GAHCHO KUÉ PROJECT

ENVIRONMENTAL IMPACT STATEMENT

SECTION 11.11

SUBJECT OF NOTE: OTHER UNGULATES

December 2010 09-1365-1004

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11.11 SUBJECT OF NOTE: OTHER UNGULATES

11.11.1 Introduction

11.11.1.1 Context

This section of the Environmental Impact Statement (EIS) for the Gahcho Kué Project (Project) consists solely of the Subject of Note: Other Ungulates. 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) provided a rationale for including Other Ungulates as a subject of note:

> *"The proposed development is closer to the tree line than previous diamond mines in the NWT. There may therefore be different species present, resulting in ungulates other than caribou being affected to a larger extent than was the case with previous diamond mines in the NWT."*

This subject of note includes a detailed assessment of impacts on muskoxen (*Ovibos moschatus*) and moose (*Alces alces*), the two species of ungulates other than caribou that could potentially be affected by the Project. However, related assessments, which might overlap slightly with this subject of note, are provided in the following subjects of note:

- Mine Rock and Processed Kimberlite Storage (Section 11.5);
- Vegetation (Section 11.7);
- Traffic and Road Issues (Section 11.8);
- Waste Management and Wildlife (Section 11.9);
- Carnivore Mortality (Section 11.10);
- Climate Change Impacts (Section 11.13);
- Tourism Potential and Wilderness Character (Section 12.7.3); and
- Proposed National Park (Section 12.7.4).

Where there is overlap between this subject of note and another key line of inquiry or subject of note, information will be provided in both locations as required by the Terms of Reference.

11.11.1.2 Purpose and Scope

The purpose of the Subject of Note: Other Ungulates is to meet the Terms of Reference for the EIS issued by the Gahcho Kué Panel. The Terms of Reference for this subject of note are shown in Table 11.11-1. 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.

11.11.1.3 Study Areas

11.11.1.3.1 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 11.1-1).

11.11.1.3.2 Study Area Selection

To assess the potential effects of the Project on other ungulates, it is necessary to define appropriate spatial boundaries. The geographic study area for this Subject of Note was not specifically identified in the final Terms of Reference (Gahcho Kué Panel 2007). However, the Terms of Reference indicated that this Subject of Note must include the frequency of muskoxen and moose use of the development area, development components that may cause a sensory disturbance to muskoxen or moose, as well as possible sources of contamination and on-site hazards, and consideration of potential impacts caused by an access via the MacKay Lake road into an area previously inaccessible to vehicular traffic (Gahcho Kué Panel 2007).

Wildlife baseline studies were completed before the Terms of Reference were issued. The spatial boundaries were initially delineated based on the extent of the Project-related effects and life history attributes of wildlife species, including other ungulates, potentially inhabiting the area around the Project. The baseline studies for all wildlife species were conducted within the following areas:

- Regional Study Area (RSA);
- Local Study Area (LSA); and
- Winter Access Road corridor.

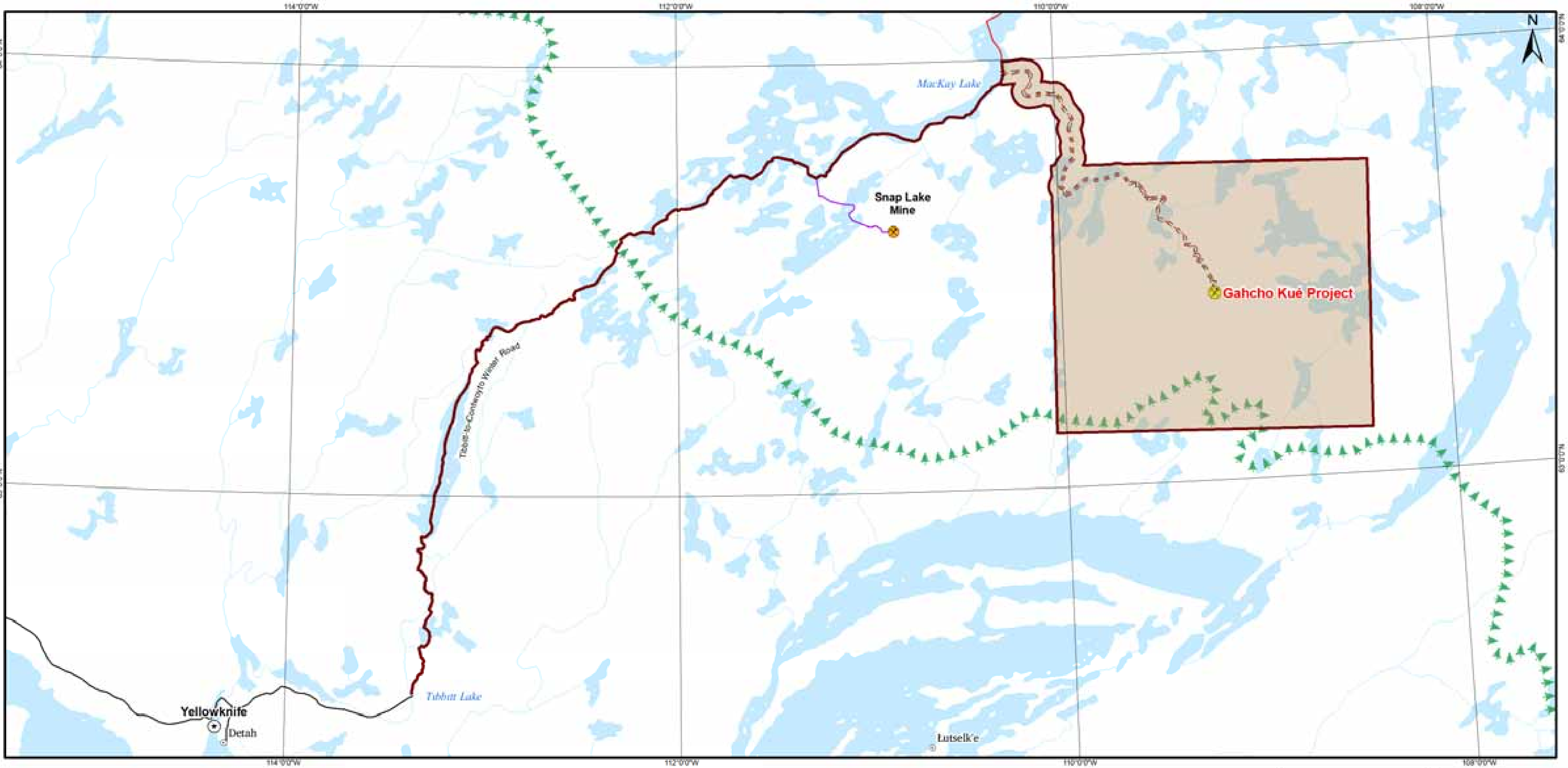
Table 11.11-1 Terms of Reference Pertaining to Other Ungulates

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
3.1.3 Existing Environment: Mammals (Excluding Caribou)	Describe species present, and for each describe: - abundance, distribution, seasonal movements, habitat requirements; - areas of specific habitat use at various life stages; - any sensitive time periods or habitat; and - any other relevant sensitivities or limiting factors, such as behaviours or territory requirements.	11.11.2.3
	Describe key species used during traditional harvesting activities.	11.11.2.3
	Describe any known issues currently affecting wildlife (excluding caribou) in the development area, (e.g., contamination of food sources, parasites, disease).	11.11.2.3
5.2.9 Biophysical Subjects of Note: Other Ungulates	Specific information requirements pertaining to other ungulates include:	
	Frequency of muskoxen and moose utilizing the development area and including information such as time of the year, abundance, and other developments that may impact on the same muskoxen population.	11.11.2.3.1, 11.11.2.3.2
	Development components that may cause a sensory disturbance to muskoxen or moose as well as possible sources of contamination and on-site hazards.	11.11.3.2.1, 11.11.4.2.1, 11.11.4.2.2, 11.11.5.2.1, 11.11.5.2.2, 11.11.6.2
	Potential changes to the predator-prey relationship of any potentially affected ungulate population and predicted long-term effects on the population.	11.11.3.2.2
	Any mitigation measures to avoid or reduce these impacts.	11.11.3.2
	Potential development-related changes to harvest levels for each potentially affected ungulate population, e.g., by creating an access via the Mackay Lake road into an area previously inaccessible to vehicular traffic.	11.11.3.2
7 (7-1) Wildlife Issues	Remaining wildlife issues pertaining to other ungulates include: - impacts on muskoxen distribution; - impacts on moose; and - sensory disturbance to muskoxen.	 11.11.4 11.11.5 11.11.4, 11.11.6
	Remaining wildlife issues pertaining to changing water levels include: - drawdown impacts on habitat; - downstream impacts; and - wildlife impacts from freeze- and break-up timing changes.	 11.11.3.2.2 11.11.3.2.2 Section 11.13

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.	11.11.10
	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.	11.11.10

Source: Terms of Reference for the Gahcho Kué Environmental Impact Statement (Gahcho Kué Panel 2007).

EIS = environmental impact statement.



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
- Other Ungulates Study Area

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Other Ungulates Study Area

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale: 1:1,000,000 (20 10 0 20 Kilometres)	
FILE No: SON-11-11-008-GIS	DATE: October 7, 2010
JOB NO: 09-1365-1004	REVISION NO: 3
OFFICE: GOLD-SAS	DRAWN: MGD / CHECK: JV

DE BEERS CANADA

Figure 11.11-1

The wildlife baseline LSA (about 200 square kilometres [km^2]) was selected to assess the immediate direct and indirect effects of the Project on individual animals and wildlife habitat. The wildlife baseline RSA was selected to capture any effect that may extend beyond the LSA and subsequently effects to the abundance and distribution of populations. The Winter Access Road corridor was included to identify potentially sensitive habitat within the associated right-of-way. Baseline survey intensity varied within each spatial boundary, with broader studies completed within the RSA to assess seasonal distribution of moose and muskoxen, and detailed studies completed within the LSA to assess direct habitat changes for these ungulates (Section 6.4).

11.11.1.3.3 Other Ungulates Study Area

The Subject of Note: Other Ungulates was completed within the Other Ungulates Study Area (Figure 11.11-1), which consists of the following spatial boundaries:

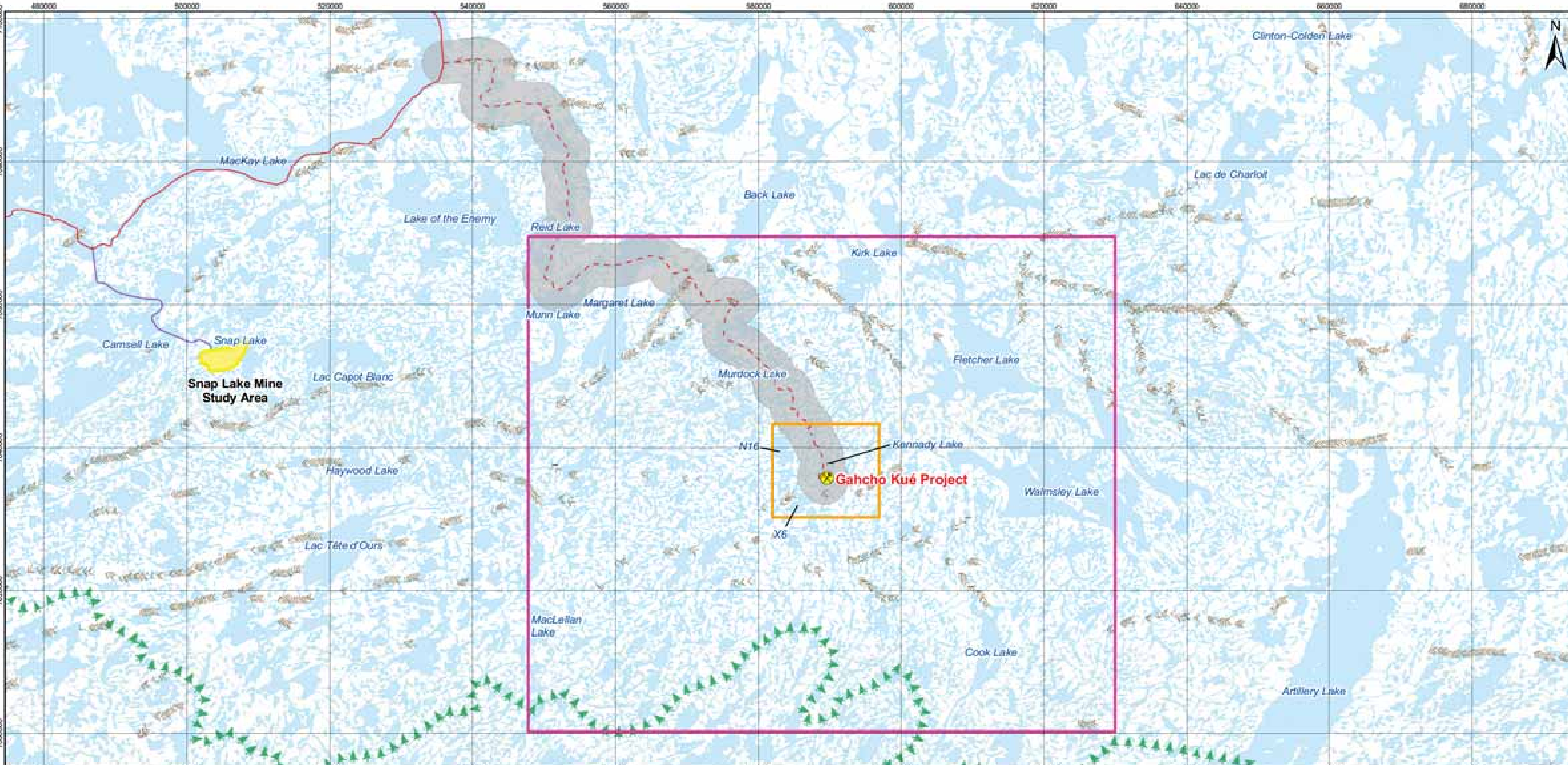
- wildlife baseline RSA;
- Winter Access Road from MacKay Lake to Kennady Lake; and
- Tibbitt-to-Contwoyto Winter Road from Tibbitt Lake to MacKay Lake.

The effects analysis and assessment was therefore conducted within a geographic area identical to that for the baseline studies, with the addition of the portion of the Tibbitt-to-Contwoyto Winter Road from Tibbitt Lake to MacKay Lake.

Regional Study Area

The wildlife baseline RSA is approximately 5,700 km^2 in size. The RSA boundary is delineated approximately by the following lakes: Reid Lake in the northwest, MacLellan Lake in the southwest, Cook Lake in the southeast, and Fletcher Lake in the northeast (Figure 11.11-2). The RSA encompasses part of the treeline within the Taiga Shield Ecozone and the Slave Geological Province (SGP) (Ecological Stratification Working Group 1995).

The term taiga refers to the northern edge of the boreal conifer forest. In northern Canada, much of this forest occurs on the bedrock of the Canadian Shield and just south of the tundra. At its closest point, the treeline is about 20 km south of Kennady Lake and extends across the southern portion of the RSA. Extensive bedrock outcrops that are characteristic of the Canadian Shield are found primarily to the south and southwest of the Project. Steep rock walls and narrow canyons were identified near Margaret Lake along the western edge of the RSA.



LEGEND

- Gahcho Kué Project
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Snap Lake Mine Study Area
- Local Study Area
- Regional Study Area
- Winter Access Road Study Area

NOTES

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

GAHCHO KUÉ PROJECT

Boundaries for the Regional, Local, and Winter Access Road Study Areas

PROJECTION: UTM Zone 12	DATUM: NAD83
Scale: 1:550,000 (10 5 0 10 Kilometres)	DE BEERS CANADA
FILE No: SON-11-11-004-GIS	DATE: October 7, 2010
JOB NO: 09-1365-1004	REVISION NO: 3
OFFICE: GOLD-SAS	DRAWN: MGD / CHECK: JV

Figure 11.11-2

The assessment of Project effects on muskoxen and moose is completed at the scale of the RSA, which is likely large enough to contain all or most individuals that comprise the local populations that inhabit the area for part or all of the year. Here, a local population is regarded as a group of individuals of the same species occupying an area, and changes in abundance and distribution are strongly influenced by dispersal or migration (Berryman 2002). The RSA should be large enough to assess the incremental and cumulative effects from the Project and other developments on the local populations of muskoxen and moose that form part of larger populations. At the larger scale, emigration and immigration are infrequent, and most of the changes in population abundance and distribution are determined by reproduction and survival (Berryman 2002).

Winter Access Road Study Area

The Winter Access Road to the Project extends 120 km from the Tibbitt-to-Contwoyto Winter Road southeast to Kennady Lake. The route leaves the Tibbitt-to-Contwoyto Winter Road on MacKay Lake and reaches the Project site via Reid, Munn, Margaret, and Murdock lakes as well as several smaller lakes and streams. The baseline study area was 6 km wide, extending 3 km on either side of the access road centre line (Figure 11.11-2). Northwest of the RSA boundary, habitat conditions along the Winter Access Road Study Area resemble the undulating terrain of the barren tundra. Rocky terrain is less common farther north along this route and a few minor esker systems are present.

The Winter Access Road Study Area used in the baseline was included as part of the study area for the Subject of Note: Other Ungulates to account for potential effects of the Winter Access Road on muskoxen and moose.

Tibbitt-to-Contwoyto Winter Road

The Tibbitt-to-Contwoyto Winter Road has been constructed annually since 1982, from the end of the Ingraham Trail about 70 km northeast of Yellowknife at Tibbitt Lake in the NWT to the Lupin mine on Contwoyto Lake, Nunavut. The road is usually open from January to March. The primary use of this winter road is to re-supply mines and exploration camps near the winter road. The Lupin, Diavik, Ekati and Snap Lake mines are the primary users of the road. Lodges and outfitters located near the road also use it to re-supply their sites. Although the Tibbitt-to-Contwoyto Winter Road is primarily used for commercial purposes, it is open to the public for use (Annex N, Non-traditional Land and Resource Use Baseline).

The Other Ungulates study area includes the portion of the Tibbitt-to-Contwoyto Winter Road from Tibbitt Lake to MacKay Lake, where the Winter Access Road to the Project would intersect. This portion of the Tibbitt-to-Contwoyto Winter

Road is about 271 km. It was included in the Subject of Note: Other Ungulates, to assess the potential cumulative effects of the Project, in combination with existing, proposed, and reasonably foreseeable future developments, on muskoxen and moose in the region. The part of the Tibbitt-to-Contwoyto Winter Road included in this subject of note is shown as part of the Other Ungulates study area in Figure 11.11-1.

11.11.1.4 Content

Section 11.11 provides details of the effects analysis and assessment related to ungulates other than caribou. The headings in this section are arranged according to the sequence of steps in the assessment. The following briefly describes the content under each heading of this subject of note.

- **Existing Environment** summarizes baseline information for ungulates other than caribou, including the general environmental setting in which the Project occurs, methods used to collect the baseline data, and baseline results (Section 11.11.2).
- **Pathway Analyses** identifies all the potential pathways by which the Project could affect other ungulates, and provides a screening level assessment of each identified pathway after applying environmental design features and mitigations that should eliminate or limit effects (Section 11.11.3).
- **Muskoxen** explains the scientific methods that were used to predict changes to muskoxen populations as a result of Project activities, identifies the effects of the Project activities on muskoxen populations (including effects on habitat quantity and quality, behaviour and distribution, and survival and reproduction), and identifies the effects that flow to people as a result of the effect of Project activities on muskoxen populations (Section 11.11.4).
- **Moose** explains the scientific methods that were used to predict changes to moose populations as a result of Project activities (including effects on habitat quantity and quality, behaviour and distribution, and survival and reproduction), identifies the effects of Project activities on moose populations, and identifies the effects that flow to people as a result of the effect of Project activities on moose populations (Section 11.11.5).
- **Residual Effects Summary** summarizes the effects on muskoxen and moose populations and related effects on people that are expected to remain after all environmental design features and mitigation to eliminate or reduce effects have been incorporated into the Project design (Section 11.11.6).

- **Residual Impact Classification** describes methods used to classify residual effects and summarizes the classification results (Section 11.11.7).
- **Environmental Significance** summarizes the overall impacts from the Project on other ungulates, and considers the entire set of pathways to evaluate the significance of impacts from the Project on other ungulates (Section 11.11.8).
- **Uncertainty** discusses sources of uncertainty surrounding the predictions of effects on muskoxen and moose (Section 11.11.9).
- **Monitoring and Follow-up** describes monitoring programs, contingency plans, and adaptive management strategies that will be implemented related to muskoxen and moose (Section 11.11.10).
- **References** lists all documents and other material used in the preparation of this section (Section 11.11.11).
- **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 11.11.12).

11.11.2 Existing Environment

11.11.2.1 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 (Figure 11.1-1). 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 RSA, approximately 5,700 km^2, was defined to capture the large-scale direct and indirect effects of the Project on valued components (VCs) or populations with wide distributions (Figure 11.11-2). The Project is within the transition zone between the tundra and the treeline, and species that are characteristic of both habitat types 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, particularly in the LSA. 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 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 SGP (Section 11.7).

The LSA encompasses the Project, which includes the proposed development of the anticipated core mine footprint. The LSA is approximately 200 km^2, centered on Kennady Lake (Figure 11.11-2). The LSA was designed to assess direct effects from the mine footprint (e.g., habitat loss) and small-scale indirect effects on individual animals from Project activities (e.g., changes in habitat quality resulting from dust deposition). The LSA contains habitat that is characteristic of regional habitat conditions, including eskers and other glaciofluvial deposits, wetlands, riparian habitats, lakes, and vegetation that is typical of the tundra.

Terrain is less varied within the LSA, and 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 percent (%) 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 to Kennady Lake (Figure 11.11-2). 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 barren 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 minor 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. Ground and aerial surveys were designed to provide estimates of the natural variation in wildlife presence, abundance, distribution, and movement. The baseline data collected on wildlife are presented in Annex F, Wildlife Baseline.

11.11.2.2 Methods

The following section integrates a historical and regional perspective on muskoxen and moose populations in the study area from available literature and existing knowledge. Baseline survey data were supplemented with ecological information from regional wildlife studies, published and unpublished scientific literature, discussions with wildlife experts, and traditional knowledge (TK). 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). Results of regional effects monitoring and research programs in the NWT and Nunavut (e.g., the Diavik, Ekati, and Snap Lake mines) are also included. Information obtained from each of these data sources is used for the assessment of potential effects on muskoxen and moose from the Project, and to provide a basis for finalization of wildlife mitigation and monitoring plans.

