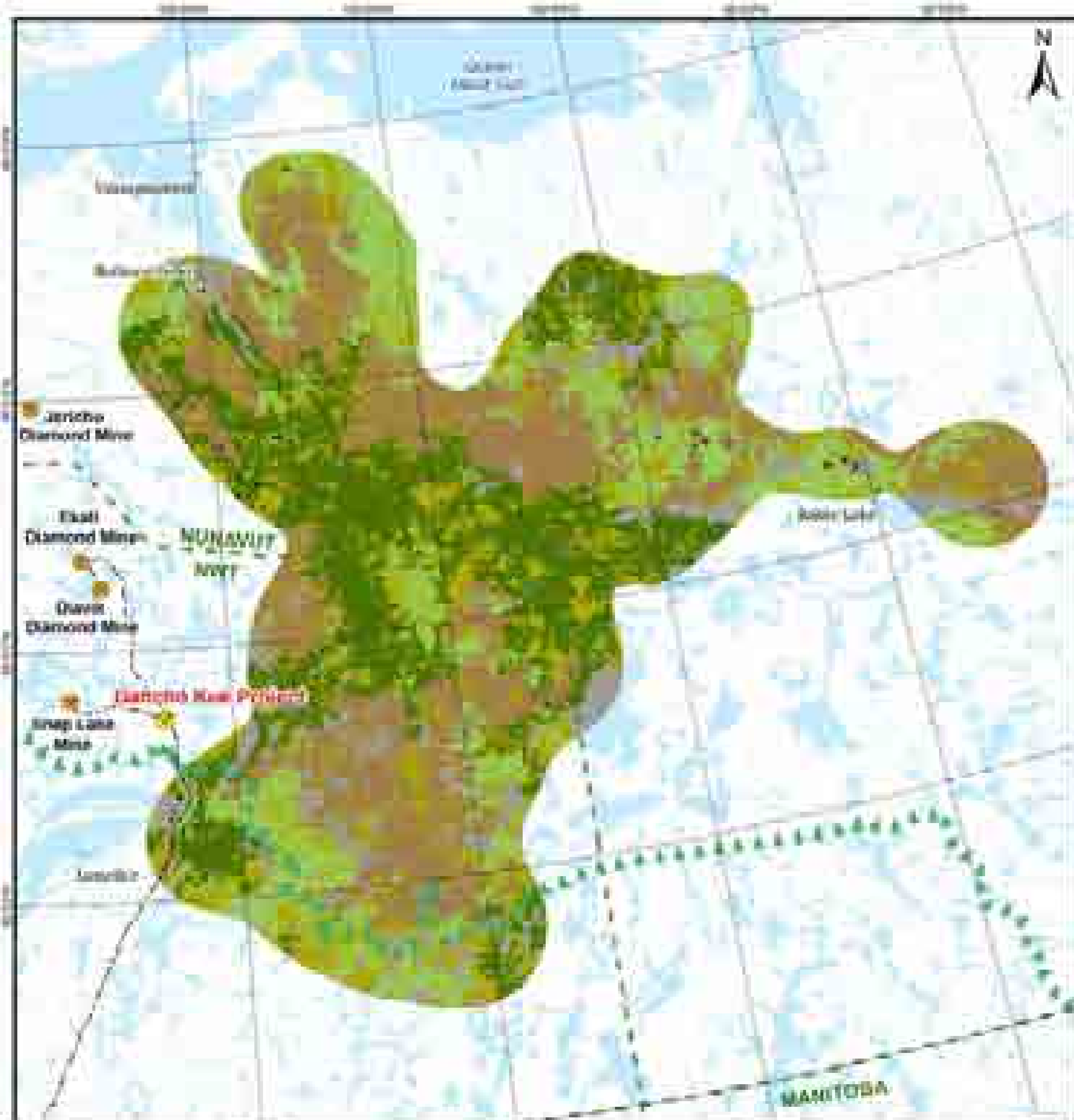
- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT	
Habitat Suitability for Ahiak Caribou in Autumn: Application Case	
PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale: 1:3,500,000	DE BEERS
FILE No.: KLOI-07-041-GIS	DATE: November 23, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 3
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	**Figure 7.IV-35**



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Existing Transmission Line
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Ahiak Caribou in Autumn: Future Case

PROJECTION	DATUM NAD83
FILE No. KLOI-07-042-GIS	DATE November 23, 2010
JOB NO. 09-1365-1004	REVISION NO. 2
OFFICE GOLD-SAS	DRAWN ANK / CHECK JV

Figure 7.IV-36