Surveys for muskoxen populations were completed by government biologists in 1989, 1991, and 1998, and included the eastern and northeastern edge of the RSA (Wildlife Management Area U/MX/02 and Wildlife Management Area U/MX/01). Because the Project lies within the transition zone between the tundra and the treeline, moose, which are characteristic of boreal habitat types, may also occur within the RSA. Incidental observations of muskoxen and moose were documented within the RSA, from 1995 to 2005, during surveys for caribou and other wildlife species. The objective was to estimate the annual and seasonal occurrence, abundance, and distribution of muskoxen and moose in the RSA. Esker surveys completed in 2007 also were used to document the presence of muskoxen sign on all eskers within 35 km of the Project.

11.11.2.3 Results

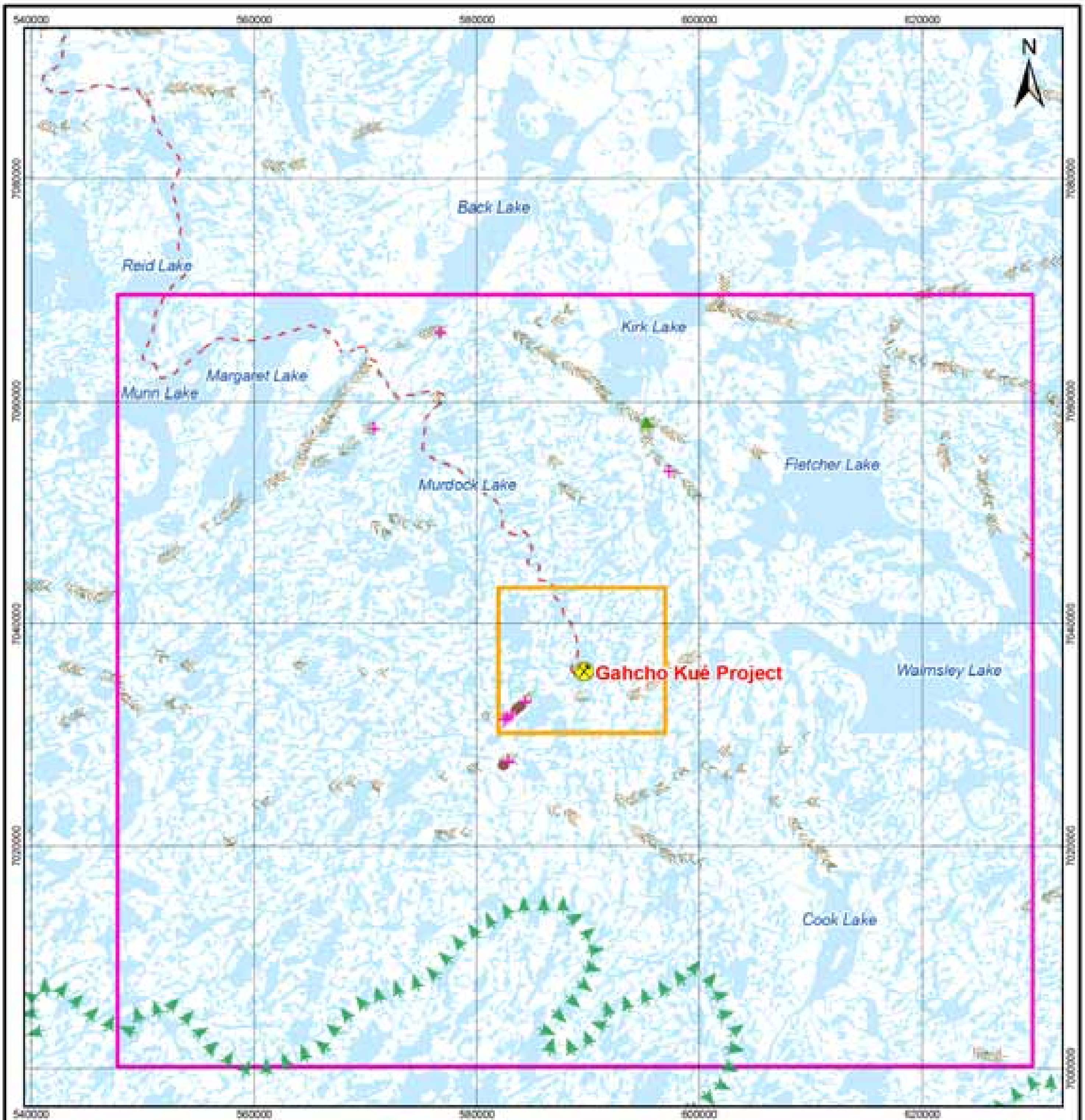
11.11.2.3.1 Muskoxen

Habitat Use

Forage requirements for muskoxen vary seasonally. Forage availability in winter is limited primarily by hard-packed or deep snow cover, or by thick layers of ice that make cratering difficult (Gunn and Fournier 2000). Towards the end of March, snow becomes harder and denser with daytime heating. During this time, muskoxen can be found on slopes (i.e., eskers) and plateaus where the vegetation has been exposed by wind (Sly et al. 2001), or by warm spring days. According to the Łutselk'e Dene First Nation (LKDFN 2001), eskers are also important transportation corridors, as they offer easy travel and a windy refuge from mosquitoes. Esker surveys completed in the RSA in 2007 estimated muskoxen sign at 0.14 sign per km surveyed (Figure 11.11-3).

Calving occurs from late April to early May (ENR 2010a, internet site). Ridges that are free of snow provide a better opportunity for the herd to protect newborn calves from predators, and muskoxen will seek out these areas (Gunn and Fournier 2000). Daily movements for cows with calves are reduced in the spring and through the summer period (Gunn and Fournier 2000). Calves are born several weeks before plant growth begins and cows lose considerable weight during the first six weeks of lactation (Sly et al. 2001). Although muskoxen were common in the RSA during 2004 and 2005, few calves were observed.

A similar suite of sedges (*Carex* spp.), grasses (*Kobresia* spp.), and deciduous shrubs, especially willows (*Salix* spp.), dominate muskoxen diets across their circumpolar ranges (Klein 1992; Larter and Nagy 1997). As the spring and summer progress, muskoxen selectively feed based on plant emergence and nutritive value (Robus 1981). For example, in late May animals feed on cotton grass (*Eriophorum* spp.) heads, and then shift to the new leaves of sedges (Gunn and Adamczewski 2003) within riparian and wetlands habitats. By mid-June, they select young willow leaves and flowering forbs, benefiting from the earlier peak in nitrogen and later in the summer, the increase in plant biomass. Traditional knowledge also identified that muskoxen eat fern moss (*Hylocomium splendens)* on the barrenlands (LKDFN 1999).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Hair
- Scat
- Track
- Local Study Area
- Regional Study Area

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

GAHCHO KUÉ PROJECT

Esker Surveys Completed for Muskoxen in the Regional Study Area 2007

PROJECTION: UTM Zone 12		DATUM: NAD83	DE BEERS CANADA
Scale: 1:500,000 (10 5 0 10 Kilometres)			
FILE No: SON-11-11-005-GIS			DATE: October 7, 2010
JOB NO: 09-1365-1004	REVISION NO: 1		Figure 11.11-3
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	

Both males and females increase weight rapidly with the new plant growth during the summer. The rut occurs in July and August, and reaches its peak in late August (ENR 2010a, internet site). Muskoxen were found within the RSA during September and October, suggesting that a portion of the muskoxen winter range may overlap with the RSA. In winter, muskoxen will feed on grasses, willow, birch (*Betula* spp.), crowberry (*Empetrum nigrum*), and bilberry (*Vaccinium myrtillus*).

Behaviour and Distribution

Muskoxen are distributed across the tundra of the circumpolar Arctic (Gunn and Adamczewski 2003). There are about 105,000 muskoxen in the NWT, and most are found on Banks Island (about 70,000 non-calf animals in 2001) and northwest Victoria Island (about 30,000 non-calf animals in 2001) (ENR 2010a, internet site). On the mainland they are found in substantial numbers in the area north of Great Bear Lake up to the Arctic coast, and in the Queen Maud Gulf area (ENR 2010a, internet site). Lesser numbers are present in the Thelon Game Sanctuary and southwest to Artillery Lake (ENR 2010a, internet site).

Muskoxen distribution reflects the environmental conditions that support these animals, with the very northern and coastal parts of their range supporting the highest density (Sly et al. 2001). Seasonal movements typically depend on landscape and terrain features, forage availability, and snow characteristics (Gunn and Fournier 2000). Unlike caribou, muskoxen do not undertake long migrations; however in some areas, winter and summer ranges are distinct, and distances travelled can be over 160 km between these seasonal habitats (ENR 2010a, internet site). Reynolds (1998a) determined that the average size of core areas used by satellite-collared muskoxen were significantly larger ($P<0.05$) in summer (223 km^2) than in the calving season or winter seasons (27 to 70 km^2). Population density may also influence dispersal of muskoxen and range expansion (Gunn and Fournier 2000).

Muskoxen live together in loosely organized herds, averaging 15 animals in size (ENR 2010a, internet site). Herd size and composition vary with season, range conditions, and the number of bulls in the population (ENR 2010a, internet site). After the rut in July and August, the herds increase as bulls and/or mixed groups join together. In severe winter conditions, large herds may break apart as a result of limited forage.

Muskoxen are subject to a substantial decrease in both forage quantity and quality in the winter, and can be expected to be strongly selective in their feeding (Gunn and Adamczewski 2003). In winter, muskoxen minimize energy and time expended on foraging by selecting for greater food abundance (graminoids or grasses and grass-like plants such as sedges and rushes), especially where the snow is shallow. They also select for shallower and softer snow. Thresholds of snow depth where muskoxen will crater vary between 20 and 50 centimetres (cm), depending on snow hardness and density (Thomas and Edmonds 1984). In the summer, forage quantity is not usually limiting, but the pulse of highly digestible nutrients is short (Gunn and Adamczewski 2003). The constraints for muskoxen are the time and energy required to locate forage, and additionally in winter, to uncover, chew, and then warm it up to core body temperature (Gunn and Adamczewski 2003).

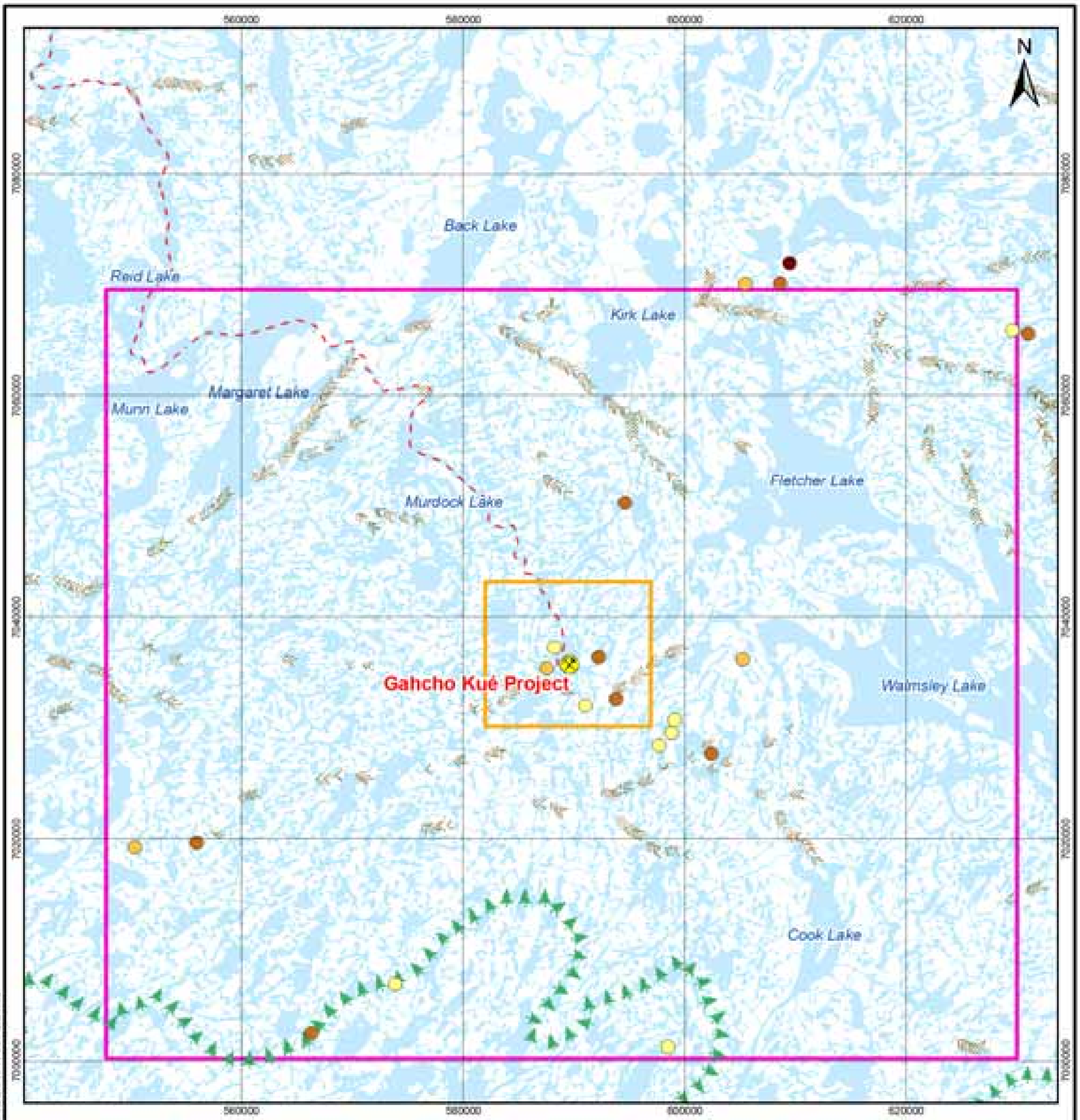
Most wildlife species are likely to exhibit some degree of sensitivity to human disturbance. A zone of influence (ZOI) is the measured or hypothetical maximum distance to which a disturbance (e.g., traffic noise) influences wildlife use of habitat. Currently, estimates of the ZOI from exploration sites or operating mines for muskoxen are not available.

Population Characteristics

The muskoxen is currently listed as *secure* within the NWT (NWT General Status Ranking Program 2010, internet site), and is not listed federally as populations appear to be increasing (COSEWIC 2009, internet site). Approximately 105,000 muskoxen in the NWT were reported by ENR (2010a), occurring mostly on Banks Island and northwest Victoria Island. Wildlife Management Areas I/MX/01, I/MX/02, I/MX03, I/MX/05, I/MX/06, and S/MX/01 are not located near the Project. However, Wildlife Management Area U/MX/01 (which now includes the former Wildlife Management Area U/MX/02), is located east of the Project, near Aylmer Lake.

In 1989, the population of muskoxen within the Wildlife Management Area U/MX/02 was estimated at 563 animals and no muskoxen were found within the RSA at that time. Surveys completed in 1991 (Wildlife Management Area U/MX/01), estimated that the density of muskoxen was highest along the eastern and northern edge of Aylmer Lake, and the population within the survey area was estimated at 161 animals. No muskoxen were found near the Project. Population surveys of the Wildlife Management Area U/MX/02 were repeated in 1998 (Bradley et al. 2001). Observers counted 1,162 muskoxen, and most animals appeared to be expanding west and northwest of Artillery Lake.

From 1995 to 2003, eight groups of muskoxen were recorded within the RSA during aerial surveys completed for caribou. Group size ranged from one to 47 individuals. In 2004 and 2005, muskoxen appeared to be relatively common (15 group observations) and were observed within the RSA during all aerial surveys (Figures 11.11-4 and 11.11-5). Group size ranged from 1 to 92 individuals in 2004 and 2005. The higher number of muskoxen observed in 2004 and 2005 may be the result of the increased survey effort in these years or may reflect potential migration or movement into the RSA.



LEGEND

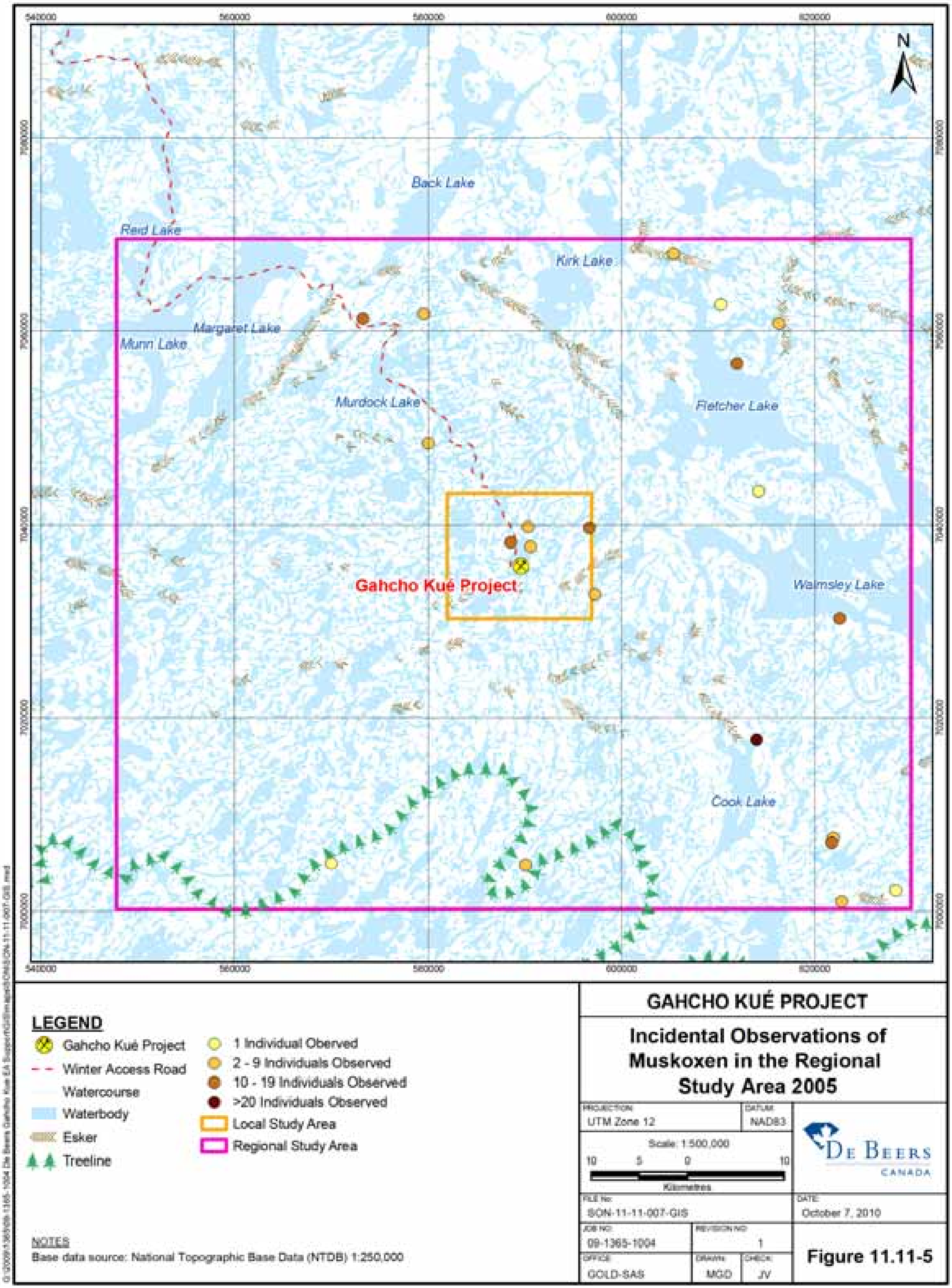
- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- 1 Individual Observed
- 2 - 9 Individuals Observed
- 10 - 19 Individuals Observed
- >20 Individuals Observed
- Local Study Area
- Regional Study Area

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

GAHCHO KUÉ PROJECT

Incidental Observations of Muskoxen in the Regional Study Area 2004

PROJECTION: UTM Zone 12		DATUM: NAD83	DE BEERS CANADA
Scale: 1:500,000 (10 5 0 10 Kilometres)			
FILE No: SON-11-11-001-GIS			DATE: October 7, 2010
JOB NO: 09-1365-1004	REVISION NO: 2		Figure 11.11-4
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	


540000
560000
580000
600000
620000
7060000
7040000
7020000
7000000
N
Back Lake
Reid Lake
Kirk Lake
Margaret Lake
Munn Lake
Murdock Lake
Fletcher Lake
Gahcho Kué Project
Walmsley Lake
Cook Lake
LEGEND
Gahcho Kué Project
Winter Access Road
Watercourse
Waterbody
Esker
Treeline
1 Individual Oberved
2 - 9 Individuals Observed
10 - 19 Individuals Observed
>20 Individuals Observed
Local Study Area
Regional Study Area
NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000
GAHCHO KUÉ PROJECT
Incidental Observations of Muskoxen in the Regional Study Area 2005
PROJECTION
UTM Zone 12
DATUM
NAD83
Scale: 1:500,000
10 5 0 10
Kilometres
DE BEERS
CANADA
FILE No.
SON-11-11-007-GIS
DATE
October 7, 2010
JOB NO.
09-1365-1004
REVISION NO.
1
OFFICE
GOLD-SAS
DRAWN
MGD
CHECK
JV
Figure 11.11-5

Conversely, observations of muskoxen are uncommon near the Snap Lake Mine. From 1999 to 2006, three observations of muskoxen have been recorded in the Snap Lake study area (3,000 km^2) (De Beers 2007). The first observation of muskoxen was a group of 11 animals recorded in September 2003. Subsequent observations included a group of nine muskoxen in 2005, and a group of ten muskoxen in 2006 (De Beers 2007).

Muskoxen predation from grizzly bear (*Ursos arctos*) and wolves (*Canis lupis*) is common, especially if animals are alone and separated from the herd (Gunn and Fournier 2000). Reynolds et al. (2002) determined that kills or scavenging of muskoxen by grizzly bears in north eastern Alaska ranged from zero to two deaths per year before 1993, one to four deaths per year in 1993 to 1996, and five to ten deaths per year in 1997 to 2001. Life expectancy is estimated at 12 to 20 years, (National Geographic 2010a, internet site).

Muskoxen are also vulnerable to disturbance in winter because of limited food accessibility, the length of the arctic winter, and their need to conserve energy throughout the winter (Reynolds et al. 2002). Disturbances that displace muskoxen from preferred winter habitats into areas of deeper snow or that increase their activity and movements could increase their energetic costs in winter. Female muskoxen that are required to expend greater energy to survive the winter will have fewer reserves for pregnancy and lactation and may not reproduce successfully (Reynolds et al. 2002). Annual variability in young animal survival followed the same annual trends as calf production and was related to snow depth and the length of the snow season (Reynolds 1998b).

Muskoxen are also susceptible to over hunting because their unwary nature and defensive posture makes them easy to approach and kill (ENR 2010a, internet site). Their relatively small range also makes them easy to locate by people familiar with their home ranges (ENR 2010a, internet site). Muskoxen may be sensitive to human disturbances, particularly during calving and post-calving periods (Miller and Gunn 1979). However, the muskoxen that were observed near the Project in the summer of 2004 foraged within a few hundred metres of camp and did not appear to be alarmed by human observers. In addition, there are no reported injuries/mortalities related to muskoxen reported for other developments in the NWT or Nunavut (Tahera 2007; BHPB 2010; DDMI 2010; De Beers 2010).

Traditional and Non-Traditional Use

Currently in the NWT, muskoxen are harvested under a quota system on three arctic islands (Melville Island I/MX/01, Banks Island I/MX/02, and northwest Victoria Island I/MX/03) and four areas on the mainland (I/MX/05, I/MX/06, S/MX/01, and U/MX/01) (ENR 2010a, internet site). Wildlife Management Areas I/MX/01, I/MX/02, I/MX03, I/MX/05, I/MX/06, and S/MX/01 are not located near the Project, however, data has been included to provide context of traditional and non-traditional use within the NWT. Wildlife Management Area U/MX/01 (which also includes the former Wildlife Management Area U/MX/02), is located east of the Project, near Aylmer Lake.

On Melville, Banks, and northwest Victoria Island, the hunting season is open from August 15 to April 30 for resident (i.e., persons living in the NWT for at least two years) and non-resident (i.e., persons living outside the NWT or who have not resided in the NWT for a full two years) hunters. Hunting season for muskoxen in Wildlife Management Areas I/MX/05 and I/MX/06 is open from October 1 to April 30, and September 15 to April 30, respectively, for both resident and non-resident hunters (ENR 2010b, internet site). Muskoxen tags are available to residents for Wildlife Management Areas S/MX/01 and U/MX/01 through a yearly draw. In the Wildlife Management Area U/MX/01, hunting season varies for resident (June 15 to 30, and July 1 to April 15) and non-resident hunters (August 1 to April 15) (ENR 2010b, internet site). The season for muskoxen hunting in Wildlife Management Area S/MX/01 is open from August 1 to April 15 for both resident and non-resident hunters (ENR 2010b, internet site).

Management of muskoxen is dependent on monitoring the trends in population size and survival rates (ENR 2010a, internet site). As a result of population increases, a quota system was instituted. Because of concerns from local people of Sachs Harbour over the effects upon caribou, the original quota of seven muskoxen was raised to 2,000 in 1981 in an attempt to slow the population growth (Gunn et al. 1991). The restriction to subsistence was also removed in 1981, allowing for the possibility of a commercial harvest (ENR 2010a, internet site). In 1991/1992, 2,213 muskoxen were harvested out of a quota of 5,000 animals (ENR 2010a, internet site). This was the largest harvest year from 1990 through 2003. In 1994, the quota for muskoxen was increased to, and currently remains at, 10,000 animals (ENR 2010a, internet site). Although efforts are underway to increase the market for muskoxen meat in southern Canada, it seems unlikely that the quota will be reached (ENR 2010a, internet site).

Traditional knowledge indicates that muskoxen are using the RSA more heavily than in the past; however, one reviewed source suggested that the muskoxen were not native to the region (LKDFN 2005, internet site).

11.11.2.3.2 Moose

Habitat Use

Optimal moose habitat consists of deciduous shrub and ground strata (i.e., layers) within deciduous, mixed, and coniferous forests that offer edge or disturbed areas of early successional vegetation (Poole and Stuart-Smith 2003; Osko et al. 2004). Deciduous browse is the primary food source, varying from twigs and bark in the winter, to leaves in the spring and summer (URSUS and Komex 1997). In spring moose tend to seek out low-elevation areas, usually wetlands, muskeg lowlands, and river floodplains, as this is typically where the first green-up occurs (Stelfox 1993). Moose obtain most of their annual salt requirements from pond lilies and aquatic vegetation (Stelfox 1993). They tend to continue to use these areas in the summer periods where they will also feed in adjacent forest stands.

During summer, moose use upland forests for eating fresh shoots and leaves from deciduous shrubs and young deciduous trees, mainly trembling aspen (*Populus tremuloides*) and balsam poplar (*Populus balsimifera*). However, moose are also known to browse on young coniferous trees in the summer, if available, such as balsam fir. The moose diet in summer is typically made up of 74% shrubs and trees, 25% forbs, and 1% graminoids (Renecker 1987).

During the fall and winter, moose typically prefer habitats where adequate browse is available. Preferred fall and winter browse includes red-osier dogwood (*Cornus sericea*), willow species, trembling aspen, balsam poplar, bog/dwarf birch (*Betula glandulosa*), alder (*Alnus* spp.), and beaked hazelnut (*Corylus cornuta*), among others (Stelfox 1993). To access this forage, habitats with high cover of shrub species are usually preferred, particularly in late winter, such as shrubby fens and bogs, and riparian habitats with open canopies. Shrub height is important during winter conditions, as forage shrub species must be higher than the snowpack to be accessed by moose. During periods of deep snow, cows, calves, and sometimes bulls, will move from open areas to areas with low snow cover (Telfer 1970; Hauge and Keith 1981; Pierce and Peek 1984; Timmerman and McNichol 1988). Dense stands with greater than 60% coniferous species and greater than 10 m in height provide maximum thermal protection and lower snow depths (Allen et al. 1987).

Behaviour and Distribution

Historical moose range encompassed suitable habitat south of the treeline throughout the NWT. However, since the early 1900s, moose have been seen at numerous locations on the tundra where adequate forage is available (ENR 2010a, internet site). South of the treeline, moose are widely distributed in the NWT, although, densities are relatively low (five to 15 moose per 100 km^2 [ENR

2010a]) compared to the southern boreal forest regions (Sly et al. 2001). The estimated number of moose in the NWT is about 20,000 (ENR 2010a, internet site).

Stenhouse et al. (1994) found that mean annual home range for cows in the Mackenzie Valley, NWT was 174 km^2 (±31 km^2, N=29). This home range estimate was larger than those reported for adult moose in other parts of North America (Stenhouse et al. 1994), which may indicate that forage abundance was lower (Mace et al. 1984; Risenhoover 1986).

The best areas for moose are characterized by semi-open forest cover, an abundance of willow and aspen stands, and are located close to lakes, river valleys, stream banks, or sand bars. During the summer, moose may move into the tundra where they feed on semi-aquatic vegetation in wetlands and shallow lakes (Bromley and Buckland 1995). Moose cows usually select areas in immediate proximity to small ponds and marshes for calving.

Traditional knowledge suggests that moose are not common to the barrenlands and RSA, and are more often harvested in forested areas such as the East Arm of Great Slave Lake around McLean Bay, the North Shore, and Wildbread Bay (LKDFN 2005, internet site). Overall, the RSA is likely used by moose during the spring to autumn seasons. Animals that have the RSA overlap a portion of their home range are likely to move to the forest during the winter. The RSA may also be used by dispersing animals during the non-winter period.

Moose are primarily threatened by direct and indirect habitat loss, altered predator/prey relationships, and hunting. Their primary predators are wolves and bears, which most often kill calves, although adults can also become prey (Ballard and Van Ballenberghe 1997). Predation and snow conditions are interrelated factors that can affect moose survival and recruitment. When snow is deep, moose “yard” together, and therefore become more accessible in greater numbers to wolves (ENR 2010a, internet site). In addition, snow depth of over 90 cm, greatly hinders their movements and reduces the availability of suitable browse species above the snowpack (ENR 2010a, internet site).

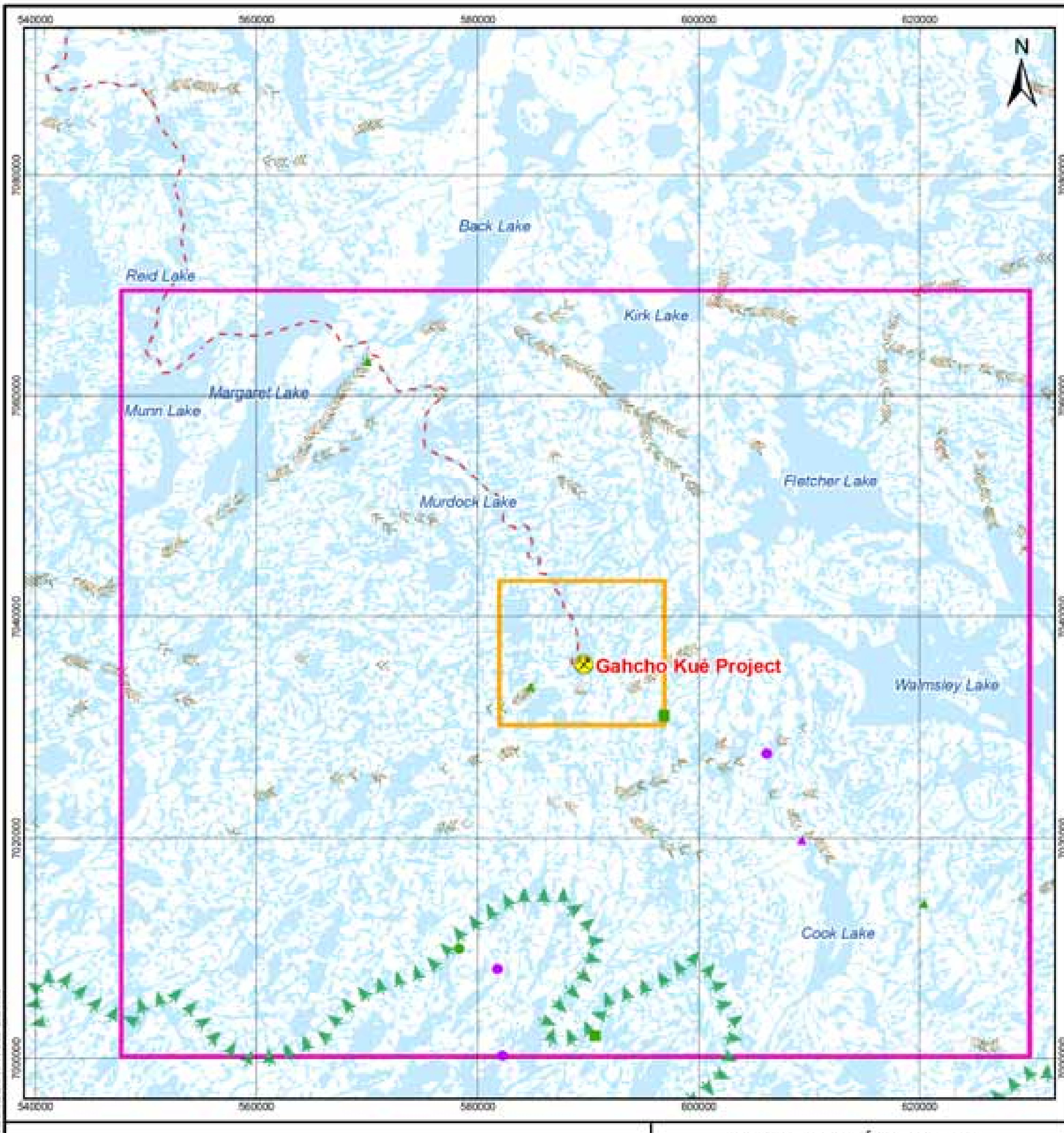
Population Characteristics

Moose populations in the NWT are listed as secure (NWT General Status Ranking Group 2010, internet site), and are not listed federally (COSEWIC 2009, internet site). Stenhouse et al. (1994) studied the productivity and survival of 30 radio-collared female moose (greater than or equal to 1.5 years) from 1985 through 1998. The productivity of female moose in the Mackenzie Valley compared favourably with that of moose across North America (Boer 1992). Pregnancy rates were 96% for adult and 40% for yearling females (Stenhouse et al. 1994). Mean newborn calf:female ratio and twinning rates were 1.2:1 and 31%, respectively (Stenhouse et al. 1994). Stenhouse et al. (1994) also found that mean annual female survival rate (hunting included) was 85%, and annual calf survival was high and stable (44 ± 0.02%) compared to other northern boreal regions (Larsen et al. 1989; Ballard et al. 1991). Life expectancy for moose is estimated at 15 to 20 years (National Geographic 2010b, internet site).

Traditional knowledge indicates that moose are not common to the RSA, although, moose have occasionally been observed. From 1996 through 2005, 14 moose were recorded within the RSA, 13 of which have been recorded since 1999 (Figure 11.11-6). Similarly, few moose have been observed within the Snap Lake Mine study area (3,000 km^2) from 1999 to 2006. No more than two observations were made in a single year until 2006 (De Beers 2007). In 2006, a cow moose was observed in June, and two bull moose were seen in August.

Traditional and Non-Traditional Use

The Deninu Kué First Nation describes moose as smart, cautious animals that are difficult to hunt (Fort Resolution Elders 1987). Currently in the NWT, moose are managed mostly by controlling the hunting season for resident and non-resident hunters (ENR 2010a, internet site). The estimated total NWT moose harvest is 1,000 to 2,000 animals per year, 80% to 90% of which is taken by General Hunting License holders who are able to hunt during any season. Traditional knowledge indicates that moose are harvested most commonly in the East Arm of Great Slave Lake around McLean Bay, the North Shore, Wildbread Bay, Basile Bay, Regina Bay, Stark Lake, Duhamel Lake, and several other places with bays and weeds (LKDFN 2005, internet site).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline

1999
- Moose
- Moose Sign

2004
- Moose
- Moose Sign

2005
- Moose
- Local Study Area
- Regional Study Area

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

GAHCHO KUÉ PROJECT

Incidental Observations of Moose in the Regional Study Area 1999, 2004, and 2005

PROJECTION: UTM Zone 12	DATUM: NAD83		
Scale: 1:500,000 (10 5 0 10 Kilometres)			
FILE No: SON-11-11-006-GIS		DATE: October 7, 2010	
JOB NO: 09-1365-1004	REVISION NO: 1		
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	

DE BEERS CANADA

Figure 11.11-6

11.11.3 Pathway Analyses

11.11.3.1 Methods

Pathway analysis identifies and assesses the issues and linkages between the Project components or activities, and the correspondent potential residual effects on other ungulates (i.e., moose and muskoxen). Pathway analysis is a three-step process for determining linkages between Project activities and environmental effects that are assessed in Sections 11.11.4 and 11.11.5. Potential pathways through which the Project could influence other ungulates 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 moose and muskoxen. 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 other ungulates. 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 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 other ungulates. 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 other ungulates.

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 other ungulates. Pathways are determined to be primary, secondary (minor), or as having no linkage using scientific and traditional knowledge, 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 other ungulate populations, and continued opportunity for traditional and non-traditional use of other ungulates. Pathways with no linkage to other ungulate populations or that are considered minor are not analyzed further or classified in Sections 11.11.4 and 11.11.5 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 other ungulates or those that are considered secondary are not predicted to result in environmentally significant effects on the persistence of other ungulate populations and continued opportunity for traditional and non-traditional use of other ungulates. Primary pathways are assessed in more detail in Sections 11.11.4 and 11.11.5.

11.11.3.2 Results

Pathways potentially leading to effects on other ungulates include direct and indirect changes to habitat, and survival and reproduction (Table 11.11-2). These changes may ultimately affect the persistence of other ungulate populations, and continued opportunity for traditional and non-traditional use of other ungulates. Evaluation of effects on other ungulates 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.

Table 11.11-2 Potential Pathways for Effects to Other Ungulates

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 moose and muskoxen 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 moose and muskoxen from the mine rock pile 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 moose and muskoxen population size		Secondary

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (continued)

<table>
<tr><th>Project Component/Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Assessment</th></tr>
<tr><td rowspan="5">Construction and Operations
(e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities)
Winter Access Road and Tibbitt-to-Contwoyto Winter Road</td><td>• dust deposition may cover vegetation and decrease abundance of forage for moose and muskoxen (i.e., habitat quantity)</td><td rowspan="4">• 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 and efficiencies will be optimized to minimize noise disturbances
• 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</td><td>Secondary</td></tr>
<tr><td>• dust deposition may cover vegetation and change the amount of different quality habitats, and alter moose and muskoxen movement and behaviour</td><td>Primary</td></tr>
<tr><td>• dust deposition and air emissions may change the amount of different quality habitats (through chemical changes in soil and vegetation), and alter moose and muskoxen movement and behaviour</td><td>Secondary</td></tr>
<tr><td>• 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 moose and muskoxen survival and reproduction</td><td>No Linkage</td></tr>
<tr><td>• sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats, and alters moose and muskoxen movement and behaviour, which can influence survival and reproduction</td><td>• 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, 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
• 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</td><td>Primary</td></tr>
</table>

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (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)	• 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 Project 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 moose and muskoxen 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 11.11-2 Potential Pathways for Effects to Other Ungulates (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 fluids at 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 if necessary • puddles of de-icing fluids in the swales will be removed by vacuum truck and deposited into waste de-icing fluid drums for shipment to recycling facilities if necessary • 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)	• 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 mine rock piles or Fine PKC Facility • care will be taken to prevent the inclusion of wastes that could attract wildlife	Secondary

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (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) (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 moose and muskoxen movement and behaviour	• mine rock used to construct the dykes will be non-acid generating (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 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 moose and muskoxen survival and reproduction		No Linkage

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (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 Fine PKC Facility, Coarse PK and mine rock piles may change the amount of different quality habitats, and alter moose and muskoxen movement and behaviour • ingestion of seepage and surface water 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 moose and muskoxen survival and reproduction	• 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	No Linkage

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Site Water Management (continued)	• ingestion of seepage and surface water 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 moose and muskoxen survival and reproduction (continued) • release of seepage and surface water runoff (including erosion) from the PK and mine rock piles may change the amount of different quality habitats, and alter moose and muskoxen movement and behaviour (continued)	• 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 • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock pile; 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 Linkage
Winter Access Road and Tibbitt-to-Contwoyto Winter Road	• road footprint decreases habitat quantity and may cause fragmentation, which can alter moose and muskoxen 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 moose and muskoxen movement and behaviour	• use of proven best practices for winter road construction	Secondary
	• increased access for traditional and non-traditional harvesting may alter moose and muskoxen 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

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Dewatering of Kennady Lake	• ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect moose and muskoxen 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 moose and muskoxen 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 moose and muskoxen 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 moose and muskoxen movement and behaviour, and could cause injury/mortality to individual animals		No Linkage

Table 11.11-2 Potential Pathways for Effects to Other Ungulates (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 moose and muskoxen 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 pit; 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 moose and muskoxen 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; % = percent.

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 other ungulates.

11.11.3.2.1 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 so that the Project results in no detectable (measurable) environmental change and residual effects to other ungulates (i.e., moose and muskoxen). The following pathways are anticipated to have no linkage to other ungulates, and will not be carried through the effects assessment.

Changes to Habitat Quality, Movement, and Behaviour

The pathways described in the following bullets have no linkage to habitat quality, movement, and behaviour of other ungulates. To be conservative, it is assumed that 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 moose and muskoxen 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 11.11-2). 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 11.11-2). 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 11.11-2).

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 11.11-2).

Progressive reclamation and closure 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 and Diavik Diamond mines. Thermistors will be installed within the mine rock piles to monitor the progression of permafrost development (Table 11.11-2). 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 processed kimberlite (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 moose and muskoxen populations, and continued opportunity for traditional and non-traditional use of moose and muskoxen.

- 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 11.11-2). 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 piles 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 11.11-2). 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 11.11-2). 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 11.11-2). 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 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 moose and muskoxen populations, and continued opportunity for traditional and non-traditional use of moose and muskoxen.

Changes to Survival and Reproduction

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

- 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 moose and muskoxen survival and reproduction.

- Ingestion of soil, vegetation, or water that has been chemically altered by leaching of PAG mine rock may affect moose and muskoxen 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 moose and muskoxen survival and reproduction.

Ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect moose and muskoxen survival and reproduction. Moose and muskoxen 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, moose and muskoxen 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 moose and muskoxen may drink from the collection ponds or associated containment ditches, which may result in negative changes to moose and muskoxen 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 11.11-2). Runoff and seepage from the Fine PKC Facility, Coarse PK and mine rock piles will not be released beyond 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 piles will be contained and drain to either Area 3 or to one of the mined-out pits using natural drainage channels (Table 11.11-2). 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 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 11.11-2).

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 11.11-2). 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 11.11-2). 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 reclamation and closure 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 and Fine PKC Facility to monitor the progression of permafrost development (Table 11.11-2). 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 11.11-2). The 5034 Pit will be backfilled to the extent possible with mine rock. 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. However, dust from Project activities may settle on the exposed portion of the lake-bed sediments, and be inadvertently ingested by moose and muskoxen foraging in this area. Moose and muskoxen 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 moose and muskoxen health. Consequently, the pathways described above were determined to have no linkage to effects on the persistence of moose and muskoxen populations, and continued opportunity for traditional and non-traditional use of moose and muskoxen.

- 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 (Tahera 2007; BHPB 2010; 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 Access Road and the Tibbitt-to-Contwoyto Winter Road (Table 11.11-2). 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.
- The waste transfer storage are 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.
- Spill containment supplies will be available in designated areas where fuel and chemicals are stored.
- 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 fluids in a specific area at the airstrip that will be equipped with swales to collect excess fluids if necessary.

- Puddles of de-icing fluids in the swales will be removed by a vacuum truck and deposited into waste de-icing fluid drums for shipment off-site and recycling if necessary.
- Prior to demolition, buildings and equipment will be inspected so that potentially hazardous materials are correctly identified and flagged for appropriate removal and disposal.
- 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 (Section 3, Appendix 3.I, Attachment 3.I.1), environmental design features, mitigation, and monitoring programs is expected to result in no detectable change to health or mortality of moose and muskoxen. Consequently, this pathway was determined to have no linkage to effects on the persistence of moose and muskoxen populations, and continued opportunity for traditional and non-traditional use of moose and muskoxen.

- 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.

Moose and muskoxen 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 11.11-2). Consequently, moose and muskoxen mortality from dewatering of Kennady Lake is determined to have no linkage to effects on the persistence of moose and muskoxen populations.

- Changes in the timing of freeze and break-up downstream may alter moose and muskoxen 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 11.11-2). 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 moose and muskoxen. 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 moose and muskoxen populations.

11.11.3.2.2 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 moose and muskoxen 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 are not carried through the effects assessment.

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 moose and muskoxen (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 11.11-2). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression (Table 11.11-2). 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 hectare per year (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 (Table 11.11-3). 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 11.11-3 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 fence line (i.e., Project footprint) and are anticipated to result in a minor change to habitat quantity relative to baseline conditions (secondary pathway; Table 11.11-2). Subsequently, residual effects to the persistence of moose and muskoxen populations, and the continued opportunity for traditional and non-traditional use of moose and muskoxen 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 moose and muskoxen 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 moose and muskoxen 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 11.11-2). 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 11.11-2). 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 flows from Lake A3 to Lake N9 will remain permanently 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 moose and muskoxen relative to baseline conditions. Therefore, the residual effects to the persistence of moose and muskoxen populations, and continued traditional and non-traditional land use of moose and muskoxen 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, will 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 moose and muskoxen relative to baseline conditions (secondary pathway; Table 11.11-2). Therefore, the residual effects to the persistence of moose and muskoxen populations resulting from the dewatering of Kennady Lake are predicted to be negligible.

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 other ungulates.

- Dust deposition and air emissions may change the amount of different quality habitats (through chemical changes in soil and vegetation), and alter moose and muskoxen 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. 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 effects 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 11.11-2). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression (Table 11.11-2). 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 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 the maximum annual dust deposition resulting 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 (Table 11.11-3). 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 11.11-3). 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 indicates 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 11.11-3). 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 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 11.11-4). 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 11.11-4). 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 11.11-4 Summary of Key Predicted Peak Annual Air Quality Concentrations in the Regional Study Area

Substance	Criteria (μg/m^3)	Maximum Predicted Concentration			
		Baseline		Application	
		Concentrations in the Regional Study Area (μg/m^3)	Distance to Peak Predictions (km)	Concentrations Outside Project Development Area Boundary (μg/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.
μg/m^3 = micrograms per cubic metre; km = kilometres; NOx = nitrogen oxides; NO_2 = nitrogen dioxide. SO_2 = sulphur dioxide. $PM_{2.5}$ = particulate matter. 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 be 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 moose and muskoxen movement and behaviour) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions (secondary pathway; Table 11.11-2). Consequently, residual effects to the persistence of moose and muskoxen populations, and continued opportunity for traditional and non-traditional use of these species 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 moose and muskoxen 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, internet site) (Section 11.7). As such, 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 (Table 11.11-2). Therefore, the residual effects to the persistence of moose and muskoxen populations are predicted to be negligible.

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 other ungulates.

- Physical hazards from the Project may increase the risk of injury/mortality to individual animals, which can affect moose and muskoxen 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 an increased frequency of injury or mortality to moose and muskoxen. However, the implementation of environmental design features (Table 11.11-2) 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 wildlife form the mine rock pile 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. No moose or muskoxen mine-related mortalities have been reported at existing mine sites in the NWT and Nunavut from 1996 to 2009 (Tahera 2007; BHBP 2010; De Beers 2010; DDMI 2010).

Although there is a potential for mortality or injury to occur, the implementation of the Wildlife Effects Mitigation and Management Plan (Appendix 7.I) is anticipated to reduce the risk of moose and muskoxen mortality from physical hazards on-site. Changes in mortality are predicted to be minor relative to baseline conditions (secondary pathway; Table 11.11-2). As such, moose and muskoxen mortality from physical hazards on-site is expected to have a negligible residual effect on the persistence of moose and muskoxen populations.

- 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 moose and muskoxen through collisions with aircraft and on-site vehicles. There are no reported injuries/mortalities related to moose and muskoxen for other developments in the NWT or Nunavut (Tahera 2007; BHPB 2010; DDMI 2010; De Beers 2010). Aircraft collisions have not been the cause of any recorded wildlife injuries or mortalities at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Mine, or the Snap Lake Mine (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 8 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). 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, internet site). 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, internet site). In March 1999, five caribou were killed by a grocery (meat) truck on a portage near Gordon Lake (EBA 2001, internet site). In 2009, a red fox was killed on the Tibbitt-to-Contwoyto Winter Road (Madsen 2010, pers. comm.)

Mitigation strategies have been established to reduce the potential for vehicle and aircraft collisions at the Project and along the Winter Access Road (Table 11.11-2). 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 moose and muskoxen:

- 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; and
- safe, effective methods will be used to remove moose and muskoxen 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 (Appendix 7.I) is anticipated to limit moose and muskoxen 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 the risk of moose and muskoxen mortality from vehicle and aircraft collisions. As such, moose and muskoxen mortality from vehicle and aircraft collisions is expected to have a negligible residual effect on the persistence of moose and muskoxen populations, and the continued opportunity for traditional and non-traditional use of moose and muskoxen.

- 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 a Project if food items are frequently present. 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.

Environmental design features and mitigation have been established to reduce the attraction of wildlife to the Project, however, 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. However, 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 moose and muskoxen, 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 11.11-2). 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 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 soring of domestic waste.
- Food waste will immediately be planced and sealed in plastic bags. The plastic bags will be stored in sealed, wildlife-resistant containmers 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 or 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.

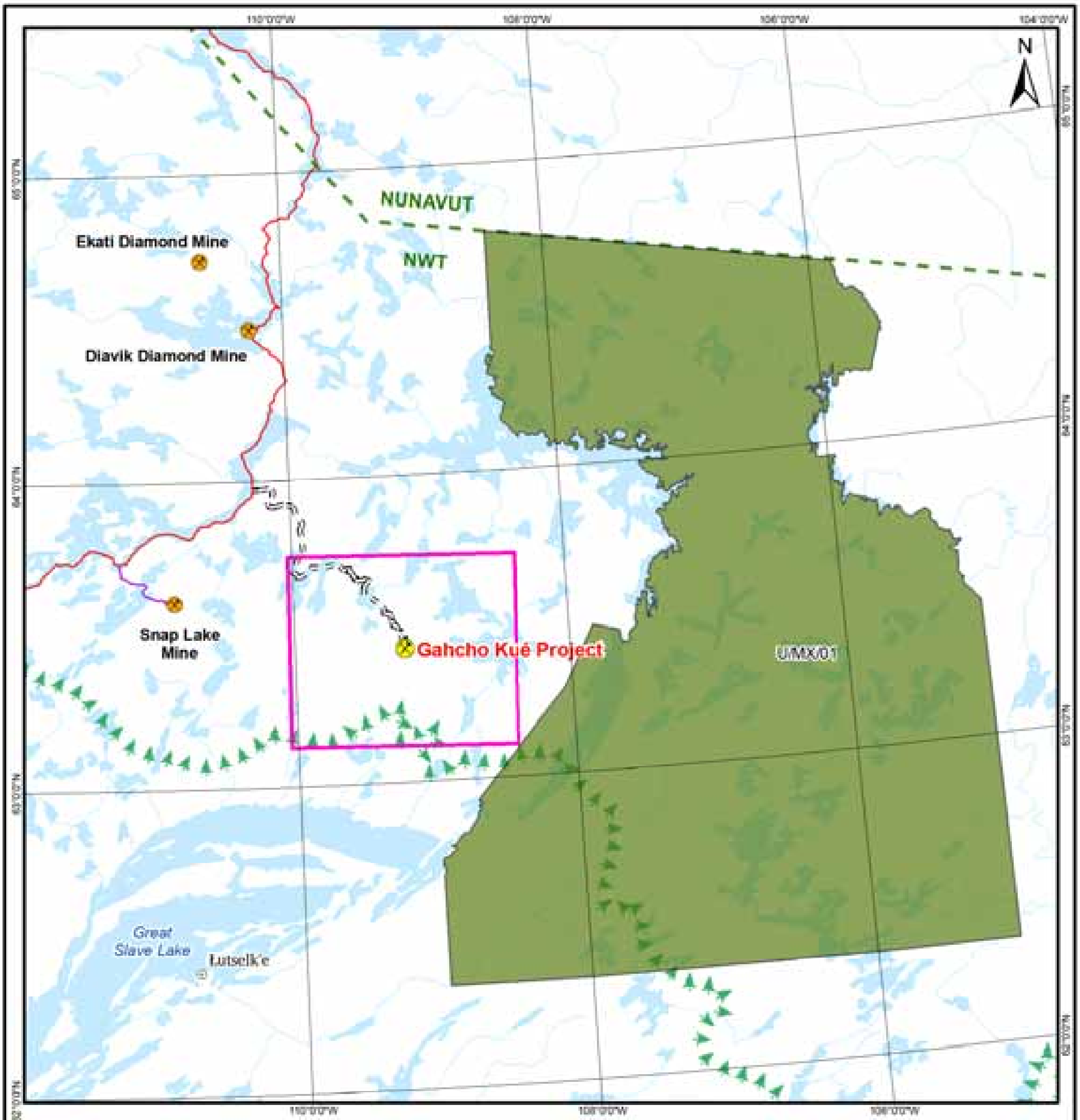
At the Snap Lake Mine, there were no reported waste or attractant-related incidents or mortalities to carnivores from 1999 to 2009 (Golder 2008, De Beers 2009, 2010), which indicates a low frequency of attractants at the site. The implementation of the Waste Management Plan (Section 11.9) and the Wildlife Effects Mitigation and Management Plan (Appendix 7.I) 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 moose and muskoxen by grizzly bears and wolves is not anticipated to increase above baseline conditions as a result of attractants to the site (Section 11.9). Therefore, moose and muskoxen mortality from increased predation is expected to have a negligible residual effect on the persistence of moose and muskoxen populations.

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

Currently in the NWT, muskoxen are harvested under quota on three arctic islands (Melville Island I/MX/01, Banks Island I/MX/02, and northwest Victoria Island I/MX/03) and four areas on the mainland (I/MX/05, I/MX/06, S/MX/01, and U/MX/01) (ENR 2010b, internet site). The Wildlife Management Area U/MX/01 is located 1.5 km east of the RSA of the Project, and is the only management area near the RSA (Figure 11.11-7). Harvesting of muskoxen is regulated by the *Wildlife Act,* Big Game Regulations. Because the RSA is not part of the Wildlife Management Area U/MX/01, hunting of muskoxen within the RSA is not permitted.

Currently in the NWT, moose are managed mostly by controlling the hunting season for resident and non-resident hunters (ENR 2010b, internet site). For resident hunters, the moose hunting season is September 1 to January 31, whereas non-resident hunters are only allowed to hunt moose from September 1 to October 31 (ENR 2010b, internet site). General Hunting Licence (GHL) holders (including all natives, most Métis, and a few long-time non-native residents) may hunt during any season. Non-residents are not allowed to hunt moose in the 'U' Wildlife Management Area (ENR 2010b, internet site), which encompasses the Project. An average of 74 moose (range 16 to 170 individuals) have been harvested per year by residents from 1984 to 2009, within the Fort Smith region (North and South Slave, excluding Yellowknife) (data provided by Environment and Natural Resources [ENR]). The estimated total NWT moose harvest is 1,000 to 2,000 animals per year, 80 to 90% of which is taken by GHL holders.

The harvest period for resident hunters for moose is from September 1 to January 31 (ENR 2010b, internet site), which partially overlaps the winter road season (approximately 8 to 12 weeks each year). Aboriginal hunters may benefit from increased access to moose from the Winter Access Road. Although no harvest data exists for the Tibbitt-to-Contwoyto Winter Road, Ziemann (Zieman 2007, internet site) has tracked the level of hunting activity for 2004 to 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, internet site). Decreases in hunting traffic may have been 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]).



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Muskoxen Wildlife Management Area
- Regional Study Area

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Location of the Project in Relation to the Wildlife Management Area U/MX/01 for Muskoxen

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale: 1:2,000,000 (30 15 0 30 Kilometres)	DE BEERS CANADA
FILE No: SON-11-11-017-GIS	DATE: October 8, 2010
JOB NO: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: MGD / CHECK: JV

Figure 11.11-7

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 winter roads is limited to an eight to 12 week period each year, and should result in minor changes to the annual harvest rate of moose and muskoxen 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 moose and muskoxen for non-residents. Policies implemented by De Beers Canada Inc. (De Beers) will prevent people at the Project site from using the Winter Access Road for hunting moose and muskoxen (while they are at site). Therefore, increased access for harvesting along the winter roads is expected to have a negligible residual effect on the persistence of moose and muskoxen populations.

11.11.3.2.3 Primary Pathways

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

Changes to Habitat Quantity and Fragmentation

- Direct loss and fragmentation of wildlife habitat from the physical footprint of the Project may alter moose and muskoxen movement and behaviour.
- Road footprint decreases habitat quantity and may cause fragmentation, which can alter moose and muskoxen movement and behaviour.

Changes to Habitat Quality, Movement, and Behaviour

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

11.11.4 Effects on the Population Size and Distribution of Muskoxen

The effects analysis considers all primary pathways that result in expected changes to muskoxen population size and distribution, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects to muskoxen are analyzed using measurement endpoints and are expressed as effects statements, including:

- effects from changes in habitat quantity and fragmentation; and
- effects from changes in habitat quality, movement, and behaviour.

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 muskoxen. For example, the pathways for effects on habitat quality, movement, and behaviour include changes due to noise, dust deposition, and the presence of vehicles and mine infrastructure, which ultimately affect muskoxen population size and distribution.

Detailed descriptions of the spatial and temporal boundaries, and methods used to analyze residual effects from the Project on muskoxen 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.

11.11.4.1 Habitat Quantity and Fragmentation

11.11.4.1.1 Methods

The incremental and cumulative direct habitat effects to muskoxen from the Project footprint and other previous, existing, and future developments in the RSA 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. Decreases in habitat area and number of similar quality habitat patches can directly influence population size by reducing the carrying capacity of the environment. Changes in the number of patches and distance between similar habitat patches can influence the distribution (and abundance) of muskoxen and moose by affecting the ability of animals to travel across the land.

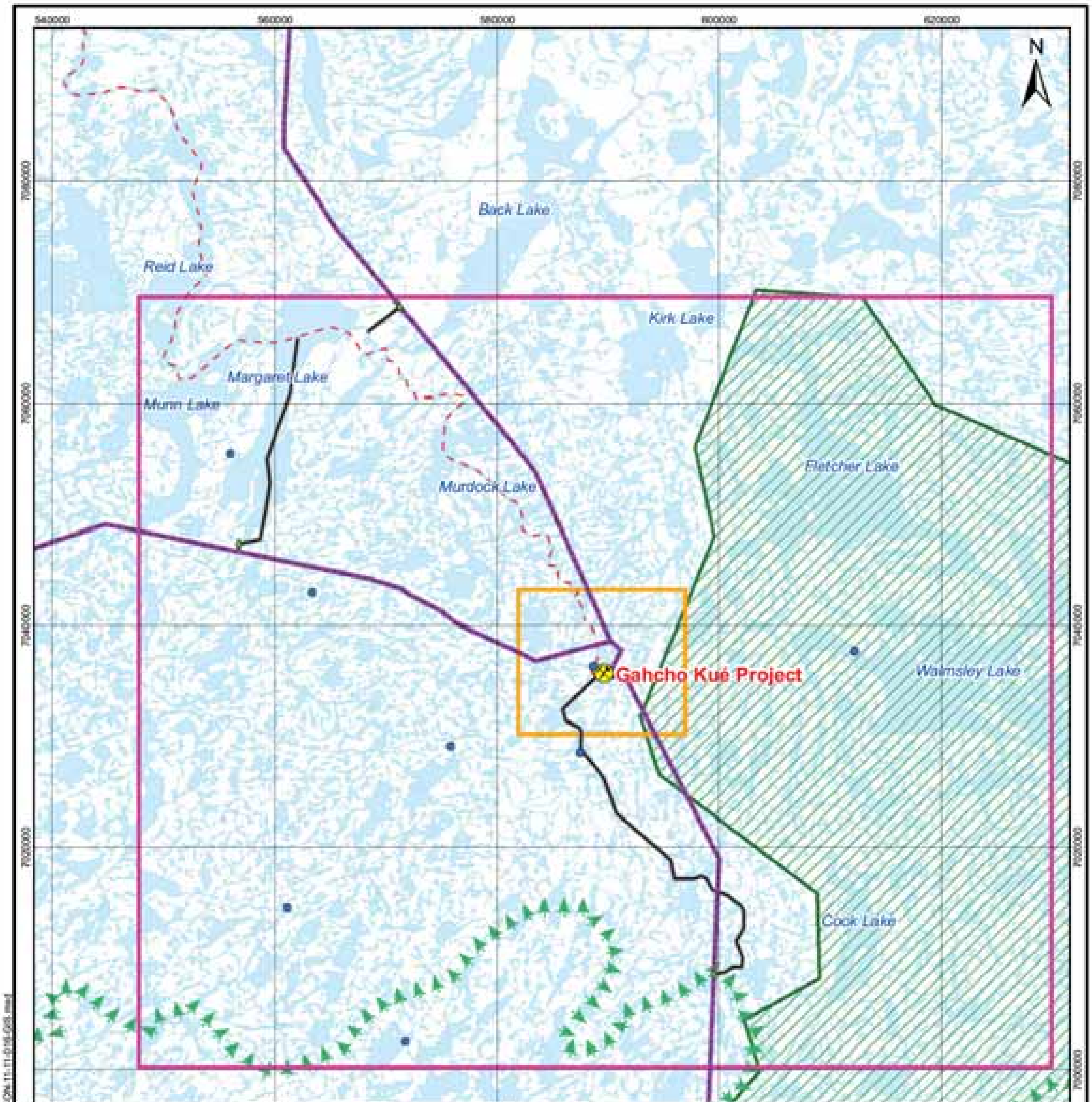
Landscape metrics were determined using the program FRAGSTATS (Version 3.0; McGarigal et al. 2002, internet site) within a Geographic Information System (GIS) platform. The analysis determined the extent of landscape fragmentation by calculating statistical outputs based on the values of each raster cell. Raster cells (25 m x 25 m) for habitats with extensive coverage in the RSA (including disturbed areas) were based on the Ecological Landscape Classification (ELC) of broad ecosystem units (Section 11.7).

Previous and existing developments in the RSA include eight mineral exploration programs (including the Kennady Lake exploration program) (Figure 11.11-8). Currently, four of these sites have active land use permits (including the Kennady Lake exploration program). 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;
- INAC: contaminated sites database;
- company websites; and
- knowledge of the area and project status.

Initially, data indicating permitted and licensed activities were obtained in spreadsheet format. 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 development layer within a GIS platform. Because the database contains no information on the size of the physical footprint for exploration programs, a 500-m radius was used to estimate the area of the footprint for exploration sites (78.5 ha), which likely overestimates the amount of habitat directly disturbed by exploration activities. 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.



LEGEND

- Gahcho Kué Project
- Watercourse
- Waterbody
- Treeline
- Local Study Area
- Regional Study Area

Previous and Existing Development

- Mineral Exploration
- Winter Access Road

Future Development

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

NOTES

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

GAHCHO KUÉ PROJECT

Previous, Existing and Reasonably Foreseeable Future Developments in the Regional Study Area

PROJECTION: UTM Zone 12	DATUM: NAD83		
Scale: 1:500,000 (10 5 0 10 Kilometres)			DE BEERS CANADA
FILE No: SON-11-11-016-GIS			DATE: October 21, 2010
JOB NO: 09-1365-1004	REVISION NO: 4		Figure 11.11-8
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

Footprints for linear disturbances (e.g., winter roads and the proposed Taltson transmission line) consisted of a 25 m right-of-way. 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. For all developments (including the Project), the physical footprint was carried through each assessment case (Section 6.6.2) as it was assumed that direct effects to the landscape had not yet been reversed. The development layer was then applied to the landscape classification of the study area for the baseline, application, and future cases (Table 11.11-5).

Table 11.11-5 Contents of Each 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 study area, 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 wildlife populations. The application case occurs in 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 known, reasonably foreseeable developments that may generate incremental changes on vegetation ecosystems (habitat) in the study area for muskoxen and moose:

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

The temporal boundary for cumulative effects from future developments is a function of the duration of effects from the Project on muskoxen. 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 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 study area. 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 project are discussed in the section on uncertainty (Section 11.11.9).

Landscape metrics were determined for the reference, 2010 baseline, application, and future case during the winter and non-winter periods. Fragmentation analysis included the Winter Access Road and other potential winter roads (i.e., associated with construction of the Taltson project) for the winter period 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 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, and provides both direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type. Alternately, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity. Appendix 11.11.I (Tables 11.11.I-1 and 11.11.I-2) provides absolute values per habitat type and assessment case (i.e., reference, baseline, application, and future).

11.11.4.1.2 Results

Effects from Project Footprints

For muskoxen (and moose), the effects assessment was based on the predicted cumulative changes from reference conditions through application of the Project and reasonably foreseeable developments. The spatial boundary of the assessment is at the scale of the range of the population (i.e., the RSA). Cumulative effects from the Project and other developments influence the entire population range (i.e., beyond local scale effects). In contrast, the geographic extent of incremental changes to habitat quantity from the Project has a local influence on the population range of muskoxen and moose.

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 PKC Facility will not be vegetated to prevent the facility from becoming attractive to wildlife (Section 11.7). The mine rock piles and PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha of terrestrial habitat.

Forage requirements for muskoxen vary seasonally, therefore, a wide range of habitat types were identified as high suitability habitat for muskoxen, including heath tundra, heath bedrock, heath boulder, birch seep, tall shrub, tussock-hummock, and sedge wetland (Section 11.11.4.2). Under reference conditions, the RSA is mainly comprised of waterbodies (25%), peat bog (9%), tussock-hummock (10%), and sedge wetlands (11%). Heath boulder, heath bedrock, tall shrub, and spruce forest each constitute less than 10% of the RSA. Birch seep and heath tundra each account for about 5% of the landscape.

At the scale of the RSA, the relative change in the amount of habitat from reference to 2010 baseline conditions is less than 0.2% for each habitat type during the non-winter period (Table 11.11-6). The anticipated incremental loss of any habitat type from the Project, relative to 2010 baseline conditions is less than or equal to 0.5% of the RSA. Development of the Project is expected to decrease highly suitable habitat (i.e., heath tundra, heath bedrock, heath boulder, birch seep, tall shrub, tussock-hummock, and sedge wetland) for muskoxen. The decrease in the amount of high quality habitat ranges from 0.07% to 0.29%, relative to 2010 baseline conditions (Table 11.11-6). Overall, the Project is expected to disturb approximately 2.6% of the landscape in the RSA.

Similarly, incremental habitat-specific changes from the Taltson project (future case) are expected to be less than 0.2%. The total combined loss of all habitats in the RSA from the Taltson project is 0.9%. The cumulative direct disturbance to the landscape from the Project and other previous, existing and future developments is predicted to be about 4.7% relative to reference conditions.

Increasing development on the landscape has also resulted in marginal changes to the number and distance between similar habitat patches in the RSA during the spring to autumn period. For a particular habitat, development of previous and existing projects decreased the number of habitat patches on the landscape from 0 to 0.1% relative to reference conditions (Table 11.11-6). Habitat-specific changes in the mean distance to nearest neighbour were estimated to be less than 0.1%. Similarly, application of the Project and other reasonably foreseeable projects changed the number and distance between patches on the landscape by less than 0.5%. The exception was for the future project case, which increased the number of esker patches by 1.4% and decreased the distance between eskers by 2% (Table 11.11-6).

Table 11.11-6 Change (%) in Area and Configuration of Habitat Types from Development within the Regional Study Area during Baseline, Application, and Future Conditions in the Spring to Autumn

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 Complex	623.63	0.00	0.00	-0.02	145	0.00	0.00	1.38	769.24	0.00	0.00	-2.02
Spruce Forest	32223.50	-0.08	-0.15	-0.07	96659	-0.08	-0.18	0.01	78.23	0.01	0.04	0.02
Birch Seep	27669.69	-0.10	-0.11	-0.09	63001	-0.08	-0.13	0.02	88.30	0.03	0.03	0.01
Peat Bog	48409.75	-0.10	-0.20	-0.08	84575	-0.06	-0.10	0.08	75.93	-0.01	0.03	-0.03
Tussock Hummock	51707.50	-0.11	-0.21	-0.07	99588	-0.08	-0.15	0.04	72.94	0.01	0.06	0.00
Heath Bedrock	38657.44	-0.09	-0.11	-0.08	55211	-0.08	-0.11	0.07	85.23	0.01	0.01	-0.04
Heath Tundra	24419.31	-0.02	-0.29	-0.12	30635	-0.04	-0.08	0.08	121.90	-0.02	0.05	-0.05
Heath Boulder	44558.88	-0.11	-0.07	-0.06	81460	-0.09	-0.09	0.03	78.35	0.01	0.00	-0.01
Boulder Assoc.	18930.25	-0.09	-0.07	-0.06	62187	-0.09	-0.09	0.00	99.07	0.03	-0.01	0.01
Bedrock Assoc.	24678.88	-0.08	-0.02	-0.05	59630	-0.08	-0.07	0.03	94.37	0.00	-0.03	-0.02
Tall Shrub	31334.25	-0.08	-0.14	-0.08	83741	-0.09	-0.17	0.04	79.04	0.03	0.02	-0.01
Sedge Wetland	56197.06	-0.11	-0.24	-0.06	53616	-0.06	-0.21	0.12	84.35	0.02	0.09	-0.04
Shallow Water	37150.56	-0.10	-0.50	-0.06	19091	-0.03	-0.32	0.20	115.21	-0.01	0.29	-0.15
Deep Water	96981.25	-0.13	-0.46	-0.02	3566	0.06	-0.36	0.23	257.93	0.02	0.01	-0.36

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).

% = percent; ha = hectares; m = metres

Effects from Winter Roads

During the winter period, previous and existing developments (which include the Winter Access Road to the Project) have physically altered about 1.6% of habitats on the landscape relative to reference conditions. This represents a marginal increase in landscape disturbance of 0.4% (from 1.2 to 1.6%) relative to the non-winter period (compare Table 11.11-6 and Table 11.11-7). Most of the change is associated with the temporary disturbance of frozen lakes (shallow and deep water) from the Winter Access Road; however, there was an additional disturbance of 0.05% to esker habitat. Similar results were produced for relative changes between the non-winter and winter periods for the number and distance between similar habitat patches (Table 11.11-6 and Table 11.11-7). However, the Winter Access Road increased the number of esker patches by 1.4% and decreased the distance between eskers by 1.7%.

Application of the Project resulted in a 2.6% decrease in habitat on the landscape during winter. The cumulative disturbance to the landscape from the Project, including the Winter Access Road and previous and existing developments relative to reference conditions is 4.2% (Table 11.11-7). Addition of the proposed Taltson project (and associated winter roads during construction) reduced the amount of habitat in the study area by approximately 1.2%. The estimated total combined loss of all habitats in the RSA from the Project and other previous, existing, and future developments is 5.4% (Table 11.11-7). Application of the Project and other reasonably foreseeable projects changed the number and distance between patches on the landscape by less than 1%. The exception was for the future case, which increased the number of esker patches by 1.4% and decreased the distance between eskers by 2% (Table 11.11-7).

The presence of Winter Access Road may represent a temporary barrier to muskoxen within the RSA. For example, roads may contribute to fragmentation of populations through both increased mortality and modifications of behaviour that makes animals less likely to cross roads (Trombulak and Frissell 1999). In some cases, roads appear to be “leaky barriers” (some animals do manage to cross successfully) but they may nevertheless restrict the regional-scale dynamics of species (Treweek 1999).

Table 11.11-7 Change (%) in Area and Configuration of Habitat Types from Development within the Regional Study Area during Baseline, Application, and Future Conditions in the Winter

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 Complex	624	-0.05	0.00	-0.02	145	1.38	0.00	1.36	769	-1.74	0.00	-2.00
Spruce Forest	32224	-0.09	-0.15	-0.09	96659	-0.08	-0.18	0.01	78	0.01	0.04	0.02
Birch Seep	27670	-0.13	-0.11	-0.10	63001	-0.05	-0.13	0.03	88	0.02	0.03	0.01
Peat Bog	48410	-0.11	-0.20	-0.08	84575	-0.04	-0.10	0.09	76	-0.02	0.03	-0.05
Tussock Hummock	51708	-0.12	-0.21	-0.08	99588	-0.08	-0.16	0.05	73	0.01	0.06	0.00
Heath Bedrock	38657	-0.10	-0.10	-0.09	55211	-0.08	-0.11	0.08	85	0.02	0.01	-0.05
Heath Tundra	24419	-0.03	-0.29	-0.12	30635	-0.02	-0.08	0.09	122	-0.03	0.05	-0.04
Heath Boulder	44559	-0.12	-0.07	-0.07	81460	-0.09	-0.09	0.04	78	0.01	0.00	-0.01
Boulder Assoc.	18930	-0.10	-0.07	-0.08	62187	-0.10	-0.09	0.02	99	0.03	-0.01	0.00
Bedrock Assoc.	24679	-0.09	-0.02	-0.06	59630	-0.08	-0.07	0.03	94	0.01	-0.03	-0.01
Tall Shrub	31334	-0.10	-0.14	-0.10	83741	-0.08	-0.17	0.06	79	0.03	0.02	-0.02
Sedge Wetland	56197	-0.14	-0.24	-0.09	53616	-0.01	-0.21	0.16	84	0.01	0.08	-0.05
Shallow Water	37151	-0.15	-0.50	-0.10	19091	0.18	-0.36	0.39	115	-0.18	0.33	-0.31
Deep Water	96981	-0.25	-0.45	-0.09	3566	0.20	-0.36	0.39	258	-0.10	0.01	-0.59

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).

% = percent; ha = hectares; m = metres

11.11.4.2 Habitat Quality, Behaviour, and Movement

11.11.4.2.1 Methods

In addition to direct habitat effects, changes to habitat quality from the Project have the potential to indirectly affect the population size and distribution of muskoxen in the RSA, through altered movement and behaviour of individuals. To estimate the change in habitat quality associated with the Project and other developments, habitat suitability index (HSI) modelling was completed for the RSA. Habitat suitability models are analytical tools for determining the relative potential of an area to provide quality habitat to support wildlife species. To estimate the effects of the Project on muskoxen, an HSI model was used to quantify habitat changes between the 2010 baseline and reference case, between the application and 2010 baseline case, and between the future and application case.

A literature review was used to identify the known habitat requirements and relationships for muskoxen. The HSI values allocated for each habitat type in the RSA are shown in Table 11.11-8.

Table 11.11-8 Habitat Suitability Index Values for Muskoxen

Habitat Type	Habitat Suitability (Index Value; 0-3)
Esker Complex	Low (1)
Boulder Association	Low (1)
Bedrock Association	Low (1)
Heath Tundra	High (3)
Heath Bedrock	High (3)
Heath Boulder	High (3)
Birch Seep	High (3)
Tall Shrub	High (3)
Spruce Forest	Low (1)
Peat Bog	Low (1)
Tussock Hummock	High (3)
Sedge Wetland	High (3)
Shallow Water	Poor (0)
Deep Water	Poor (0)
Disturbance	Poor (0)
Unclassified	Poor (0)

Sources: Klein 1992; Larter and Nagy 1997; Gunn and Adamczewski 2003.

Most wildlife species are likely to exhibit some degree of sensitivity to human disturbance. Therefore, a ZOI and associated disturbance coefficients (DC) were applied to estimate the combined direct and indirect effects (e.g., fugitive dust disposition, and sensory disturbance from noise and human activities) from development footprints (e.g., mineral exploration, Project, winter roads, and proposed Taltson transmission line). A DC reduces the original habitat suitability index (HSI) value for each habitat within the ZOI. For the muskoxen assessment, the DC value was subtracted from the HSI value to provide a reduction in habitat suitability scores where the lowest possible adjusted HSI score is zero. For all development scenarios (except transmission lines), habitat quality within all development footprints was reduced to zero (direct effects). For the proposed Taltson project, habitat quality for the footprint was reduced by 66% as habitat under the transmission is not completed degraded.

To estimate indirect effects project-related activities on muskoxen habitat, ZOIs and DCs were applied from the edge of active development footprints (Table 11.11-9). The size of the ZOI for the Project, active exploration sites, winter roads (for the Project and construction of the Taltson project), and the proposed Taltson transmission line was set at 1 or 5 km. The predicted ZOI was based on the extent of dust deposition, air emissions, and continuous noise levels during operation. Studies at the Ekati Diamond Mine have found that caribou with calves spent less time feeding within 5 km of the mine site (BHPB 2004). The zones of influence and disturbance coefficients for the Project (anticipated mine site) were also applied to smaller and less active exploration sites, which likely overestimates the effect from exploration activities.

Habitat modeling was completed for the winter period as access to food at this time of year is a limiting factor for muskoxen (Parker 1978; Gunn et al. 1991; Gunn and Fournier 2000). In addition, the winter period contains the maximum number of disturbances on the landscape (i.e., includes winter roads). Therefore, the winter represents the maximum predicted effect to muskoxen from natural factors and human development activities.

Table 11.11-9 Disturbance Coefficients for Development Footprints and Associated Zones of Influence for Muskoxen

Disturbance Type	Feature Type	Footprint		Concentric ZOI 1		Concentric ZOI 2	
		Extent (m)	DC	Range (km)	DC	Range (km)	DC
Anticipated mine site	polygon	actual	3	0 to 1	2	1 to 5	1
Mineral exploration/Camp	point	500	3	0 to 1	2	1 to 5	1
Taltson Staging Area/Barge Landings	point	500	3	0 to 1	1	1 to 5	NA
Transmission line	line	25	2	0 to 1	1	1 to 5	NA
Winter roads	line	25	3	0 to 1	1	1 to 5	NA

Note: DC reduces suitability scores through the difference between HSI value and DC value, where lowest possible HS score is zero.
ZOI = zone of influence from edge of footprint; m = metre; DC = disturbance coefficient; km = killometre;
NA = not applicable

The following equations were used to calculate the relative change in the amount of different quality habitats for the different conditions on the landscape.

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

Although the indirect effects from dust deposition and sensory disturbance are included in the HSI modelling, the potential effects on muskoxen 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. Air quality modeling was completed for the baseline case, the construction case, and the application case. 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. Assumptions incorporated into the model 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 movement and behaviour of muskoxen. Sensory disturbance can result in increased levels of stress and energy expenditure, and disruption of feeding behaviour. Therefore, a noise assessment was completed to identify the sound emissions associated with the Project activities and the potential effects on muskoxen.

The focus of the noise assessment is 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 (Section 7; Appendix 7.II). Because there are no noise level guidelines for wildlife, human noise level guidelines were applied to predicting effects on muskoxen. The evaluation of 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 affect noise levels (e.g., blasting, crusher, mill, workshop, power plant, and auxiliary equipment).

The Project will be accessed annually for delivery of major construction and operations goods and materials via the Winter Access Road, which will typically be in operation from late January or early February through March. This may result in noticeable noise increases 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.

11.11.4.2.2 Results

Effects from Project Activities

The total area of suitable habitat (i.e., low, good, and high) available in the RSA under reference conditions is approximately 70% (Table 11.11-10). Previous and existing developments (including the Winter Access Road for the Project) in the RSA have resulted in a 4.2% decrease in high quality habitat. The predicted incremental change of high and good quality habitat from the development of the Project, relative to 2010 baseline conditions, is less than 2% (Table 11.11-10). Relative to reference conditions, cumulative changes from the Project and previous, existing, and potential future developments are expected to reduce high quality habitat by 7.9% and increase poor quality habitat by 3.5%. Most of the change in high quality habitat from reference to future conditions was associated with an increase in good quality habitat (Table 11.11-10). Figures 11.11-9 to 11.11-12 illustrate the changes to muskoxen habitat suitability in the RSA for reference conditions, 2010 baseline conditions, application of the Project, and future conditions.

Table 11.11-10 Relative Changes in the Availability of Different Quality Habitats in the Regional Study Area for Muskoxen (Winter Period) from Reference to Reasonably Foreseeable Projects

Habitat Category	Reference (ha)	% Change Reference to 2010 Baseline	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
High	274213	-4.20	-1.11	-2.55	-7.85
Good	0	3.90	0.67	2.51	7.08
Low	124921	-1.62	-0.04	-1.04	-2.70
Poor	169410	1.92	0.47	1.08	3.47
Total	**568544**				

Note % change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous time period. Cumulative values may not exactly sum due to rounding.

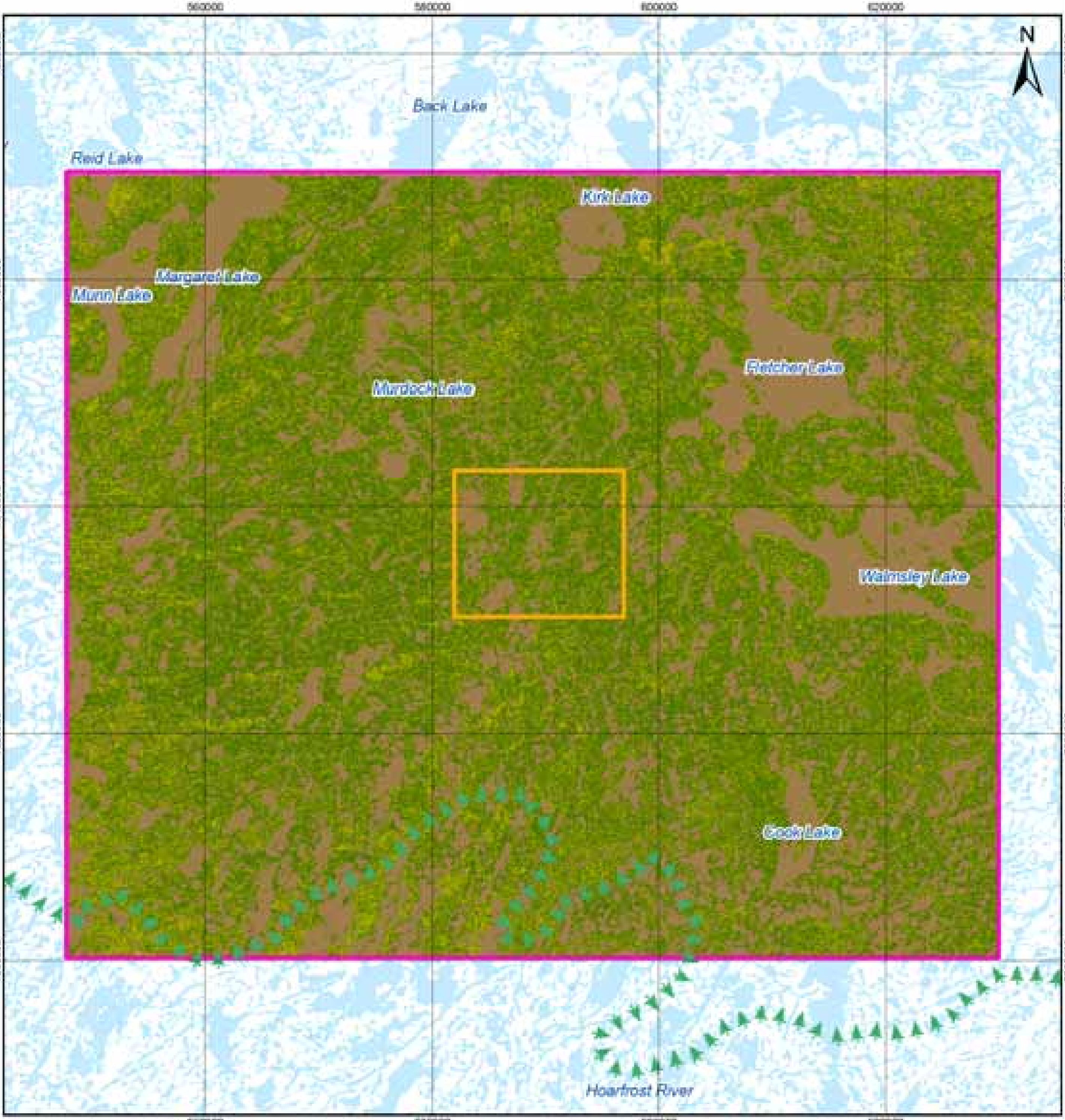
Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2010 Baseline case = previous and existing developments up to 2010

Application case = Gahcho Kué Project plus 2010 baseline conditions.

Future case = Taltson project plus application case.

ha = hectares; % = percent.



LEGEND

Watercourse
Waterbody
Treeline

Habitat Suitability Index

High
Low
Poor
Local Study Area
Regional Study Area

NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Muskoxen: Reference Conditions

PROJECTION: UTM Zone 12	DATUM: NAD83
Scale: 1:500,000 (10 5 0 10 Kilometres)	
FILE No: SON-11-11-009-GIS	DATE: October 21, 2010
JOB NO: 09-1365-1004	REVISION NO: 1
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

DE BEERS CANADA

Figure 11.11-9

LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Treeline
- Development Footprint

Habitat Suitability Index

- High
- Good
- Low
- Poor
- Local Study Area
- Regional Study Area

NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Muskoxen: 2010 Baseline Conditions

PROJECTION	DATUM	
UTM Zone 12	NAD83	DE BEERS CANADA
Scale: 1:500,000 (10 5 0 10 Kilometres)		
FILE No: SON-11-11-010-GIS		DATE: October 21, 2010
JOB NO: 09-1365-1004	REVISION NO: 2	Figure 11.11-10
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV	

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LEGEND

- Gahcho Kué Project
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Treeline
- Development Footprint

Habitat Suitability Index

- High
- Good
- Low
- Poor
- Local Study Area
- Regional Study Area

NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Muskoxen: Application Case

PROJECTION: UTM Zone 12	DATUM: NAD83		
Scale: 1:500,000 (10 5 0 10 Kilometres)			
FILE No: SON-11-11-011-GIS		DATE: October 25, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

DE BEERS CANADA

Figure 11.11-11

LEGEND

- Gahcho Kué Project
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Treeline
- Proposed Taltson Winter Road
- Proposed Taltson Transmission Line
- Development Footprint

Habitat Suitability Index

- High
- Good
- Low
- Poor
- Local Study Area
- Regional Study Area

NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Muskoxen: Future Case

PROJECTION: UTM Zone 12	DATUM: NAD83
Scale: 1:500,000 (10 5 0 10 Kilometres)	
FILE No: SON-11-11-019-GIS	DATE: November 4, 2010
JOB NO: 09-1365-1004	REVISION NO: 3
OFFICE: GOLD-SAS	DRAWN: ANK · CHECK: JV

DE BEERS CANADA

Figure 11.11-12

Construction and operation of the Project may cause an accumulation of dust within the study area. Therefore air quality modelling was completed to estimate the extent of deposition. The results of the air quality modelling predicted the maximum annual dust deposition resulting 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 deleterious effects of 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.

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 (dBA). This is the average nighttime (23:00 to 07:00) sound level L_{eq} 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 Leq[1] with higher winds, precipitation, and thunder being the principal sources of increase above this value (Section 7; Appendix 7.II). During daytime hours these levels can be higher, due to higher levels of human activity and associated tolerance for noise levels. The projected noise levels from the various Project activities are compared with benchmarks in Table 11.11-11. 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).

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). Although no data are available for muskoxen responses to blasting vibrations, the behaviour reported for caribou may be similar for muskoxen.

[1] ERCB 2007, Directive 038, Noise Control

Table 11.11-11 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] World Health Organization 1999;

[b] ERCB

[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.

A summary of the maximum distances for Project noise to attenuate to background levels are shown in Table 11.11-12. The distances indicate 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.

Table 11.11-12 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 = decibels; km = kilometres.

The distance for noise attenuation to background levels for mining operations is 3.5 km. Various studies have documented that muskoxen are alerted by the noise from snowmobiles at distances over 1 km (McLaren 1981; McLaren and Green 1985). Although high wind speeds tended to mask the noise of the snowmobile, McLaren and Green (1985) found that muskoxen were alerted by the noise at distances over 1 km on calm days, even when the machine was not moving toward them. Similarly, muskoxen on Melville Island were found to respond to the sound of a helicopter that was more than 1 km away and not visible (McLaren 1981). Although hearing is clearly important, sight and smell are also likely involved. For example, the greater reaction distances found when animals were downwind of the approach could have resulted from early detection by scent as well as sound (McLaren and Green 1985).

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 11.11-12). However, disturbance from large aircraft is expected to be infrequent and short-term (less than five minutes) in duration.

Although muskoxen herds from different regions showed various responses to the overhead flights of helicopters and other aircraft, it is not clear what elements (noise or visual) of overhead flights causes the response. For example, some muskoxen herds on Bathurst Island were easily induced into stampeding by the circling of helicopters and fixed-wing aircraft (Gray 1972). Herds will often stand in a tight group when an aircraft is overhead, but in many cases, will run as the aircraft approaches (Gray 1972). McLaren (1981) found that Melville Island animals showed no visible reaction to aircraft that flew overhead at altitudes greater than 200 m (McLaren 1981). In 1979, 43.6% of individuals on the Prince of Wales Island responded to the overhead flights at altitudes greater than 400 m (Miller and Gunn 1979), while in 1980, there was an indication that some degree of habituation had occurred (Miller and Gunn 1980).

Effects from Winter Roads

During the two-year construction period, the Project is predicted to result in an additional 25 trucks on the Tibbitt-to-Contwoyto Winter Road and 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 during operations and initial closure (two year period), respectively. The expected noise levels from the Winter Access Road are compared with relevant criteria in Table 11.11-11. The results show that while noise will be generated by the winter road, the expected levels are within relevant criteria established for remote areas. This change to habitat suitability for muskoxen is periodic, as the winter roads are in operation for an average of 8 to 12 weeks each year.

A summary of the maximum distances for Project noise to attenuate to background levels are shown in Table 11.11-12. Noise from the Winter Access Road will diminish to background noise levels within 3 km (Table 11.11-12), based on traffic volume during the construction period, and within 500 m during the operation phase. Because studies have documented that muskoxen are alerted by noise at distances over 1 km (McLaren 1981; McLaren and Green 1985), there is potential for trucks along the winter roads to alter muskoxen movement and behaviour. However, the potential effects will be limited to the seasonal use of the winter roads.

11.11.4.3 Related Effects on People

The muskoxen assessment considered the potential effects of the Project on population size and the distribution of muskoxen within the RSA. The RSA is not part of any Wildlife Management Area, therefore, hunting of muskoxen within the RSA is not permitted. As such, the Project is not likely to affect traditional and non-traditional harvesting activities of muskoxen. However, effects on muskoxen through changes in habitat quantity, quality, movement and behaviour may affect wilderness value and wildlife viewing potential.

Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project site. A second outpost camp is located on Walmsley Lake, 55 km from the Project. Given the occupancy rate for these camps (maximum six people) and distance of the Project from the Walmsley Lake camp, no noticeable changes in muskoxen abundance is anticipated. It is predicted that the effects from the Project and other developments on the wilderness value associated with muskoxen will be within the range of baseline values.

11.11.5 Effects on Population Size and Distribution of Moose

The analysis considers all primary pathways that result in expected effects to moose population size and distribution, after implementing environmental design features. Thus, the analysis is based on the residual effects from the Project. Residual effects to moose are analyzed using measurement endpoints and are expressed as effects statements, including:

- effects from changes in habitat quantity and fragmentation; and
- effects from changes in habitat quality, movement, and behaviour.

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 moose. For example, the pathways for effects on habitat quality, movement, and behaviour include changes due to noise, dust deposition, and the presence of vehicles and mine infrastructure, which ultimately affect moose population size and distribution.

Detailed descriptions of the spatial and temporal boundaries, and methods used to analyze residual effects from the Project on moose 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.

11.11.5.1 Habitat Quantity and Fragmentation

11.11.5.1.1 Methods

The incremental and cumulative direct habitat effects on moose from the Project and previous, existing, and future developments in the RSA were analyzed through changes in the area, composition, and spatial configuration of habitat types on the landscape (i.e., landscape metrics). The change in landscape metrics from the developments on the landscape was determined for the spring and autumn period. Detailed methods for the habitat fragmentation analysis completed for muskoxen during the spring and autumn period are also applicable for moose, and are found in Section 11.11.4.1.

Direct effects from winter roads on the behaviour and movement of moose were not assessed. This is because moose that have the RSA overlap a portion of their home range typically move to the forest during the winter season, and are not likely to be using the habitats along the Winter Access Road when it is in operation (Section 11.11.3).

11.11.5.1.2 Results

Effects from Project Footprints

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%.

Forage requirements for moose vary seasonally, therefore, a wide range of habitat types were identified as suitable habitat for moose. No habitats within the study area were defined as providing highly suitable habitat for moose; however, habitats with good suitability included tall shrub and birch seep (Section 11.11.5.2). Esker complex, heath tundra, heath boulder, spruce forest, peat bog, tussock-hummock, and sedge wetland were considered to be of low habitat suitability for moose.

At the scale of the RSA, the relative change in the amount of habitat from reference to 2010 baseline conditions is less than 0.2% for each habitat type during the non-winter period (Table 11.11-6). The anticipated incremental loss of any habitat type from the Project, relative to 2010 baseline conditions is less than or equal to 0.5% of the RSA. Development of the Project is anticipated to decrease good quality habitats for moose (i.e., birch seep and tall shrub) relative to baseline conditions. The decrease in birch seep and tall shrub habitat is 0.11 and 0.14%, respectively. Overall, the Project is expected to disturb approximately 2.6% of the landscape in the RSA.

Similarly, incremental habitat-specific changes from the Taltson project (future case) are expected to be less than 0.2%. The total combined loss of all habitats in the RSA from the Taltson project is 0.9%. The cumulative direct disturbance to the landscape from the Project and other previous, existing and future developments is predicted to be about 4.7% relative to reference conditions (Table 11.11-6).

Increasing development on the landscape has also resulted in marginal changes to the number and distance between similar habitat patches in the RSA during the spring to autumn period. For a particular habitat, development of previous and existing projects decreased the number of habitat patches on the landscape from 0.00 to 0.09% relative to reference conditions (Table 11.11-6). Habitat-specific changes in the mean distance to nearest neighbour were estimated to be less than 0.1%. Similarly, application of the Project and other reasonably foreseeable projects changed the number and distance between patches on the landscape by less than 0.5%. The exception was for the future project case, which increased the number of esker patches by 1.4% and decreased the distance between eskers by 2% (Table 11.11-6).

11.11.5.2 Habitat Quality, Behaviour, and Movement

11.11.5.2.1 Methods

In addition to direct habitat effects, changes to habitat quality from the Project have the potential to indirectly affect the population size and distribution of moose in the RSA, through altered movement and behaviour of individuals. To estimate the change in habitat quality associated with the Project and other developments, HSI modelling was completed for the RSA. Habitat suitability models are analytical tools for determining the relative potential of an area to provide quality habitat to support wildlife species. To estimate the effects of the Project on moose, an HSI model was used to quantify habitat changes between the 2010 baseline and reference case, between the application and 2010 baseline case, and between the future and application case.

A literature review was used to identify the known habitat requirements and relationships for moose. The HSI values allocated for each habitat type are shown in Table 11.11-13.

Although the inclusion of the Winter Access Road with the Project footprint changes the amount of different quality habitats within the RSA, HSI modeling was not completed for moose during the winter period. This is because moose that have the RSA overlap a portion of their home range are expected to move to the forest during the winter season, and are not likely to be using the habitats along the Winter Access Road when it is in operation.

Table 11.11-13 Habitat Suitability Index Values for Moose

Habitat Type	Habitat Suitability (Index Value; 0-3)
Esker complex	Low (1)
Boulder association	Poor (0)
Bedrock association	Poor (0)
Heath tundra	Low (1)
Heath bedrock	Poor (0)
Heath boulder	Low (1)
Birch seep	Good (2)
Tall shrub	Good (2)
Spruce forest	Low (1)
Peat bog	Low (1)
Tussock-hummock	Low (1)
Sedge wetland	Low (1)
Shallow water	Low (1)
Deep water	Poor (0)
Disturbance	Poor (0)
Unclassified	Poor (0)

Sources: Allen et al. 1987; Renecker 1987; Stelfox 1993; Poole and Stuart-Smith 2003; Osko et al. 2004.

Similar to HSI modelling completed for muskoxen, a ZOI and associated DC was applied to estimate the combined direct and indirect effects (e.g., dust deposition, and sensory disturbance from noise and human activities) from development footprints. For moose, a DC of zero was applied to a digitized footprint for the Project and for all active and inactive exploration footprints (direct effects). Indirect effects were estimated by reducing the HS score within 3.5 km from the edge of the footprint for active developments (i.e., the ZOI). The ZOI was based on the approximate distance from the Project that continuous noise levels from the core facilities would reach background.

The 3.5 km ZOI was applied to the Project, all active mineral exploration sites, and the proposed Taltson project. Within 3.5 km of the footprint, the suitability of all habitats was reduced to low, with the exception of poor-quality habitats, which remained poor. Applying equivalent zones of influence and disturbance coefficients for the Project (anticipated mine site) and smaller, less active exploration sites likely overestimates the effect from exploration activities.

The following equations were used to calculate the relative change in the amount of different quality habitat for the different conditions on the landscape.

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

Indirect effects from dust deposition and sensory disturbance to moose are discussed separately. Methods used to assess the potential indirect effects (i.e., fugitive dust deposition, and noise) of the Project on the habitat quality, movement, and behaviour of moose are similar to muskoxen, and described in Section 11.11.4.2.1.

11.11.5.2.2 Results

Effects from Project Activities

Without the influence of developments in the RSA (i.e., reference conditions), HSI modelling indicates that approximately 38% of the available habitat in the RSA is poorly suited for moose (Table 11.11-14). No vegetation communities were defined as providing high quality habitat for moose; however, habitats with good suitability included tall shrub and birch seep. The number of infrequent observations of moose and moose sign during baseline studies supports the predicted moderate habitat suitability in the RSA. For example, from 1996 through 2005, 14 moose were recorded within the RSA. Moose that have a portion of their home range within the RSA likely use tall shrub and birch seep habitats during the spring through fall, but move below the treeline during winter.

Previous and existing developments in the RSA have resulted in a 0.3% decrease of good quality habitat (Table 11.11-14). The estimated incremental change of any suitable habitat type from the Project, relative to 2010 baseline conditions, is less than 0.2%. Relative to reference conditions, cumulative changes from the Project and previous, existing and potential future developments are expected to reduce good quality habitat by 1.9% and increase poor quality habitat by 0.2% (Table 11.11-14). Figures 11.11-13 to 11.11-16 illustrate the marginal change to habitat suitability for moose in the RSA for reference conditions, 2010 baseline conditions, application of the Project, and future conditions.

Table 11.11-14 Relative Changes in the Availability of Different Quality Habitats in the Regional Study Area for Moose from Reference to Reasonably Foreseeable Projects

Habitat Category	Reference (ha)	% Change Reference to 2010 Baseline	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
High	0	0	0	0	0
Good	58942	-0.29	-0.13	-1.51	-1.93
Low	295144	0.23	0.00	1.47	1.69
Poor	214457	0.06	0.13	0.04	0.24
Total	**568544**				

Note Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous time period. 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.

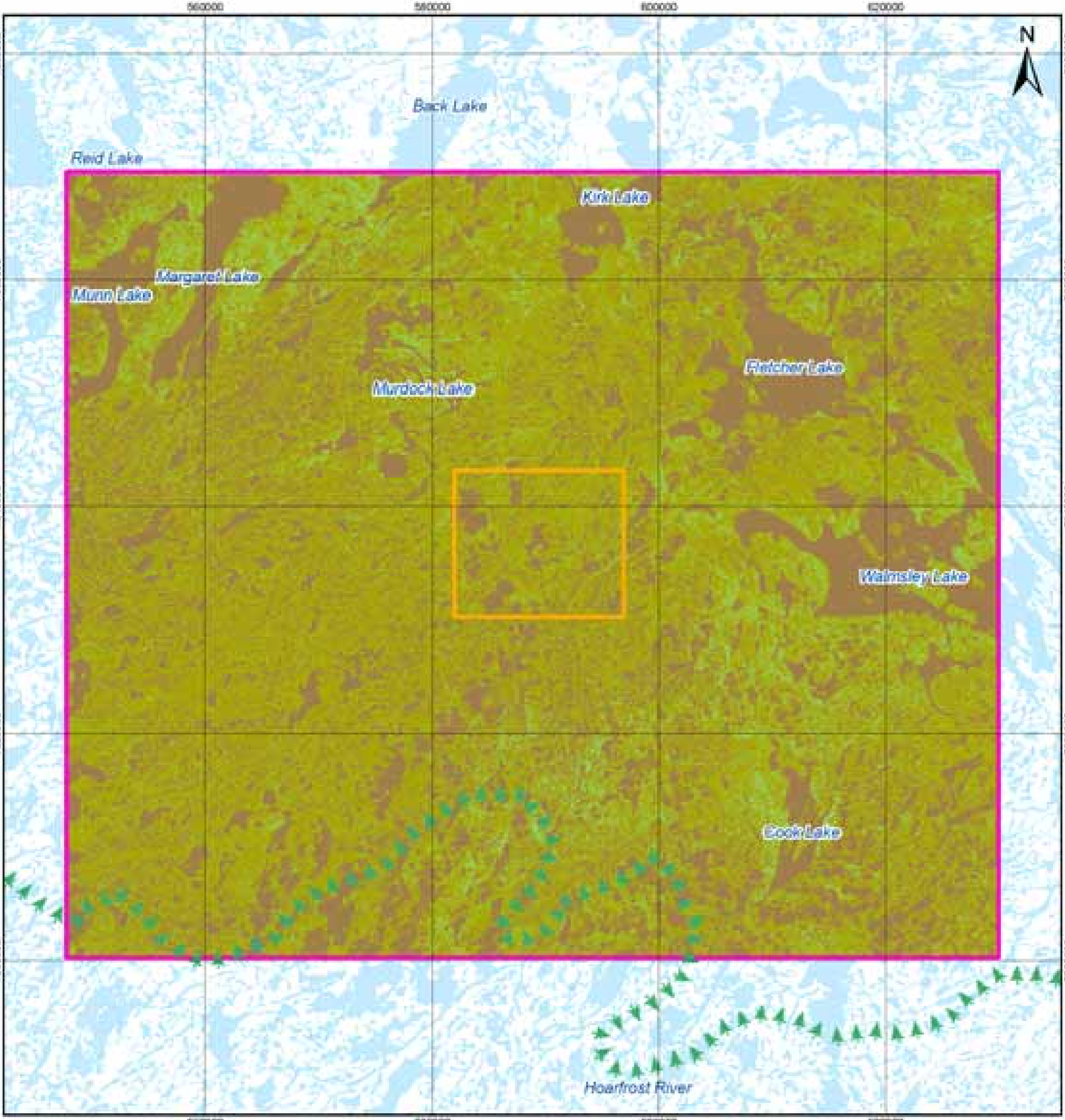
2010 Baseline case: previous and existing developments up to 2010.

Application case: Gahcho Kué Project plus 2010 baseline conditions.

Future case: Taltson project plus application case.

ha = hectares; % = percent.

Construction and operation of the Project may increase the concentration of dust within the RSA. Therefore, air quality modelling was completed to estimate the extent of deposition. The air quality modelling completed for muskoxen also applies to moose, and a summary of the air quality modelling results discussed in Section 11.11.4.2.2 is provided below.



LEGEND

- Watercourse
- Waterbody
- Treeline

Habitat Suitability Index

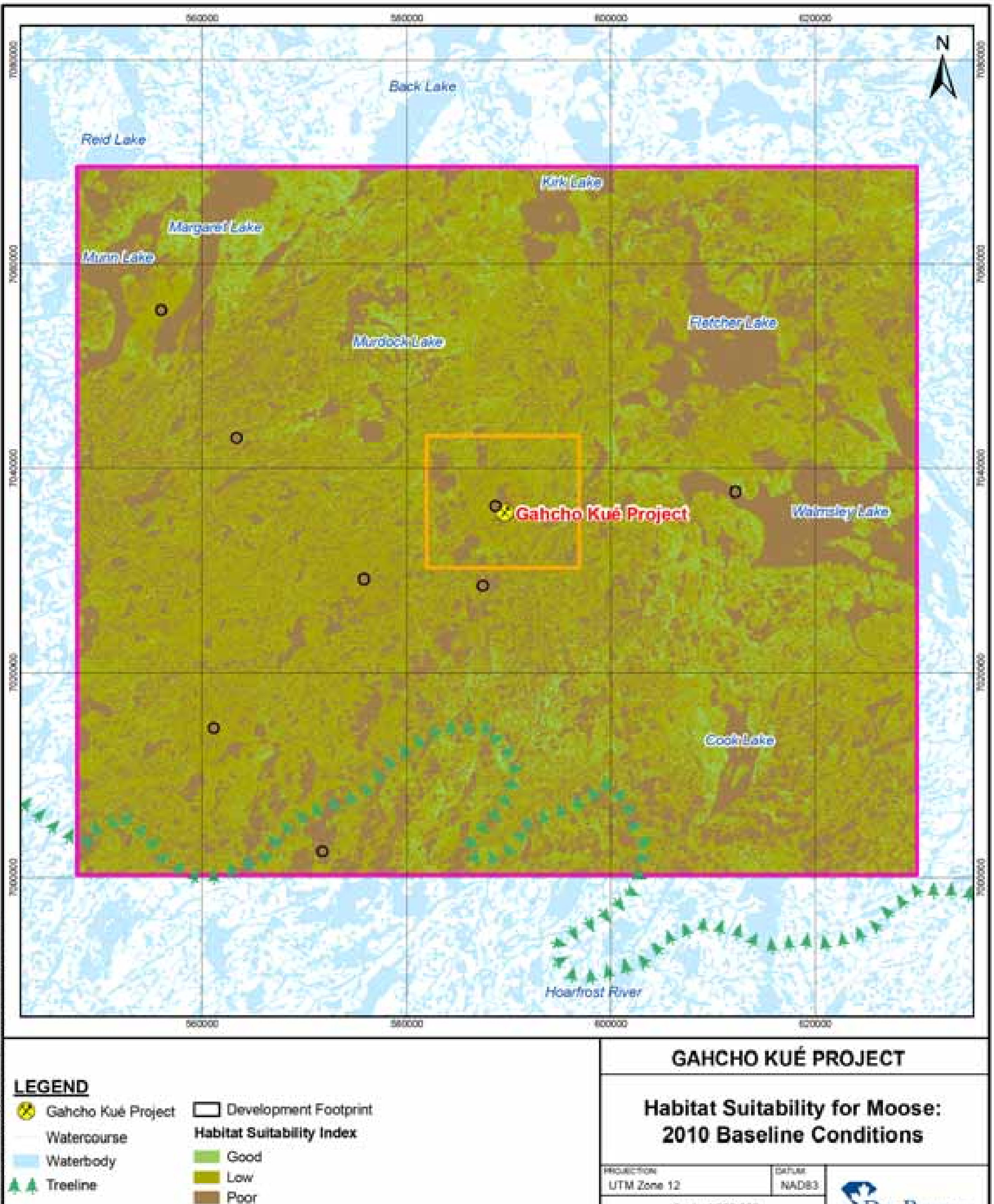
- Good
- Low
- Poor
- Local Study Area
- Regional Study Area

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Moose: Reference Conditions

PROJECTION: UTM Zone 12	DATUM: NAD83	DE BEERS CANADA
Scale: 1:500,000 (10 5 0 10 Kilometres)		
FILE No: SON-11-11-012-GIS		DATE: October 21, 2010
JOB NO: 09-1365-1004	REVISION NO: 3	**Figure 11.11-13**
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV



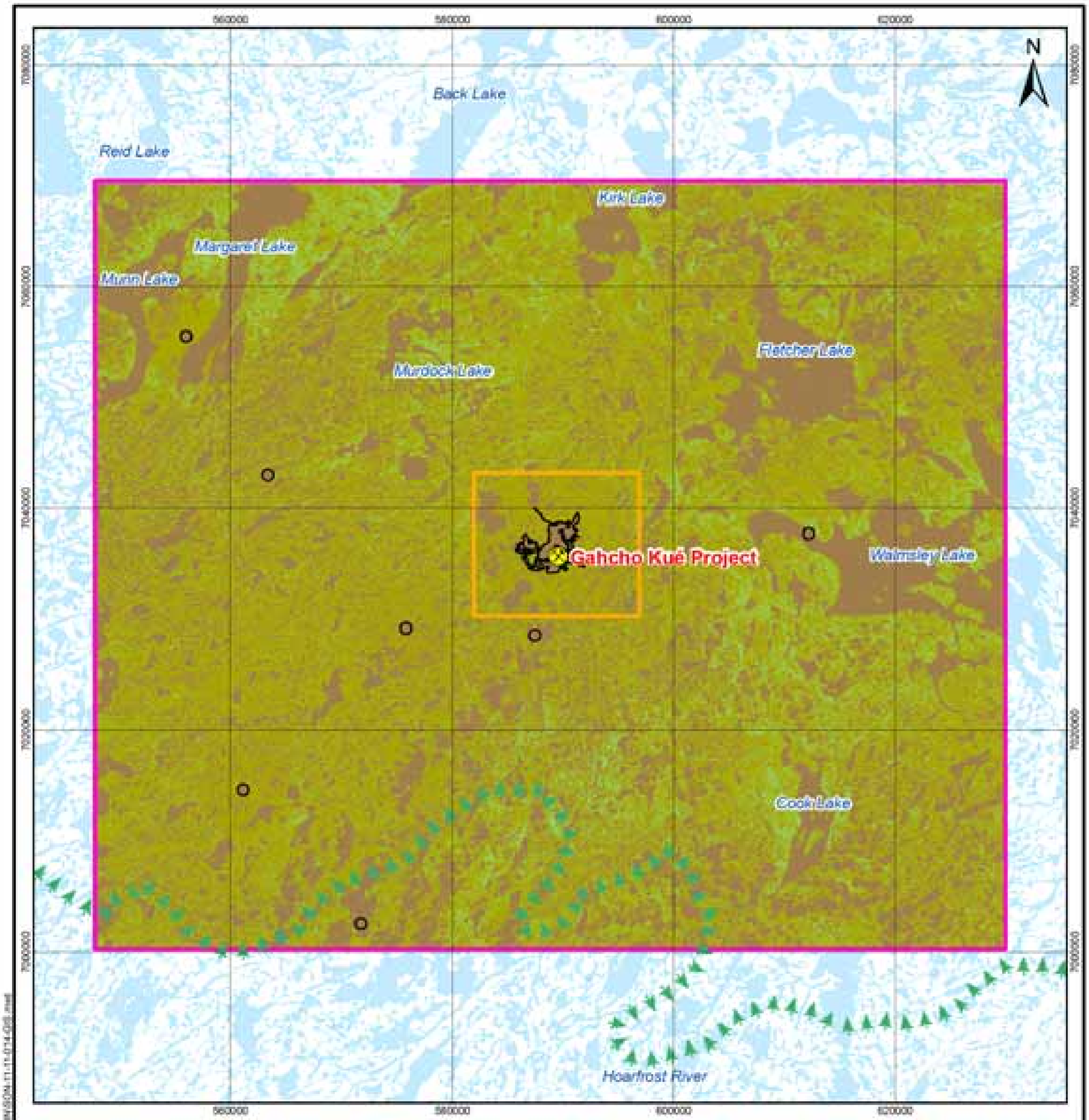
NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Moose: 2010 Baseline Conditions

PROJECTION: UTM Zone 12	DATUM: NAD83		
Scale: 1:500,000 (10, 5, 0, 10 Kilometres)			DE BEERS CANADA
FILE No: SON-11-11-013-GIS			DATE: October 21, 2010
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 11.11-14



LEGEND

Gahcho Kué Project
Watercourse
Waterbody
Treeline
Development Footprint

Habitat Suitability Index

Good
Low
Poor
Local Study Area
Regional Study Area

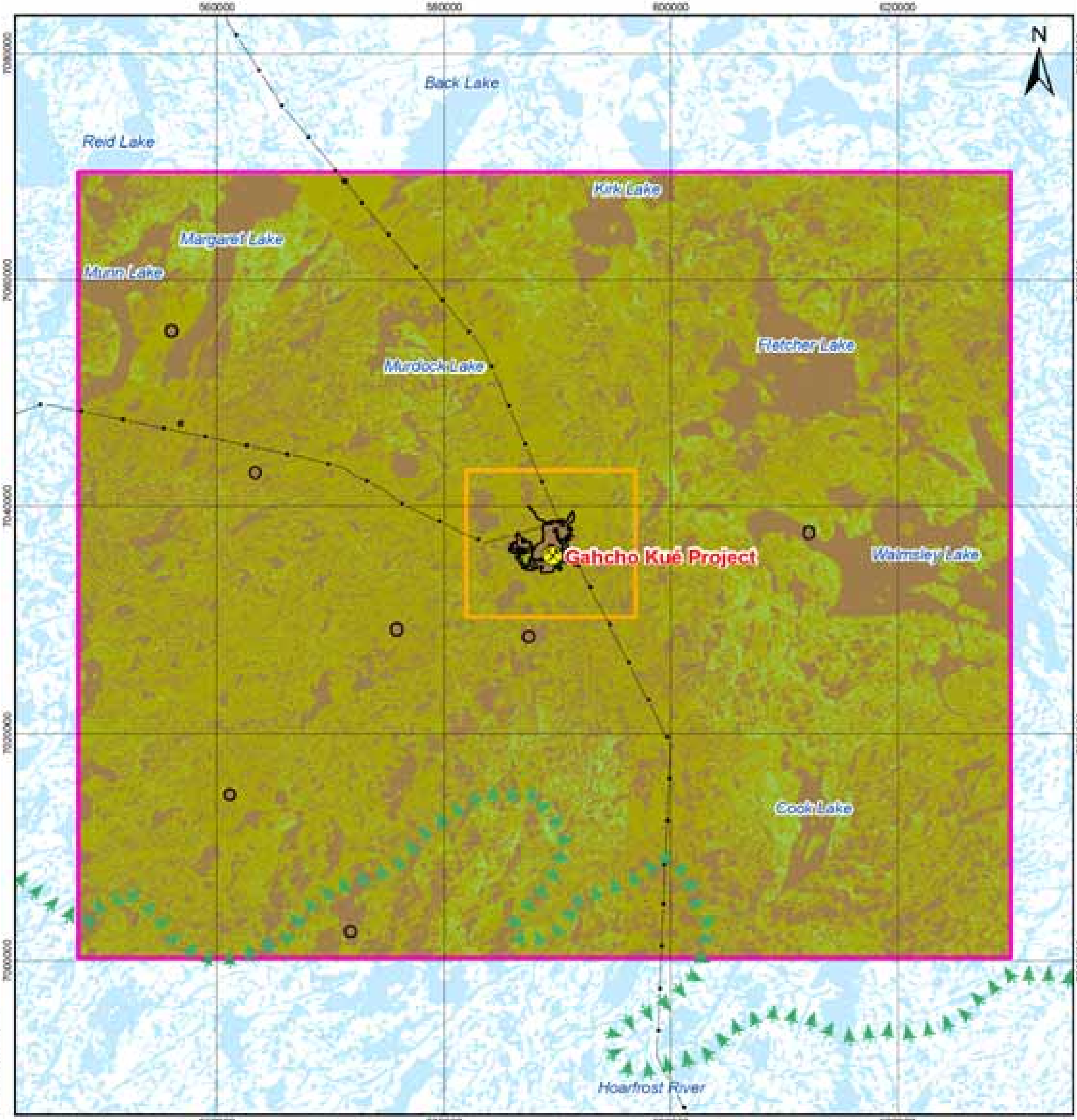
NOTES

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Moose: Application Case

PROJECTION: UTM Zone 12		DATUM: NAD83	DE BEERS CANADA
Scale: 1:500,000 (10 5 0 10 Kilometres)			
FILE No: SON-11-11-014-GIS			DATE: October 25, 2010
JOB NO: 09-1365-1004	REVISION NO: 3		Figure 11.11-15
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	



LEGEND

- Gahcho Kué Project
- Watercourse
- Waterbody
- Treeline
- Proposed Taltson Transmission Line
- Development Footprint

Habitat Suitability Index

- Good
- Low
- Poor
- Local Study Area
- Regional Study Area

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

GAHCHO KUÉ PROJECT

Habitat Suitability for Moose: Future Case

PROJECTION: UTM Zone 12	DATUM: NAD83
Scale: 1:500,000 (10 5 0 10 Kilometres)	
FILE No: SON-11-11-018-GIS	DATE: November 4, 2010
JOB NO: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: ANK
CHECK: JV	

DE BEERS CANADA

Figure 11.11-16

The results of the air quality modelling predicted the maximum annual dust deposition resulting 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 deleterious effects of dust are generally confined to the immediate area adjacent to the dust source (e.g., a haul road) (Everett 1980; Walker and Everett 1987).

Noise will be generated from mobile and stationary mining equipment, blasting, and aircraft at the Project. The results show that while noise will be generated by the Project, the expected levels at identified noise receptors are below relevant criteria established for remote areas (with the exception of the 40 dBA limit at 1.5 km from the Project due to core mine operations). 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 dBL) would be met are 596 and 730 m, respectively.

The distance for noise attenuation to background for mining operations (including blasting) is 3.5 km. Horesji (1979) reported that moose were less likely to be found within 1 km of seismic lines while seismic operations were underway. Andersen et al. (1996) found that sources of disturbance that could be identified as human elicited flight responses in moose at greater distances than disturbances that were recognized as mechanical. For example, the noise of a jet flying at an altitude of 150 m did not trigger any flight response in moose, while people on foot or skis flushed moose at 200 to 400 m (Andersen et al. 1996).

Aircraft will be used for the movement of personnel and supplies to the Project site year-round. The distance for noise to reach background levels from the airstrip is 5.5 km (Table 11.11-12). Studies of the effects of noise on moose have focused on fixed-wing aircraft. Results indicate that moose reacted visibly to aircraft 55% of the time when overhead flights were below 60 m in altitude, and 37.5% of the time when overhead flights were at altitudes between 60 and 180 m (McCourt et al. 1974). Moose were not observed to react to overhead flights above 180 m of altitude (McCourt et al. 1974). Andersen et al. (1996) found that the home range size for moose increased during active military manoeuvres (e.g., helicopters and jet fighters), but no collared individuals abandoned the area.

11.11.5.3 Related Effects on People

Currently in the NWT, moose are managed mostly by controlling the hunting season for resident and non-resident hunters (ENR 2010b, internet site). However, because the Winter Access Road will be in operation just as the moose hunting season is ending, there is limited opportunity for resident hunters using the Winter Access Road to harvest moose within the RSA. General Hunting Licence holders may hunt moose during any season.

The estimated total NWT moose harvest is 1,000 to 2,000 animals per year, 80 to 90% of which is taken by GHL holders. Although GHL holders may hunt moose during any season, moose that have the RSA overlap a portion of their home range likely move to the forest during the winter season, and are not likely to be using the habitats along the Winter Access Road when it is in operation. Therefore, the Project is not anticipated to affect the opportunity for harvesting moose by GHL hunters.

Changes in the population size and distribution of moose may also influence the wilderness value and wildlife viewing potential. Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project. A second outpost camp is located on Walmsley Lake, 55 km from the Project. Habitat quality for moose in the RSA is also low to moderate, and moose likely limit their use of the area during winter (i.e., move below the treeline). It is predicted that the effects from the Project and other developments on traditional and non-traditional use of moose will be within the range of baseline values.

11.11.6 Residual Effects Summary

11.11.6.1 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. During construction and operation, the Project footprint will decrease the lake surface area within the LSA by 2.2%.

At the scale of the muskoxen and moose populations (i.e., the RSA), the incremental loss of habitat from the Project is anticipated to be 2.6% relative to 2010 baseline conditions. During the spring to autumn period, the cumulative direct disturbance to the landscape from the Project and other previous, existing and future developments is predicted to be about 4.7% relative to reference conditions. The cumulative direct disturbance to the landscape during the winter period is anticipated to increase to 5.4%. For both seasonal periods, landscape disturbance is well below the 40% threshold value for habitat loss associated with anticipated declines in bird and mammal species (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Swift and Hannon 2010).

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 and Coarse PK Pile will not be vegetated to prevent the facility from becoming attractive to wildlife. The mine rock piles and PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha.

In addition to direct loss of habitat types, the application of the Project will also result in fragmentation of the existing landscape. Although fragmentation can influence individual and population processes, fragmentation effects have less effect than habitat loss (Andrén 1999; Fahrig 1997, 2003). Habitat fragmentation can interact with habitat loss, and result in an increased effect on populations, but this typically happens when the quantity of habitat remaining is small and approaches a threshold value (Swift and Hannon 2010).

Increasing development on the landscape has resulted in marginal changes to the number and distance between similar habitat patches in the RSA. Application of the Project and other reasonably foreseeable projects changed the number and distance between patches on the landscape by less than 1% during both the spring to autumn and winter periods. The exception was for the future project case, which increased the number of esker patches by 1.4% and decreased the distance between eskers by 2%. These small changes are predicted have little influence on the carrying capacity of the landscape, and the movement and distribution of muskoxen and moose.

Although the inclusion of the Winter Access Road with the Project increases habitat fragmentation, the disturbance is anticipated to be temporary (approximately an 8 to 12 week period each year) and restricted to the winter period when the road is in use. For muskoxen, the presence of the Winter Access Road may represent a barrier and restrict the regional-scale dynamics of this species. As such, the direct effects of habitat fragmentation to muskoxen from the Winter Access Road are regional, and predicted to reversible within 5 years following initial closure (i.e., near the end of final closure).

11.11.6.2 Habitat Quality, Behaviour, and Movement

In addition to direct habitat effects, indirect changes to habitat quality from the Project have the potential to affect the population size and distribution of muskoxen and moose through altered movement and behaviour. To estimate indirect habitat effects on other ungulates, HSI models were used to quantify habitat changes from reference conditions through application of the Project and reasonably foreseeable developments. Because most wildlife species are likely to exhibit some degree of sensitivity to human disturbance, zones of influence and associated disturbance coefficients were applied to estimate indirect effects (e.g., fugitive dust disposition, and sensory disturbance from noise and human activities) from the Project and other active projects in the RSA. The indirect effects from dust deposition and noise were also analyzed separately.

The HSI model for moose considered the spring to autumn seasons because moose that have the RSA overlap a portion of their home range are predicted to move to the forest during the winter season. Habitat modeling was completed for only the winter period for muskoxen as access to food at this time of year is a limiting factor for muskoxen (Parker 1978; Gunn et al. 1991; Gunn and Fournier 2000), and the addition of the Winter Access Road provides the maximum number of disturbances on the landscape to assess effects.

The HSI modelling results indicate that the incremental decrease from the Project on the amount of high quality habitat is less about 1% for muskoxen and less than 0.5% for moose relative to 2010 baseline conditions. Relative to reference conditions, cumulative changes from the Project and previous, existing and future developments are expected to reduce high quality muskoxen habitat by 8%. Although there is no highly suitable moose habitat within the RSA, cumulative changes from the Project and other developments are expected to reduce good quality habitat for moose by 2%.

The results of the air quality modelling showed that the maximum annual dust deposition resulting from the Project is predicted to occur within 100 m of the Project footprint, and is mostly associated with the mine pits and haul roads. The distance for noise attenuation to background for mining operations (including blasting) and the airstrip is 3.5 km and 5.5 km, respectively. Various studies have documented that muskoxen and moose are alerted by the noise at distances over 1 km (McLaren and Green 1985; McLaren 1981; Horesji 1979). Noise associated with the airstrip will be intermittent and limited to take-off and landings, whereas the frequency of noise levels from mining operations are continuous.

During the two-year construction period, the Project is predicted to result in an additional 25 trucks on the Tibbitt-to-Contwoyto Winter Road and 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 during operations and initial closure (two year period), respectively. Predicted noise levels from truck traffic during construction and operation indicate that while noise will be generated along the Winter Access Road, the expected levels are within relevant criteria established for remote areas. Noise from the Winter Access Road will diminish to background noise levels within 3 km, based on traffic volume during the construction period, and within 500 m during normal operations. The potential noise effects associated with the winter roads are temporary each year, and limited to the seasonal use of the Winter Access Road (8 to 12 weeks per year).

The spatial extent of effects on muskoxen and moose populations from incremental and cumulative changes in habitat quality is predicted to be regional. Although dust deposition and most noise sources contributes to local changes in habitat quality, the combined effect from the Project and other developments on the movement and behaviour of other ungulates extends to the population within the RSA. The duration of sensory disturbance effects on other ungulates from noise, dust, and the presence of people, vehicles, and aircraft traffic is anticipated to occur over a 27 to 32 year period (i.e., effects should be reversed within five to ten years following final closure).

11.11.6.3 Related Effects on People

Changes in the population size and distribution of muskoxen and moose may influence harvesting activities, and wilderness value and wildlife viewing potential. The RSA is not part of any Wildlife Management Area, therefore, hunting of muskoxen within the RSA is not permitted. As such, the Project is not likely to affect traditional and non-traditional harvesting activities of muskoxen.

The estimated total NWT moose harvest is 1,000 to 2,000 animals per year, 80% to 90% of which is taken by GHL holders. Although GHL holders may hunt moose during any season, moose that have the RSA overlap a portion of their home range are expected to move to the forest during the winter season, and are not likely to be using the habitats along the Winter Access Road when it is in operation. Therefore, the magnitude of effects from the Project on hunting of moose by GHL holders in the RSA is anticipated to be similar to baseline conditions.

Changes in the population size and distribution of other ungulates may also influence the wilderness value and wildlife viewing potential. Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project. A second outpost camp is located on Walmsley Lake, 55 km from the Project. The magnitude of the cumulative direct and indirect habitat effects from the Project and other developments on muskoxen and moose are approximately 8% and 2%, respectively. Baseline studies indicated that muskoxen were frequently observed in the RSA during aerial surveys for caribou, while the occurrence of moose was low. Habitat quality for moose in the RSA is low to moderate, and moose are not likely to be present within the RSA during the winter (i.e., they move below the treeline). It is expected that the effects on potential for viewing other ungulates in the RSA due to the Project and other developments should be within the range of baseline conditions.

11.11.7 Residual Impact Classification

The purpose of the residual impact classification is to describe the residual effects from the Project on other ungulates 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.

11.11.7.1 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, all residual effects are discussed and classified in terms of impacts to other ungulates.

The effects analyses and residual effects summary presented both the incremental and cumulative changes from the Project and other developments on the environment, other ungulates, and use of other ungulates 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., zone of influence]) (Section 6.7.4).

Cumulative effects are the sum of all changes from reference values through application of the Project and reasonably foreseeable developments. In contrast to Project-specific (incremental) effects, the geographic extent of cumulative effects is determined by the distribution of the defined population. This is because the local and regional effects from the Project and other developments overlap with the distribution of muskoxen and moose populations.

For other ungulates, the assessment and classification of residual impacts was 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 regional scale or the distribution of the populations, 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 cumulative and incremental 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 annual range of the populations. In contrast, the geographic extent of incremental impacts from the Project may have a local or regional influence on the range of the populations.

Effects statements are used to focus the analysis of changes to other ungulates that are associated with one or more primary pathways. The residual effects summary (Section 11.11.6) 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 other ungulates. 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 other ungulates, and definitions for each criterion are provided in Table 11.11-15. More detailed explanations for magnitude, geographic extent, and duration are provided below.

Table 11.11-15 Definitions of Criteria Used in the Residual Impact Classification of Pathways for Effects on Population Size and Distribution of Other Ungulates

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 predicted detectable change from baseline values **Low:** impact is predicted to be within the range of baseline values **Moderate:** impact is predicted to be at or slightly exceeds the limits of baseline values **High:** impact is predicted 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 (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **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 predicted values from reference conditions (no development) through 2010 baseline conditions.

[b] “similar” implies an environment of the same type, region, and time period.

% = percent; < = less than; > = greater than

11.11.7.1.1 Magnitude

Magnitude (i.e., intensity of the impact) for Project-specific (incremental) effects is scaled to the expected change (quantified or qualified) from 2010 baseline conditions to application of the Project. Magnitude for cumulative effects is scaled to the expected quantified and/or qualified 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 other ungulates. Environmental selection pressures include both natural (e.g., weather, changes in gene frequencies, predation, and competition) and human-related factors (e.g., mineral development, traditional harvest, and sport hunting).

Depending on which selection pressures are currently driving changes to other ungulates and the system, baseline conditions typically fluctuate within a range of variation through time and space. The fluctuations are generated by changes in natural factors (natural variation) and variation associated with human influences. 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 muskoxen and moose populations.

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 11.11-15 is applicable for more qualitative results (e.g., impacts on ungulate movement and behaviour, and related impacts to people). For quantitative analyses and results (e.g., loss and fragmentation of habitat, and changes to habitat suitability), 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 changes in rates of population parameters in 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 demonstrated negative effects on insects, plants, birds, and mammals when remaining habitat cover ranged from 10 to 30% (i.e., more than 70% habitat loss).

11.11.7.1.2 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., 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) of other ungulates (Section 11.11.4 and 11.11.5).

However, the geographic extent of impacts can occur on a number of scales within the spatial boundary of the assessment. As defined in Table 11.11-15, 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 muskoxen and moose 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 other ungulates and are defined by the expected maximum distance or area (i.e., ZOI) of the effect from the Project (e.g., changes to other ungulate behaviour and movement from noise). However, at the scale of the population, changes at the regional scale also include cumulative direct and indirect impacts on muskoxen and moose from the Project and neighbouring developments (which is the study area or spatial boundary for the assessment). Cumulative impacts from the Project also occur at the regional scale for traditional and non-traditional use of muskoxen and moose.

11.11.7.1.3 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 other ungulates 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 reclamation and closure 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 end at closure, but the impact on other ungulates may continue beyond Project closure. Some impacts may be reversible soon after removal of the stressor, such as effects on air quality from power generation and equipment operation (e.g., medium-term impact).

For other ungulates, 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 muskoxen and moose are influenced. The anticipated duration of effects on other ungulates are then used to determine the number of human generations that may be affected by the related changes to traditional and non-traditional land use practices (e.g., wildlife viewing). In this manner, the impact assessment links the duration of Project impacts on other ungulates 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. An example of an irreversible impact includes the localized loss of vegetation and habitat due to the mine rock piles, Coarse PK Pile and Fine PKC Facility.

11.11.7.2 Results

Direct incremental impacts from the Project footprint (i.e., habitat loss) are local in spatial extent. At the local scale, the magnitude of incremental impacts from the Project footprint on muskoxen and moose populations is predicted to be low (i.e., the Project will alter 4.4% of the LSA). However, individuals from muskoxen and moose populations may interact with other developments and activities in the RSA (defined as the distribution of these populations). Therefore, the cumulative impacts from direct habitat loss and fragmentation from the Project footprint and other developments on population size and distribution are expected to be regional in geographic extent (Table 11.11-16).

The frequency of the direct impacts from the Project to muskoxen and moose will occur continuously over the assessment period. Cumulative impacts of direct habitat loss from the Project and previous, existing, and reasonably foreseeable future developments during the spring, summer, and autumn is expected to be 4.7% of the RSA, while 5.3% of the RSA is expected to be disturbed during the winter (because of the Winter Access Road) (low magnitude) (Table 11.11-16). As a proportion of the RSA, the incremental loss of habitat from the Project, relative to 2010 baseline conditions, is anticipated to be 2.6% (low magnitude).

Cumulative and incremental habitat loss values are below the 40% threshold value for habitat loss associated with expected declines in bird and mammal species (Andrén 1994, 1999; Fahrig 1997; Swift and Hannon 2010). Species that are habitat generalists (such as muskoxen and moose), which live in open populations and move effectively over long distances, are much less affected by habitat fragmentation or insularization (i.e., combination of habitat reduction, fragmentation and isolation) (Treweek 1999; Flather and Bevers 2002; Swift and Hannon 2010).

Although progressive reclamation will be integrated into mitigation and management plans for the Project, and is part of the land use permits for existing developments, arctic terrestrial ecosystems are slow to recover from disturbance. In addition, not all the areas for the Project will be reclaimed. For example, as a result of locally expressed concerns, the mine rock cap on the Fine PKC Facility will not be vegetated to prevent it from becoming attractive to wildlife. The Fine PKC Facility and mine rock piles will be permanent features on the landscape, covering approximately 302.7 ha. Development footprints and related loss of habitat for baseline and application landscapes was assumed to be permanent (i.e., not reversible within the temporal boundary of the assessment) (Table 11.11-16).

Table 11.11-16 Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects on Population Size and Distribution of Other Ungulates and Related Effects to People

Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes fragmentation	negative	low	low	local	regional	permanent	continuous	irreversible	highly likely
Winter access road footprint causes habitat fragmentation for muskoxen	negative	negligible	low	regional	regional	medium-term	periodic (winter season only)	reversible	highly likely
The combined indirect effects (i.e., dust deposition, noise, and human activity- sensory effects) from the Project and the Winter Access Road changes the amount of different quality habitats, and alters movement and behaviour	negative	negligible to low	low	local to regional	regional	long-term	continuous	reversible	highly likely
Vehicles on the Winter Access Road and Tibbitt-to-Contwoyto Winter Road- sensory effects (e.g., noise, presence, lights, smells) changes the amount of different quality habitats, and alters movement and behaviour of muskoxen	negative	low	low	regional	regional	medium-term	periodic (winter season only)	reversible	highly likely
Effects on population size and distribution changes the availability of animals for traditional and non-traditional use	negative	negligible to low	negligible to low	regional	regional	long-term	continuous	reversible	possible

Direct impacts from the Winter Access Road are expected to be reversible within five years after initial closure (medium-term).

Development of the Project is expected to cause indirect changes to the amount of different quality habitats for muskoxen and moose populations in the region. These changes are expected to result from the combination of dust, noise, and other sensory disturbance from the Project, and are local to regional in geographic extent (Table 11.11-16). For example, dust deposition is anticipated to have impacts within 100 m of the Project footprint (a local impact). Impacts from blasting are 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 (local impacts). Sensory disturbance from vehicles travelling on the Winter Access Road are expected to diminish within 3 km of the road, however this impact will be regional in extent because of the length of the winter road. All of these Project pathways can combine with similar impacts from other developments in the region and decrease the amount of quality habitat for muskoxen and moose (except for the winter road) populations.

Indirect impacts from the Project (including the Winter Access Road) decreased high quality habitat for muskoxen by 1.1% (low magnitude). Although there is no highly suitable moose habitat within the RSA, indirect impacts from the Project (excluding the Winter Access Road) decreased good quality moose habitat by less than 0.2% (negligible magnitude). Relative to reference conditions (no development), cumulative indirect impacts from the Project and previous, existing, and reasonably foreseeable future developments are expected to reduce high quality muskoxen habitat by 8%, and good quality moose habitat by 2%. Therefore, the magnitude of cumulative effects on the population size and distribution of other ungulates is expected to be low (Table 11.11-16). Indirect effects from the Project footprint will be continuous, while indirect effects from the Tibbitt-to-Contwoyto Winter Road and the Winter Access Road will be limited to the seasonal use of the roads (i.e., periodic frequency).

Impacts on the population size and distribution of moose and muskoxen from changes in habitat quality, movement, and behaviour from Project activities are expected to be reversible within five to ten years following final closure (long-term). The use of the Winter Access Road is expected to end in year 2 of closure (i.e., medium-term duration). Thus, assuming that the average life span of muskoxen (National Geographic 2010a, internet site) and moose (National Geographic 2010b, internet site) is 15 years, the duration of the long-term impact is 27 to 32 years or about two life spans for muskoxen and moose (Table 11.11-16).

Changes in the population size and distribution of muskoxen and moose may influence harvesting activities. The RSA is not part of any Wildlife Management Area, therefore, incremental and cumulative changes from the Project on opportunities for hunting muskoxen within the RSA was considered negligible (Table 11.11-16). General Hunting Licence holders may hunt moose during any season. However, analysis showed that the quality of moose habitat in the RSA is low to moderate, and that the incremental and cumulative impacts from the Project are expected to be of negligible to low magnitude. Therefore, the magnitude of impacts to GHL users for hunting moose is expected to be negligible (Table 11.11-16).

Changes in muskoxen and moose populations also may influence the wilderness value and wildlife viewing potential of the region. The magnitude of the incremental and cumulative direct and indirect habitat effects from the Project and other developments is predicted to be negligible to low. Baseline studies indicated that muskoxen were frequently observed in the study area during aerial surveys, while the occurrence of moose was extremely low. Habitat quality for moose in the study area is also low, and moose likely limit their use of the area during winter (i.e., occupy more forested habitats). It is therefore expected that the magnitude of the change in potential for viewing other ungulates due to the Project and other developments should be negligible to low (Table 11.11-16). The duration of the impacts to other ungulates is expected to last for 27 to 32 years (2 life spans), which is equivalent to about 1.5 human generations (assuming human generation time is 20 years). The impact is reversible in the long term (Table 11.11-16).

11.11.8 Environmental Significance

11.11.8.1 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 muskoxen and moose, and by extension, on the use of other ungulates by people. The evaluation of significance was based on ecological principles, to the extent possible, but also involved professional judgment 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 muskoxen and moose populations. 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 traditional land use.

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).

The evaluation of significance for other ungulates considers the entire set of primary pathways that influence the assessment endpoint (e.g., persistence of muskoxen and moose populations). The relative contribution of each pathway is used to determine the significance of the Project on other ungulates, 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 muskoxen and moose 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 other ungulates. The following definitions are used for assessing the significance of impacts on the persistence of muskoxen and moose, and the associated continued opportunity for traditional use of these populations.

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 (regional scale) would likely be significant.

11.11.8.2 Results

The results predict that the incremental and cumulative impacts from the Project and other developments should not significantly influence the persistence of muskoxen and moose populations. For all primary pathways influencing population size and distribution, cumulative impacts were determined to be regional in geographic extent, which implies that at least some portion of the populations are affected. For incremental impacts, the geographic extent of pathways ranged from local to regional. Local impacts to habitat were associated with the Project footprint, dust deposition, and noise, and will continuously influence individuals that travel through or occupy habitats within 1 to 3.5 km from the Project site, and periodically up to 5.5 km (e.g., during take-off and landing of aircraft). Regional impacts to habitat, movement, and behaviour were related to the winter roads and the cumulative effects from dust deposition, noise, lights, and human activities from the Project and other developments.

The likelihood of the impacts occurring is expected to be possible to highly likely for all pathways (Table 11.11-16), which does not change the expected magnitude and duration (or environmental significance). Similarly, the frequency of most impacts is anticipated to occur continuously throughout the life of the Project, except for impacts from winter roads, which occur seasonally (periodically) during the life of the Project.

Overall, the duration of the impacts from the different pathways were expected to be reversible in the medium to long term for other ungulate assessment endpoints (Table 11.11-16). An exception was the incremental and cumulative direct disturbance impacts to populations from development footprints, which were assumed to be irreversible within the temporal boundaries of the assessment. Sensory disturbance impacts associated with influences of exploration and mining activities on muskoxen and moose populations are anticipated to be reversible over the long term (27 to 32 years [2 moose or muskoxen life spans]). Impacts from winter roads on populations and traditional and non-traditional use of other ungulates are expected to be reversible in the medium term (five years after initial closure).

The magnitude for the four primary pathways impacting other ungulates ranged from negligible to low (Table 11.11-16). The magnitude of the cumulative impact from direct habitat loss associated with the Project and previous, existing, and reasonably foreseeable future developments is expected to be about 5% relative to reference conditions. The relative amount of change in quality habitats in the region is estimated to be 2% for moose and 8% for muskoxen. The incremental impact from the Project on direct and indirect habitat effects to other ungulates is less than 3% relative to 2010 baseline conditions. Incremental and cumulative changes to the behaviour and movement of other ungulates from winter roads also are expected to be within the range of baseline conditions.

There is a moderate to high degree of confidence in the predictions of environmental significance from the incremental and cumulative impacts on other ungulates. The frequency of baseline observations of muskoxen and moose in the study area correlated well with the independent assessment of habitat quality for the two species. Groups of muskoxen were often observed during aerial surveys for caribou and other wildlife, and the region contains high and good quality muskoxen habitat. In contrast, 14 moose were observed from 1999 through 2005, and the study area largely contains low and poor quality moose habitat. In addition, habitat models contained conservative estimates for influences from development to increase confidence that the assessment would not underestimate impacts (Sections 11.11.4, 11.11.5, and 11.11.9).

The current level of activity (i.e., four active exploration sites) in the region and environmental design features that will be implemented to limit impacts from the Project should not negatively influence the resilience of muskoxen and moose populations. The recent expansion of muskoxen into their historic range suggests that these animals have the capability to adapt to and resist the current level of disturbance from development on the landscape. Moose display life history traits (e.g., high reproductive rates, ability to eat many types of plants) that provide flexibility to adapt to different ecozones and rates of development across North America. This resilience in muskoxen and moose populations suggests that the impacts from the Project and existing and future developments should be reversible. Overall, 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 an adverse significant impact on the persistence of other ungulate populations. Subsequently, cumulative impacts from development also are not predicted to have a significant adverse effect on continued opportunities for use of muskoxen and moose by people that value these animals as part of their culture and livelihood.

11.11.9 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 impacts are not worse than expected. 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., zone of influence and disturbance coefficients from developments);
- 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 other ungulates); and
- knowledge of the effectiveness of the environmental design features (mitigation) for reducing or removing impacts (e.g., revegetation of wildlife 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. However, there remains a degree of uncertainty surrounding the degree to which some effects may occur (e.g., magnitude and duration).

It is understood that development activities will directly and indirectly affect habitat, and muskoxen and moose behaviour and movement. However, long-term monitoring studies documenting the resilience of these species to development and the time required to reverse impacts are lacking. Although direct disturbance from development footprints was calculated to be about 5% of the regional habitat for the populations, there remains a high degree of uncertainty in the effectiveness of revegetation techniques for reversing the impact to habitat. De Beers will develop an adaptive management approach to reclamation that will incorporate results of the reclamation trials completed throughout the mine life, as well as new research and reclamation approaches that are being developed as part of other mining operations in the Arctic.

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 proposed Taltson Expansion Project and East Arm National Park also generate uncertainty in impact predictions. The Taltson 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 pass through the RSA. Infrastructure required for the Taltson Project in the study area includes the placement of transmission towers. The magnitude of incremental changes to muskoxen and moose habitat quantity and quality from the Taltson project was predicted to be negligible to low. Most impacts from the Taltson Project should be associated with localized changes in movement and behaviour of muskoxen and moose 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 muskoxen and moose from a conservation perspective.

Although quantitative and less biased than models based on expert opinion, HSI-based habitat maps have numerous 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 are a static view between a species and its environment, ignoring changes over time with ecological succession and natural disturbances such as climatic events. However, when considering the predictions on the effects from the Project on muskoxen and moose habitat, sources of uncertainty were reduced by using multiple habitat mapping methods (Burgman et al. 2005). For example, the assessment included both fragmentation analyses and the use of HSI models, which together limit bias and imprecision in predictions.

To reduce uncertainty associated with changes in habitat quality, and altered movement and behaviour of muskoxen and moose, conservative estimates of the zones of influence and disturbance coefficients were applied to the HSI models. For example, the zones of influence and disturbance coefficients for muskoxen and moose used for the Project were also applied to smaller and less active exploration sites. In addition, a 500 m radius was used to estimate the area of the footprint for exploration sites (78.5 ha). This likely overestimates direct habitat loss as drilling activities are generally completed in the winter to avoid rutting from the rig and on-site vehicles (unless a heli-portable drill rig is used).

Zones of influence were also applied to all active exploration sites in the RSA for the entire permit period even though activities typically do not occur throughout the year, and some sites may have been abandoned before permit expiration. 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. All of these attributes provide confidence that the assessment has not underestimated the environmental significance of the incremental and cumulative impacts from the Project on muskoxen and moose, and the people that value these species for their livelihood.

11.11.10 Monitoring and Follow-Up

Upon approval of the Project, a wildlife effects monitoring program (WEMP) will be implemented to test impact predictions and further reduce any uncertainty related to each prediction. The principal goal of the WEMP is to provide information required for the Project 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 evaluate the impacts from the Project on the persistence of populations, and the continued opportunity for traditional and non-traditional use (i.e., assessment endpoints). Based on the definitions of monitoring in Section 3.2.7 of the Terms of Reference (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 zone of influence); 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, traditional knowledge (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, Diavik Mine, and Ekati diamond mines), 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 the appropriate government agencies responsible for wildlife, 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 may include muskoxen and moose. Following the principles of adaptive management, species selected for monitoring may be periodically reviewed by government, community, and regulatory agencies, and changed as necessary.

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.

11.11.11 References

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11.11.12 Acronyms and Glossary

11.11.12.1 Abbreviations and Acronyms

CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DC	disturbance coefficients
De Beers	De Beers Canada Inc.
EIS	environmental impact statement
ELC	ecological land classification
ENR	Department of Environment and Natural Resources
GHL	General Hunting Licence
GIS	geographic information system
HSI	habitat suitability index
INAC	Indian and Northern Affairs Canada
L_{eq}	equivalent continuous sound and noise level
LKDFN	Łutsel K'e Dene first Nation
L_{max}	maximum sound and noise level
LSA	local study area
MVEIRB	Mackenzie Valley Environmental Impact Review Board
MVLWB	Mackenzie Valley Land and Water Board
MVRMA	*Mackenzie Valley Resource Management Act*
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NWT	Northwest Territories
PAG	potentially acid-generating
PAI	potential acid input
PK	processed kimberlite
PKC	processed kimberlite containment
PM	particulate matter
PM_{10}	particulate matter with particle diameter nominally smaller than 10 µm
$PM_{2.5}$	particulate matter with particle diameter nominally smaller than 2.5 µm
Project	Gahcho Kué Project
RSA	regional study area
SGP	Slave Geological Province
SO_2	sulphur dioxide
spp.	species
Terms of Reference	*Terms of Reference for the Gahcho Kué Environmental Impact Statement*
TK	traditional knowledge
TSP	total suspended particulates
VC	valued component
WEMP	Wildlife Effects Monitoring Program

ZOI	zone of influence

11.11.12.2 Units of Measure

%	percent
<	less than
>	greater than
≥	greater than or equal to
±	plus or equal to
μg/m^3	micrograms per cubic metre
cm	centimetre
dBA	decibels
dBL	linear decibels
ha	hectare
keq/ha/y	kiloequivalent per hectare
kg/ha/y	kilograms per hectare per year
km	kilometre
km^2	square kilometres
m	metre
mm/s	millimetres per second

11.11.12.3 Glossary

Abundance	The number of individuals.
Accuracy	The nearness of a measurement to the actual value of the variable being measured.
Air quality	A measure of substance concentrations in ambient air. The less the concentration of a particular substance the better the air quality.
Ambient air quality guideline	Is an ambient outdoor air concentration or deposition value for a specific substance, or groups of substances that has been established to safeguard the health of ecosystem components (most often sensitive humans or vegetation).
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.
Community	Group of co-existing organisms in an ecosystem.
Competition	Interactions among organisms that use the same limiting resources (resource competition) or that harm one another in the process of seeking a resource (interference or intraspecific competition).

Coniferous	This term is used to describe a tree that bears cones. Evergreens comprise the majority of this type of tree. They are called evergreens because they do not shed their leaves in the fall.
Critical load	Quantitative estimate of an exposure, in the form of deposition, to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.
Cratering	Small depressions in the snow made by moose and muskoxen (or other ungulates) searching for lichens.
Deciduous	Deciduous means *temporary* or *tending to fall* off (deriving from the Latin word *decidere*, to fall off) and is typically used in reference to trees or shrubs that lose their leaves seasonally.
Density	The number of individuals per unit area.
Distribution	The pattern of dispersion of an entity within its range.
Disturbance Coefficient	The effectiveness of the habitat within the disturbance zone of influence in fulfilling the requirements of a species.
Drumlins	A long narrow hill, made up of till, which points in the direction of the glacier movement.
Ecosystem	Ecological system consisting of all the organisms in an area and the physical environment within which they interact.
Esker	Linear structures of loose sand and gravel, formed by glacial rivers. They provide critical habitat for carnivores and ungulates in the arctic.
Eutrophication	Excessive growth of algae or other primary producers in a stream, lake or wetlands as a result of large amounts of nutrient ions, especially phosphate or nitrate.
Exposure Ratios	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.
Fen	Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters. Minerotropic peat-forming wetlands that receive surface moisture from precipitation and groundwater. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.
Forbs	A broad-leaved herb, that is not a grass.
Freshet	A sudden overflow of a stream caused by heavy rain or nearby thawing of snow or ice.
Fugitive Dust	Contaminants emitted from any source except those from stacks and vents. Typical particulate sources include wind blown dust, bulk storage areas, open conveyors, construction areas, or roads.
Graminoid	Grasslike plant (grasses, sedges, and rushes).
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 available	The accessibility and use of physical and biological components in a habitat.
Habitat use	A hierarchial process involving a series of innate and learned behavioural decisions made by an animal about what habitat it would use at different scales of the environment.
Home range	The way an animal uses (or *consumes*, in a generic sense) a collection of physical and biological entities in a habitat.

Kames	Steep-sided mounds of stratified material deposited against an ice-front.
Landscape	Mosaic of patches that differ in ecologically important properties.
Open Canopy	Less than 6% tree cover.
Particulate Matter	Dust
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Polycyclic Aromatic Hydrocarbons	A group of aromatic organic compounds (consisting of several inter-bonded benzene rings) associated, in trace amounts, with incomplete fuel and waste material combustion.
Population	Classically, a collection of interbreeding individuals.
Potential Acid Input	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.
Range	The geographic limits within which an organism occurs.
Raster	A graphic structure where the data is divided into cells on a grid. An example would be a computer screen where an image is represented by horizontal lines of coloured pixels. Shapes are represented by cells of the same colour or content adjacent to each other.
Resource	Any biotic and abiotic factor directly used by an organism.
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.
Scale	The resolution at which patterns are measured, perceived, or represented. Scale can be broken into several components, including geographic extent, resolution, and other aspects.
Sedge	Any plant of the genus *Carex*, which are perennial herbs, often growing in dense tufts in marshy places. They have triangular jointless stems, a spiked inflorescence, and long grass-like leaves which are usually rough on the margins and midrib. There are several hundred species.
Study area	An arbitrary spatial extent chosen by the investigator within which to conduct a study.
Successional Stage	A particular phase of the forest succession continuum with its own characteristic of age, structure, and composition of species. Stages may include the following: pioneer, young seral, maturing seral, old seral, young edaphic, mature edaphic, young climatic, mature climatic and disclimax.
Total Edge	The perimeter of a patch, or the total distance of the edge of a patch of habitat.
Total Suspended Particulate	Dust (the same as particulate matter (PM). Total suspended particulate contains $PM_{2.5}$, PM_{10} and bigger than 10 μm in diameter particles.
Treeline	An area of transition between the tundra and boreal forest to the south

Tundra	A vast, mostly flat, treeless Arctic region of Europe, Asia, and North America in which the subsoil is permanently frozen. The dominant vegetation is low-growing stunted shrubs, mosses, lichens.
Ungulates	A hoofed, grazing mammal (e.g., moose and muskoxen, muskox, deer, moose).
Upland Areas	Ground elevated above the lowlands along rivers or between hills; highland or elevated land; high and hilly country.
Volatile Organic Compounds	Volatile Organic Compound (that boils below a temperature of about 100°C), excluding methane.
Zone of Influence	The surrounding area of a development site in which animal occurrence is reduced or increased due to avoidance or attraction.

APPENDIX 11.11.I

ABSOLUTE VALUES FOR CHANGES IN LANDSCAPE METRICS IN THE REGIONAL STUDY AREA FOR OTHER UNGULATES

Table 11.11.I-1 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) in the Regional Study Area (Spring to 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 Complex	624	624	624	624	145	145	145	147	769	769	769	754
Spruce Forest	32,224	32,199	32,150	32,128	96,659	96,583	96,411	96,425	78	78	78	78
Birch Seep	27,670	27,641	27,610	27,586	63,001	62,953	62,872	62,886	88	88	88	88
Peat Bog	48,410	48,363	48,264	48,227	84,575	84,526	84,442	84,513	76	76	76	76
Tussock Hummock	51,708	51,650	51,543	51,506	99,588	99,506	99,353	99,391	73	73	73	73
Heath Bedrock	38,657	38,622	38,582	38,551	55,211	55,167	55,108	55,148	85	85	85	85
Heath Tundra	24,419	24,414	24,344	24,316	30,635	30,624	30,600	30,626	122	122	122	122
Heath Boulder	44,559	44,508	44,476	44,450	81,460	81,389	81,316	81,339	78	78	78	78
Boulder Association	18,930	18,913	18,900	18,889	62,187	62,130	62,076	62,078	99	99	99	99
Bedrock Association	24,679	24,659	24,653	24,640	59,630	59,584	59,541	59,557	94	94	94	94
Tall Shrub	31,334	31,309	31,266	31,242	83,741	83,664	83,520	83,557	79	79	79	79
Sedge Wetland	56,197	56,136	56,001	55,965	53,616	53,583	53,472	53,535	84	84	84	84
Shallow Water	37,151	37,115	36,927	36,906	19,091	19,086	19,025	19,063	115	115	116	115
Deep Water	96,981	96,855	96,409	96,392	3,566	3,568	3,555	3,563	258	258	258	257

ha = hectares; m = metres

Table 11.11.I-2 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) in the Regional Study Area (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 Complex	624	623	623	623	145	147	147	149	769	756	756	741
Spruce Forest	32,224	32,195	32,147	32,119	96,659	96,582	96,409	96,422	78	78	78	78
Birch Seep	27,670	27,634	27,604	27,576	63,001	62,967	62,886	62,904	88	88	88	88
Peat Bog	48,410	48,355	48,258	48,217	84,575	84,539	84,451	84,531	76	76	76	76
Tussock Hummock	51,708	51,645	51,539	51,497	99,588	99,511	99,356	99,404	73	73	73	73
Heath Bedrock	38,657	38,620	38,579	38,545	55,211	55,166	55,108	55,153	85	85	85	85
Heath Tundra	24,419	24,411	24,342	24,313	30,635	30,628	30,603	30,630	122	122	122	122
Heath Boulder	44,559	44,506	44,474	44,441	81,460	81,389	81,316	81,350	78	78	78	78
Boulder Association	18,930	18,912	18,898	18,884	62,187	62,127	62,073	62,083	99	99	99	99
Bedrock Association	24,679	24,657	24,652	24,636	59,630	59,583	59,540	59,558	94	94	94	94
Tall Shrub	31,334	31,303	31,261	31,228	83,741	83,672	83,526	83,578	79	79	79	79
Sedge Wetland	56,197	56,121	55,988	55,938	53,616	53,609	53,497	53,582	84	84	84	84
Shallow Water	37,151	37,094	36,908	36,872	19,091	19,126	19,058	19,133	115	115	115	115
Deep Water	96,981	96,739	96,300	96,210	3,566	3,573	3,560	3,574	258	258	258	256

ha = hectares; m = metres